Universidad Pública de Navarra
Nafarroako Unibertsitate Publikoa

Facultad de Ciencias Económicas y Empresariales

TRABAJO FIN DE GRADO EN

PROGRAMA INTERNACIONAL DEL DOBLE GRADO EN ADMINISTRACIÓN Y DIRECCIÓN DE EMPRESAS Y EN ECONOMÍA

INTERNATIONAL TRADE IN MEDICAL PRODUCTS: AN ANALYSIS OF SPANISH IMPORTS OF PHARMACEUTICAL PRODUCTS AND PERSONAL PROTECTIVE EQUIPMENT

Laura Martín Lizaso

Pamplona-Iruña 18 de mayo de 2020

Director: Antonio Gómez Gómez-Plana

Economía Española, Internacional y Sectorial

ABSTRACT

This paper is aimed at describing the framework in which international trade in medical products takes place, and analyzing the determinants of Spanish imports of the cited products from OECD countries and China. Regarding the latter, two econometric analyses based on the Gravity Model of world trade are performed, concerning 2016 cross-sectional data and 2007-2017 panel data. Results from these analyses suggest that total Spanish imports of the pharmaceutical products and personal protective equipment studied are explained by distinct variables. These variables are EU membership, trade competitiveness, number of researchers and share of high technology exports of the exporting country. Likewise, certain variables determining Spanish imports of various types of pharmaceutical products appear to diverge, including the cited regressors, as well as the value of exports of the same products by Spain. Moreover, the Gravity Model seems to hold over time for Spanish imports of all the medical products considered.

KEYWORDS

International trade, Gravity Model, medical products, Spain, Covid-19

0. INDEX

1. INTRODUCTION

International trade has nowadays reached unprecedented levels as a proportion of total world production (Krugman et al., 2018). Although trade may adversely affect particular groups within nations, it almost always brings mutual benefits to the trading countries, such as increasing the variety of goods available to people or bringing down domestic prices. There are two main reasons explaining trade among countries: (i) Comparative advantage, as a consequence of differences in resources, tastes or technology; and (ii) economies of scale that make it profitable for states to specialize in the production of a small number of products (Krugman et al., 2018). Regarding economies of scale, they may take the form of internal or external. The unitary cost in the former decreases with the size of an individual firm, while that in the latter does so with geographical concentration of the industry. The main focus of the present study is international trade in pharmaceutical products, being the pharmaceutical industry a notable example of internal economies of scale.

As regards internal economies of scale, increasing returns lead to imperfect competition (Krugman et al., 2018). High entry barriers exist in the pharmaceutical sector, as large R&D investments are required, while there is little certainty about the final result at the beginning of the process of drug development (Priede Bergamini et al., 2009). Therefore, most of the firms engaging in those processes are large companies.

Internal economies of scale create incentives for international specialization and subsequent trade and, consequently, production is concentrated among better-performing firms, leading to an improvement of the general efficiency of the industry (Krugman et al., 2018). In this vein, due to the need of a larger market size so as to cover the high costs incurred by firms operating in the sector, international trade in pharmaceutical products is high (Priede Bergamini et al., 2009). Based on the data provided by World Trade Organization (2020a), world exports of pharmaceutical products in 2019 amounted to $547.69 billion, while imports had a value of $566.33 billion.

Given the importance of international trade in personal protective equipment (PPE) as a consequence of the Covid-19 outbreak and, due to the close connection existing between these goods and medicines being both part of medical products, they are also included in the present analysis. World imports of PPE[1] in year 2019 had a value of $131.47 billion, whereas exports added up to $139.42 billion in the same year (World Trade Organization, 2020a).

[1] As defined by World Trade Organization (2020a).

This paper is aimed at (i) describing the context in which international trade in medical products takes place, and (ii) analyzing the determinants of Spanish imports of medical goods, namely of pharmaceutical products and PPE, from OECD countries and China. An econometric analysis concerning 2016 cross-sectional data and 2007-2017 panel data is performed for the purpose of the latter. From now on, medical goods will jointly refer to medicines and PPE. The analysis is focused on OECD countries and China, since 92.84% of Spanish imports of pharmaceutical products and 95.11% of PPE imports by Spain in 2019 had their origin in this group of countries (DataComex, 2020).

An econometric analysis seeking to find out the determinants of Spanish exports of medical goods to OECD countries and China has also been performed. Nevertheless, given that the results obtained do not seem to be consistent with the industry characteristics and trade regulation of the products in matter, it has been decided not to include it in the present paper.

The paper structure is as follows. Firstly, it provides information about the main characteristics of the market for pharmaceutical products and of that for PPE in sections 2 and 3, respectively. Section 4 summarizes the current situation of international trade in medical products in the Covid-19 context. Then, an overview of the evolution and main trading partners of Spain, as regards its trade in medical goods with the rest of the world, is provided in section 5. Section 6 presents an econometric analysis of Spanish imports of medical products from OECD countries and China, involving two analyses: one based on 2016 cross-sectional data; and the other one employing 2007-2017 panel data. Finally, section 7 describes the conclusions drawn from the present study.

2. THE MARKET FOR PHARMACEUTICAL PRODUCTS

This section provides an overview of the main characteristics regarding the market for pharmaceutical products. Note that the terms pharmaceutical product and medicine are used interchangeably along this paper. The issues addressed, concerning pharmaceutical products, are: (i) Definition and classification; (ii) supply and demand; and (iii) international trade.

2.1. Definition and classification of pharmaceutical products

The Spanish Ministerio de Sanidad, Consumo y Bienestar Social (2020a) defines pharmaceutical products as "every medicinal substance and its associations or combinations intended for human or animal use, that feature properties for prevention, diagnosis, treatment, relief or cure of diseases, or for affecting body functions or mental state". Medicines may be classified according to various criteria, including: (i) Process of creation

(Otero García-Castrillón, 2006); (ii) distribution (OECD, 2019); and (iii) trade purposes (World Customs Organization, 2020; European Commission, 2020a), among others.

Regarding the process of creation, (i) drugs protected by a patent, and (ii) generic drugs exist (Otero García-Castrillón, 2006). The former are "medicines created as a result of a long and costly R&D process" (Montpart & Martín, 2001). Consequently, their price is substantially higher than that of generics. Regarding generics, they are "drugs developed from the experience of an innovative medicine, as they contain the same active pharmaceutical ingredient, in the same quantity" (Montpart & Martín., 2001).

Concerning the place where these products are distributed, (i) retail pharmaceuticals, and (ii) hospital pharmaceuticals exist (OECD, 2019). The OECD (2019) defines retail pharmaceuticals as "provided outside hospital care, such as those dispensed through a pharmacy", while hospital pharmaceuticals "include drugs administered or dispensed during an episode of hospital care".

As for the classification of medicines based on trade purposes, it draws from that provided by the 2017 Harmonized System (HS) Nomenclature, developed by World Customs Organization. It is arranged in chapters, being pharmaceutical products covered in Chapter 30 of the HS 2017 Nomenclature (World Customs Organization, 2020). The HS 2017 Nomenclature headings of interest to the present paper, which are the ones included in the definition of medicines by World Trade Organization (2020a), are presented in Table 1.

Table 1
HS 2017 Nomenclature headings and description of pharmaceutical products

HS Heading	Description
3002	Human blood; animal blood prepared for therapeutic, prophylactic or diagnostic uses; antisera, other blood fractions and immunological products, whether or not modified or obtained by means of biotechnological processes; vaccines, toxins, cultures of micro-organisms (excluding yeasts) and similar products.
3003	Medicaments (excluding goods of heading 30.02, 30.05 or 30.06) consisting of two or more constituents which have been mixed together for therapeutic or prophylactic uses, not put up in measured doses or in forms or packings for retail sale.
3004	Medicaments (excluding goods of heading 30.02, 30.05 or 30.06) consisting of mixed or unmixed products for therapeutic or prophylactic uses, put up in measured doses (including those in the form of transdermal administration systems) or in forms or packings for retail sale.

Source: Own compilation based on data from World Customs Organization (2020).

2.2. Supply and demand of pharmaceutical products

On the one hand, the pharmaceutical industry is characterized by high R&D investment rates, since the competitive advantage of pharmaceutical laboratories lies in innovations. In fact, "on average across OECD countries, the industry spent nearly 12% of its gross value added on R&D" (OECD, 2019). Evidence from UNCTAD (2019) shows that pharmaceutical companies were the ones exhibiting the highest R&D intensities[2] among world Top 100 Multinational Enterprises in 2018.

It is worth of mention that developing a new drug is a costly and risky task, as it takes around ten to fifteen years to develop and commercialize a new medicine, while there is little certainty about the final result along the process (Priede Bergamini et al., 2009). Thus, many of the companies operating in the pharmaceutical sector are large multinationals, while there also exist numerous small national biotechnological firms in the sector, which frequently license their rights to large companies (Otero García-Castrillón, 2006; ICEX, 2019).

Furthermore, the pharmaceutical industry has a high market concentration. Evidence provided by Christel (2019) suggests that the ten world largest pharmaceutical producers by sales covered 51.64% of the market share in the industry[3] in 2018. Table 1A in Annex 1 provides some indicators of the structure of the pharmaceutical sector, for world largest fifty pharmaceuticals in 2018. Note that high market concentration in the sector empowers these companies for deciding about quantities to be produced and their prices in the market.

In addition, there is also geographical concentration in the pharmaceutical sector. Considering the world largest fifty pharmaceutical manufacturers in 2018, 40% were based in Europe, 34% in US and 16% in Japan (Christel, 2019). Likewise, the sector is characterized by a high degree of internationalization, probably due to the need to serve large markets so as to cover the high costs incurred by pharmaceutical companies (Priede Bergamini et al., 2009). According to World Trade Organization (2020a), world exports of medicines in 2019 amounted to $547.69 billion, while imports had a value of $566.33 billion.

On the other hand, the demand of medicines has increased in recent years, as a consequence of the ageing of the population and the prevalence of degenerative chronic illnesses in developed countries, among others (ICEX, 2019).

The demand of medicines in developed countries is considered to have a low elasticity, since national governments are the main direct clients (Otero García-Castrillón, 2006). Evidence shows that, in OECD countries, government funding and compulsory financing schemes were the most important players in the demand of medicines, as they represented 58% of total spending on retail pharmaceuticals in 2017 (OECD, 2019). In addition to the co-

[2] R&D expenditure as a percentage of total revenue.

[3] For the purpose of studying the structure of the pharmaceutical industry, the market is considered to be made up of the fifty firms included in Table 1A in Annex 1.

financing of medicines for citizens, government adopted measures in this context include the reduction of prices set by manufacturers (Otero García-Castrillón, 2006; OECD, 2019). The main purpose of the cited public interventions is to grant access to medicines and ensure public health. Moreover, Jacobzone (2000) claims that "a higher share of public spending in pharmaceutical spending increases pharmaceutical expenditure".

Even when no reimbursement exists for consumers, and especially in developed countries, buyers are still willing to pay high prices for certain medicines. This means that "the demand for many drug products is fairly inelastic up to rather high price levels before income effects begin imparting appreciable elasticity" (Scherer, 2000). Furthermore, pharmaceutical spending appears to increase linearly with income (Jacobzone, 2000). However, even if price intervention by the State exists in developing countries, policy inefficiency causes demand of medicines to be elastic, as most pharmaceutical expenditure in these countries comes from out-of-pocket payments (Otero García-Castrillón, 2006).

2.3. International trade in pharmaceutical products

Medicines are considered as products with a high added value in economic terms, while having a large strategic value from the health and industrial perspective. Since they are essential for granting public health, and may bring important consequences to the latter, they are the most regulated products by states (Antoñanzas et al., 2005).

2.3.1. World.

The legal framework governing international trade in medicines is determined by the norms included in World Trade Organization's (WTO) Agreements.

The *General Agreement on Tariffs and Trade 1994* (GATT-1994) establishes the norms aimed at reducing or eliminating tariff and non-tariff barriers to trade among Member States, prohibiting discrimination. As a result of the Uruguay Round negotiations, twenty-two countries[4], which together produced 90% of world pharmaceutical production, agreed on reciprocal tariff elimination on medicines and substances used for their production, in the *1994 WTO Pharmaceutical Agreement* (Office of the United States Trade Representative, 2020). Current participants in this agreement are Canada, EU, Japan, Macao (China), Norway, Switzerland and US (World Trade Organization, 2020a).

Nowadays, medicines are the medical goods with the lowest average Most Favored Nation (MFN) tariff applied by WTO members, with an average MFN tariff of 2.1% applied by the

[4] Australia, Austria, Canada, Czech Republic, European Communities, Finland, Japan, Norway, Slovak Republic, Sweden, Switzerland and US.

latter on pharmaceutical products (World Trade Organization 2020a). However, there exists inter-country variation in the tariffs applied, being the MFN tariff applied currently by the EU on medicines 0% (World Trade Organization, 2020a).

Nevertheless, *Technical Barriers to Trade* and *Sanitary and Phytosanitary (SPS) Measures* are applied on trade in medicines. With the purpose of avoiding discrimination and the existence of unnecessary barriers to trade posed by these measures, the *Agreement on Technical Barriers to Trade* and the *Agreement on SPS Measures* exist. These complementary agreements only allow the implementation of protectionist measures if they are aimed at protecting public health (World Trade Organization, 2011, 2020b). Moreover, Intellectual Property Rights may also affect trade in medicines. They are regulated in the *Agreement of Trade-Related Aspects of Intellectual Property Rights (TRIPS)*, which pursues the liberalization of trade in products that are protected by intellectual rights, maintaining an equilibrium between the protection of the cited rights and that of public interests, such as health (Otero García-Castrillón, 2006; World Trade Organization, 2020c).

2.3.2. European Union

Regarding extra-EU trade, the European Commission (EC) and the European Medicines Agency (EMA) cooperate with partner organizations from all around the world, by means of bilateral and multilateral relations.

As for bilateral relations, they generally take place through bilateral regulatory dialogue, which exists with the US, China and India (European Commission, 20202b). Confidentiality Arrangements and Mutual Recognition Arrangements (MRA) are also of great importance in this sense. The former enable the sharing of confidential information between regulatory authorities, and are in place with Australia, Canada, Japan, Switzerland and US (European Commission, 2020b). On the question of MRAs, they pursue promoting market access of medicines and boosting “international harmonization of compliance standards”, without giving up public health (European Medicines Agency, 2020). Currently, MRAs exist with Australia, Canada, Israel, Japan, New Zealand, Switzerland and US (European Commission, 2020b). Regarding multilateral relations, the EMA cooperates with authorities from different countries in multilateral coalitions and initiatives, such as the International Coalition of Medicines Regulatory Authorities, mainly aimed at the convergence of global standards and at the sharing of regulatory and scientific information (European Commission, 2020b).

Concerning intra-EU trade, it takes place in the context of the Single Market, where the free movement of goods is granted. Nevertheless, technical barriers are still an important issue regarding intra-EU trade in products such as medicines, which have a direct impact on consumer safety (Jordán Galduf & Tamarit Escalona, 2013). Moreover, because of the application of the *subsidiarity principle*[5], the pharmaceutical policy of EU Member States is fragmented, when it comes to price regulation particularly (Costa-Font & Kanavos, 2004).

The simultaneous existence of a Single Market and inter-country price differences in the EU leads to arbitrage practices known as *parallel trade*. The latter consists in buying medicines in one EU Member State where price is low and reselling them in another EU country, where prices are higher and the commercialization of those drugs is also authorized (Costa-Font & Kanavos, 2004). *Parallel trade in medicines* involves trading through channels other than those established by the manufacturer and regardless of her will and, in certain countries including Spain, it is enough with getting an authorization for the commercialization of the product by the parallel trader[6] (González-Baizán González-Lamuño, 2018). The European Commission (2018) claims that *parallel trade in medicines* is a legitimate act inside the Single Market, while exceptionally allowing for restrictions when justified by the protection of public health.

3. THE MARKET FOR PERSONAL PROTECTIVE EQUIPMENT

This section deals with describing the main features present in the market for personal protective equipment (PPE). It is composed of three parts, regarding PPE: (i) Definition and classification; (ii) supply and demand; and (iii) international trade.

3.1. Definition and classification of personal protective equipment

Given the health oriented focus of the present paper, a suitable definition of PPE is that formulated by the World Health Organization (2020a), which defines PPE as "garments placed to protect the health care workers or any other persons to get infected". The classifications of PPE presented below are those provided by (i) World Trade Organization (2020a); and (ii) European Commission (EUR-Lex, 2020b).

World Trade Organization (2020a) considers being PPE the following: (i) Hand soap; (ii) washing and cleaning preparations; (iii) hand sanitizer; (iv) face masks; and (v) protective spectacles and visors. This classification of PPE is employed in the sections that follow.

The EC (EUR-Lex, 2020b) regards PPE to be composed of the following: (i) Protective spectacles and visors; (ii) face shields; (iii) mouth-nose protection equipment; (iv) protective garments; and (v) gloves.

---

[5] It is aimed at ensuring that "decisions are taken as closely as possible to the citizen" (EUR-Lex, 2020a).

[6] If no reconditioning, packaging and/or relabeling is to be performed by the trader.

3.2. Supply and demand of personal protective equipment

The PPE market has a high degree of internationalization, with trade in PPE[7] having an average value of $135 billion in the period 2017-2019 (World Trade Organization, 2020a). Given the low profit margins on most of these products, they are mainly produced in Asia, where labor costs are significantly lower than in western economies (Deutsche Welle, 2020). Thus, most countries rely on China for imports of PPE (Peterson Institute for International Economics, 2020a). Regarding the EU, production of PPE is concentrated in a small number of countries including Czech Republic, France, Germany and Poland (EUR-Lex, 2020b).

According to World Trade Organization (2020a), 17.2% of the exports of these products came from China in the period 2017-2019, 12.7% of them were produced in Germany, and the US was the country of origin of 10.2% of them. If the PPE definition provided by the EC is regarded, 43% of total world imports of these products in 2018 came from China, while being China the of origin of 50% of imports of PPE by the EU in the same year (Peterson Institute for International Economics, 2020a).

Regarding the demand of PPE, it is not limited to the health care sector. However, given the health orientation of this paper, the focus will be placed in the latter. In this sense, the main purpose of PPE is to protect health care workers, as well as citizens in face of a pandemic (World Health Organization, 2020b).

PPE represented 13% of world medical product imports in 2019, and the US and Germany were the largest importers of PPE[8] in that year, as their imports accounted together for more than 22% of total world imports of the cited products (World Trade Organization, 2020a).

3.3. International trade in personal protective equipment

Although not being as highly regulated as medicines, due to their effect on citizens' health, there exist strong regulations on PPE. Most of the regulation is materialized in certificates of compliance with the safety standards established by countries on the cited products.

Moreover, tariff barriers pose significant obstacles to international trade in PPE (World Trade Organization, 2020a). The average MFN tariff applied by WTO member countries to PPE relevant for Covid-19 is 11.5%, more than five times greater than that applied on medicines by the same countries (World Trade Organization, 2020a). Furthermore, if analyzing separately PPE products, hand soap has an average MFN tariff of 17% regarding WTO members, whereas the average MFN tariff on hand sanitizers is of 5% and that on

[7] As defined by World Trade Organization (2020a).
[8] As defined by World Trade Organization (2020a).

face masks of 9.1% (World Trade Organization, 2020a). Nevertheless, the application of tariffs varies among the countries considered. According to World Trade Organization (2020a), the latest average MFN tariff applied on Covid-19 PPE products by the EU is 3.9%.

4. COVID-19: CURRENT SITUATION OF TRADE IN MEDICAL PRODUCTS

The current global health emergency situation caused by Covid-19 has significantly affected trade in medical goods, especially that in PPE. It has led to increases in the stocking levels of PPE by countries, so as to keep medical workers safe and prevent the propagation of the virus. Consequently, the demand of these products has increased globally, and so has import demand, as many countries are highly dependent on PPE imports.

Nevertheless, many international orders of PPE in recent months have not arrived at the buying country in the previously agreed conditions. In fact, in some cases products arrive at a later date than that initially agreed upon, in other instances a lower amount of the goods is received, while it may even be the case that no product reaches the importing country. There are two main reasons explaining these happenings: (i) Intercepts of shipments bought by some countries, by other countries, and (ii) trade restrictive policy measures implemented by states. A more detailed account of these issues follows.

4.1. Intercepts of shipments

Intercepts of shipments ordered by other countries consist in diverting shipments of PPE intended for other countries by outbidding the original importer. Although this behavior is not allowed under international trading rules, it has become a reality in the context of the Covid-19 pandemic. For instance, the US has been blamed by several countries, including Brazil, Canada, France, Germany and Paraguay, for having intercepted their shipments of PPE ordered to China. According to authorities in these countries, US buyers went to Chinese airports where shipments were about to be sent to their destination countries, they paid upfront three to four times the price paid by original buyers, and diverted shipments to the US (El País, 2020; Financial Times, 2020).

4.2. Trade policy measures

Many countries have implemented export restrictions on medical products, which are justified on public health reasons. Among these countries, the EU is found. At the start of Covid-19 pandemic, the EC published a regulation requiring that all exports of PPE to countries outside the EU were subject to an export authorization by Member States (EUR-Lex, 2020b). Nevertheless, the EC subsequently amended this Regulation restricting the cited export authorization to protective masks, spectacles and garments (EUR-Lex, 2020c).

In addition to EU Member States, four OECD Member Countries have recently adopted trade restrictive measures. In this sense, Switzerland has established exports of PPE and vital medical goods subject to export authorization, while South Korea, Australia and the UK have implemented export bans on face masks, non-commercial exports of PPE and certain medicines, respectively (World Trade Organization, 2020d). Concerning extra-OECD territories, twenty-six[9] of them have also implemented temporary export restrictions and/or prohibitions on medical goods recently (World Trade Organization, 2020d).

However, not every country agrees on the implementation of protectionist measures for fighting Covid-19. In this sense, Australia, Brunei Darussalam, Canada, Chile, the Republic of the Union of Myanmar, New Zealand and Singapore have recently committed to remove existing trade barriers on medical products (World Trade Organization, 2020d). Furthermore, the US has excluded temporarily certain Chinese exports from additional tariffs (World Trade Organization, 2020d). In the same vein, the EC appealed the EU Member Countries to include measures at national level that would guarantee the availability of PPE across the EU where needed, as Member States were requested to minimize border-crossing procedures to what it is rigorously necessary (European Commission, 2020c).

Besides, export restrictions on PPE by China, being many countries dependent on the latter, have not taken place. In fact, trade measures adopted by China in this context include decreasing temporarily import tariffs on medical equipment, and exempting certain US imports from additional tariffs (World Trade Organization, 2020d). However, China eventually limited exports of medical goods to those products that have obtained a license for commercialization in the Chinese market, as a consequence of existing deviations between actual quality and that claimed by the exporting company in some international purchases, such as the acquisition of test kits by the Spanish Government (Ministerio de Sanidad, Consumo y Bienestar Social, 2020b).

Moreover, according to World Trade Organization (2020f), WTO members have liberalized trade in more than 84% of medical goods inside their Regional Trade Agreements by 2020.

4.3. Consequences

Among the most affected parties by these measures aimed at fighting Covid-19, developing countries are found. A relevant amount of exports of PPE by developed countries are

[9] Albania; Algeria; Argentina; Azerbaijan; Bangladesh; Brazil; Colombia; Costa Rica; Ecuador; Georgia; India; Indonesia; Kyrgyz Republic; Malaysia; Moldova; Morocco; Pakistan; Paraguay; Peru; Russian Federation; Serbia; South Africa; Separate Customs Territory of Taiwan, Penghu, Kinmen and Matsu; Sri-Lanka; Thailand & Ukraine.

directed to these nations, which are often reliant on them, while many developing countries lack the domestic industry necessary for self-supply of the products in matter. Thus, international trade is an essential tool for alleviating the effects of Covid-19 in these countries (Peterson Institute for International Economics, 2020c). For instance, countries located in Eastern Europe, north of Africa and Sub-Saharan Africa highly depend on EU exports of certain PPE products, as they make up more than 50% of their total imports of these goods in some cases (Peterson Institute for International Economics, 2020b).

However, the cited measures have also led to a shortage of PPE in developed countries, causing increases in prices of PPE and encouraging self-supply of these goods by states. Moreover, export bans may halt cross-border supply chains of medical goods that are vital in the context of the Covid-19 pandemic. What is more, they may disrupt exports of inputs to third countries that manufacture the medical goods subsequently imported by the country imposing the ban. Besides, these measures may induce the trading partners of the countries imposing the export ban to adopt export restrictions too, as a response to their *beggar-thy-neighbor* policy. Given that EU imports of the products initially subject to its own export restrictions amounted to $17.6 billion in 2019 (Peterson Institute for International Economics, 2020b), these measures might have a significant impact on public health.

According to Peterson Institute for International Economics (2020c), trade measures to sustain health care systems and save lives should be adopted. These include (i) decreasing tariffs in medicines and other medical goods, (ii) facilitating cross-border movement of health products, (iii) making available technical standards by countries, and (iv) ensuring that intellectual property regulation does not obstruct access to medical goods.

5. TRADE IN MEDICAL PRODUCTS BETWEEN SPAIN AND THE REST OF THE WORLD

Firstly, the evolution of Spanish trade flows of medical products with the rest of the world for the period 1995-2018 is presented in this section, followed by a description of the main Spanish trading partners for these products in 2019.

5.1. Spanish trade in medical products in the period 1995-2018

The evolution of Spanish imports and exports of medical products[10] with the rest of the world, together with the trade balance for these goods, for the period 1995-2018, is displayed in Figure 1.

[10] Medicines and PPE, as defined by World Trade Organization (2020a).

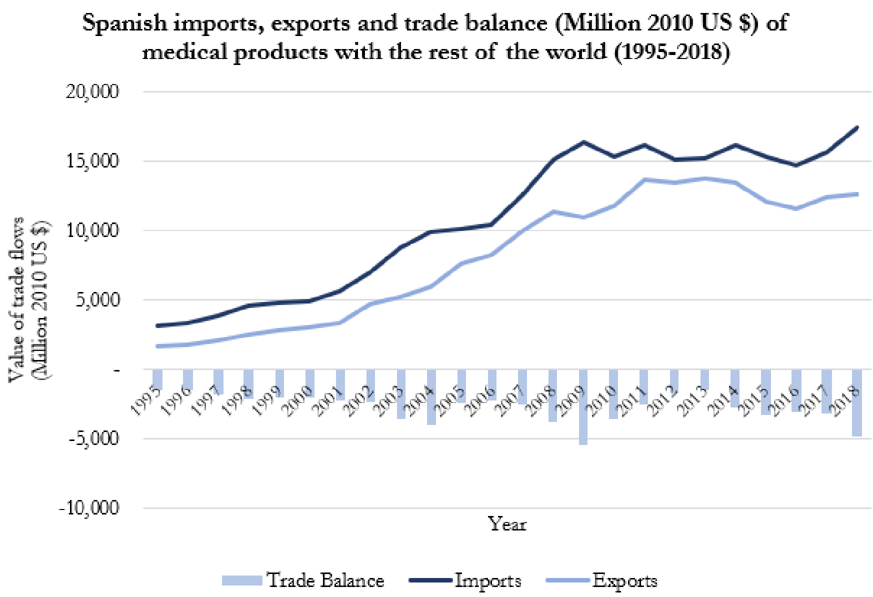


Figure 1. Spanish imports and exports (million 2010 US $) of medical products for the period 1995-2018.
Source: Own compilation based on data from DataComex (2020).

As evidenced by Figure 1, Spanish imports and exports of medical products have followed a similar trend throughout the period considered. From 1995 to 2002, both trade flows experienced a rather constant and slow growth. Beginning in year 2002, imports and exports increased their growth rates considerably, coinciding with the entry into circulation of the Euro[11]. Presumably, progress in technical harmonization regarding intra-EU trade in medicines has also contributed to the cited acceleration in growth rates, being worth of mention a Directive passed by the European Parliament and the Council on the establishment of a Community code for human medicines in 2001 (EUR-Lex, 2020d).

Since 2008, year to which the beginning of the global financial crisis is attributed, the values of Spanish imports and exports of medical goods have undergone slight fluctuations but have remained around their 2008 levels. This behavior in world trade flows of medical products, which is noteworthy given that trade in other goods fell significantly as a consequence of the crisis (Eurostat, 2020), is probably due to their essential nature regarding citizen's health. With respect to the Spanish trade balance for medical goods, Figure 1 shows that it has been negative for Spain for the duration of the whole period.

5.2. Main Spanish trading partners for medical products in 2019

The main five trading partners of Spain regarding imports and exports of medicines[12] in 2019 are presented in Figure 2. Interestingly, four of the five most important Spanish trading partners for medicines coincide for imports and exports, yet their order of relevance differs

[11] Spain and twelve of the countries in the sample had the Euro as their national currency in 2008.
[12] As defined by World Trade Organization (2020a).

between both trade flows. This fact evidences the importance of intra-industry trade in the pharmaceutical sector.

Intra-industry trade is defined as bilateral trade in different varieties of goods belonging to the same industry, and it generally takes place between countries which have similar factor endowments. This kind of trade is explained by imperfect competition models, which are based on economies of scale, leading to the concentration of production on a small number of firms (Krugman, 1980; Krugman et al., 2018).

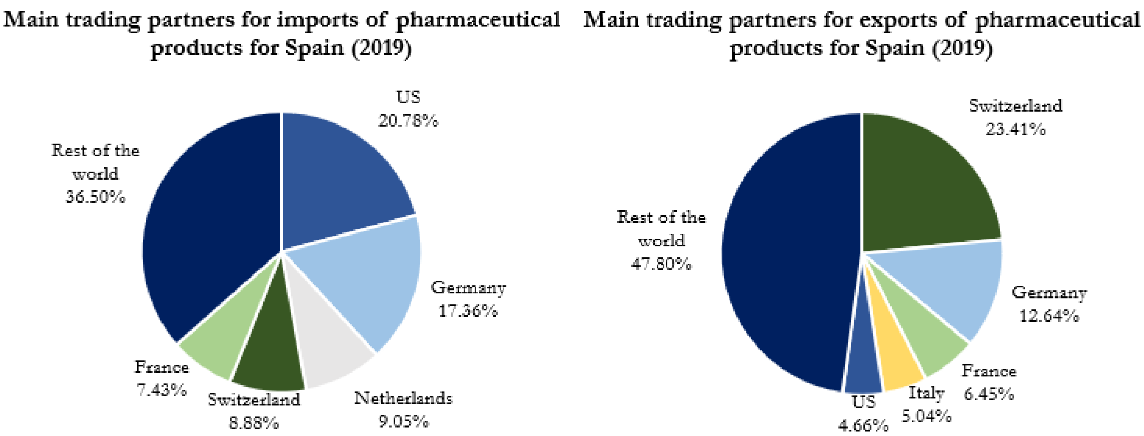


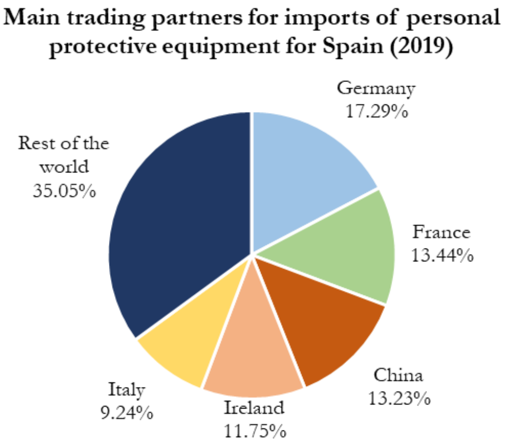
Figure 2. Main trading partners for trade in pharmaceutical products for Spain in 2019.
Source: Own compilation based on data from DataComex (2020).

Furthermore, three of the five most relevant countries regarding Spanish medicine trade belong to the EU, whereas the most important trading partner of Spain in both cases is an extra-EU country: US in the case of imports and Switzerland in the case of exports. These findings go in line with data about the EU, since US and Switzerland were the most important trading partners of the EU considering trade in medicines in 2019 (Eurostat, 2020). Moreover, with respect to Member States, Germany, the Netherlands and France were among the largest exporters of medicines in 2019 (Eurostat, 2020), which may explain why they are part of the five most important trading partners for Spain in 2019 regarding imports of the products in matter. Likewise, Germany was one of the most relevant destinations for Spanish exports of medicines in 2019, while evidence from Eurostat (2020) shows that it was the third largest medicine importer among EU Member States in the same year.

Spain's trading partners for trade in PPE[13] are displayed in Figure 3. One could argue that some degree of intra-industry trade is also present in the industry of PPE, since three of the five most relevant trading partners for Spain coincide both for imports and exports. Nevertheless, with respect to at least some PPE products, such as face masks, trade is mainly justified by differences in factor endowments. As for imports, Germany and France are the

[13] As defined by World Tarde Organization (2020a).

two most important Spanish trading partners, while being two of the countries at which EU production of these goods is concentrated (EUR-Lex, 2020b). China is the third country with the highest share in Spanish imports of PPE, which is sensible given that it was the world largest exporter of these products in 2019 (World Trade Organization, 2020a). Concerning Spanish exports of PPE, the top five trading partners for Spain are EU members[14]. Besides, the two main destination countries for Spanish exports of PPE are Portugal and France, which are both neighboring countries to Spain.



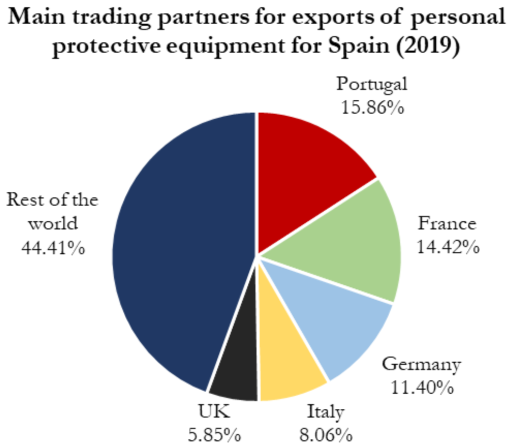


Figure 3. Main trading partners for trade in personal protective equipment for Spain in 2019.
Source: Own compilation based on data from DataComex (2020).

6. EMPIRICAL ANALYSIS OF SPANISH IMPORTS OF MEDICAL PRODUCTS FROM OECD COUNTRIES AND CHINA

This section presents an econometric analysis of Spanish imports of medical products from OECD countries and China. The focus has been narrowed to this group of countries since 92.84% of medicine imports and 95.11% of PPE imports by Spain in 2019 had their origin in OECD countries and China (DataComex, 2020).

The first part of the section provides the theoretical background of the Gravity Model of world trade, as the econometric models presented in the following subsections draw from it. The second and third parts are concerned with modelling 2016 cross-sectional data and 2007-2017 panel data about Spanish imports of medical products from OECD countries and China, respectively.

An econometric analysis has also been performed for Spanish exports of medical products to OECD countries and China. Regarding 2016 cross-sectional data, variations in Spanish exports of both medicines and PPE seem to be positive if, other things equal, the GDP or the share of pharmaceutical spending on health spending in Spain's trading partner rise by

[14] UK left the EU on 31/01/2020.

1%, while a 1% ceteris paribus increase in the distance between Spain and the importing country causes a negative variation of exports regarding both medical products considered. Moreover, EU membership by the importing country appears to affect only Spanish exports of medicines, positively. For 2007-2017 panel data, exports of both medical goods appear to increase when the GDP of the importing country increases by 1%, ceteris paribus. EU membership by Spain's trading partner has been found as having no effect on Spanish exports of neither medical good, while a 1% increase in the number of researchers in the importing country appears to affect only exports of PPE, positively.

Since these conclusions do not appear to be consistent with the industry characteristics and trade regulation concerning the products considered, it has been decided not to include the analysis of Spanish exports of medical goods in the present paper, and to focus on imports.

6.1. Gravity model

The Gravity Model of world trade was named after Newton's law of gravity, since it is based on the idea that "trade between any two countries is, other things equal, proportional to the product of their GDPs and diminishes with distance" (Krugman et al., 2018). Tinbergen (1962) was the first person employing this model to explain international trade flows and, nowadays, it is one of the most popular econometric models in international trade.

Equation (1) is used for estimating trade between two countries. Where, K is the regression constant to be fitted to real data, T_{ij} is the value of trade between country i and country j, Y_i is country i's GDP, Y_j is country j's GDP, and D_{ij} is the distance between country i and country j. Furthermore, a, b and c are indexes introduced so as to get a better fit of real data.

$$T_{ij} = K \frac{Y_i^a * Y_j^b}{D_{ij}^c} \quad (1)$$

According to Equation (1), the determinants of the value of trade between two countries, i and j, are the GDPs of both countries and the distance between country i and country j. In fact, other things equal, a higher value of the GDP of either country, which is a proxy of the size of their economies, will lead to a higher value of trade. The reason behind is that economies with larger GDPs (i) tend to produce more products and, consequently, draw in more foreign spending, and (ii) they often have larger incomes, which may lead to spending more in consumption and, thus, also in imports. However, trade costs negatively affect the value of trade between country i and country j. Distance is the most commonly used proxy for trade costs, since it usually involves larger transport costs.

The gravity model is also useful for analyzing anomalies in trade. Some of the factors that may explain why the value of trade between two countries is far from that predicted by the gravity model are (i) cultural similarities such as language, (ii) adjacency, (iii) colonial links, (iv) trade agreements, (v) geography, (vi) bilateral exchange rates between currencies, and, in case trade flows of a particular industry are being analyzed, (vii) specific characteristics of the industry, among others. Cultural similarities, adjacency, colonial links and trade agreements are expected to positively affect trade flows between two countries.

6.2. Cross-sectional analysis for 2016

Based on the Gravity Model, a model for Spanish imports of medical goods for year 2016 is constructed in this section. Although data about the aforementioned imports is available for years after 2016, the existing lack of data regarding some of the relevant variables for the study concerning certain countries for subsequent years, would lead to weaker estimations. Thus, Spanish imports of medical products from OECD countries and China in 2016 are analyzed.

The analysis is performed with the econometrics package Gretl. The aim is to find the OLS estimators of the constant and the parameters for the regressors determining the considered trade flows. For this purpose, a cross-sectional database consisting of thirty-six cross-sections (countries) and six variables has been constructed. The countries included are the thirty-five OECD member countries[15] (other than Spain) and China, while the variables incorporated are described in the next section.

6.2.1. Variables

Data about Spanish imports of medical products has been retrieved from *DataComex*, the database containing Spanish foreign trade statistics. Imports in the database are measured in current US$. Thus, they have been transformed into constant 2010 US$ by using the Spanish GDP deflator obtained from the World Development Indicators database provided by *World Bank*. Total imports of medical goods are disaggregated into imports of (i) medicines[16] and (ii) PPE[17], as defined by World Trade Organization (2020a). Imports are included as "IM" in

[15] Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Sweden, Switzerland, Turkey, United Kingdom and United States. Although Colombia joined the OECD on 28/04/2020, it is not included in the analysis.

[16] HS 2017 Headings 3002, 3003 and 3004 (World Trade Organization, 2020a).

[17] Hand soap, washing and cleaning preparations, hand sanitizer, face masks, and protective spectacles and visors (World Trade Organization, 2020a).

the following models. Furthermore, given the differences in the nature of medicines belonging to different HS headings, a separate analysis for each group is also performed.

The size of a country's economy is proxied by the GDP of the country. Data about GDP expressed in constant 2010 US$ has been retrieved from the *World Bank* database for the thirty-six member countries of OECD, including Spain, and China. "GDP_i" will denote the Spanish GDP, whereas "GDP_j" stands for that of exporting countries.

Distance, denoted by "D_{ij}", is employed as a proxy for trade costs, it is measured in kilometers and it has been obtained from the GeoDist database by *CEPII*. Distances are computed "following the great circle formula, which uses latitudes and longitudes of the most important cities/agglomerations (in terms of population)" (Mayer & Zignago, 2011).

European Union (2020) data have been employed to construct a dummy variable indicating membership to the EU by Spain's trading partners. This variable, denoted by "EU", takes value 1 when the exporting country is an EU Member State, and 0 otherwise.

Given the importance of R&D investments on the pharmaceutical industry, data about the number of researchers in R&D per million people for each country has been retrieved from the World Development Indicators database provided by the *World Bank*. The purpose of including this explanatory variable is to proxy R&D activity in the countries considered. This regressor will be denoted by "RD", and it will be referred to as "number of researchers".

Likewise, data about high-technology exports as a share (%) of total manufacture exports of countries has been obtained from the World Development Indicators database by *World Bank*. High-technology exports refer to "products with high R&D intensity" (World Bank, 2020). According to the Heckscher-Ohlin theorem, the more relatively abundant a factor is in one country, the more concentrated are its exports in sectors with a higher relative intensity in that factor (Krugman et al., 2018). Thus, this regressor has been introduced aimed at proxying the relative abundance of knowledge in each country. The variable will be included as "HTEX" in the models, and it will be referred to as "share of high-technology exports".

6.2.2. Variable and model transformations

Variables are checked for normality prior to modelling imports since, if data about the variables does not follow a normal distribution, usually normality of the error does neither hold. Among the implications of lacking normality in data, the possible loss of validity of hypothesis testing is found (Universidad Complutense de Madrid, 2013). The Jarque-Bera (JB) test is employed for this purpose, where the null hypothesis claims normality of data. For a 5% significance level, variables reporting a p-value smaller than 0.05 are not considered normally distributed. According to the JB Test, imports of all the medical goods regarded, the GDPs of Spain's trading partners and the distance between Spain the exporting country do not follow a normal distribution. Consequently, as they only take strictly positive values, they are included in logarithmic form in the models. The p-values resulting from the JB test are provided in Table 2A in Annex 2 to the present paper.

Heteroskedasticity, which refers to the lack of a constant variance of the error of the General Linear Model, also leads to inefficient OLS estimators. With the purpose of basing the present analysis on homoscedastic models, all the models are tested for heteroskedasticity by the means of White's Test. The null hypothesis in this test claims homoscedasticity. Therefore, for a 5% significance level, those models reporting a p-value smaller than 0.05 are considered heteroskedastic and, thus, have been corrected for heteroskedasticity. The p-values resulting from White's Test are found in Table 3A in Annex 2 to the present paper.

6.2.3. Analysis of Spanish imports of medical products in 2016

Table 2
Value of 2016 Spanish medical product imports by groups

Goods	Value (constant 2010 US $)	Share on total imports
Total Medicines	**12,402,516,477**	**89.56%**
3002 - Blood, vaccines and similar products.	2,644,462,127	21.32%
3003 - Medicaments not put up in doses or packagings for sale*	233,952,673	1.89%
3004 - Medicaments put up in doses or packagings for sale*	9,524,101,677	76.79%
Personal Potective Equipment	**1,445,796,976**	**10.44%**
Total Medical Products	**13,848,313,453**	

* Excluding goods of heading 3002.
Source: Own compilation based on data from DataComex (2020).

From data in Table 2, it is apparent that the value of Spanish medicine imports as a share of the total Spanish medical product imports considered is more than eight times that of imports of PPE in 2016. Moreover, in the same year, more than 75% of Spanish medicine imports correspond to medicines under HS heading 3004.

Different models are introduced for "Total medicines", "HS 3002 medicines", "HS 3003 medicines", "HS 3004 medicines" and "PPE" imports by Spain.

$$l\_IM_{ij} = \alpha + \beta_1 GDP_i + \beta_2 l\_GDP_j + \beta_3 l\_D_{ij} + u_{ij} \qquad \text{(Model 1)}$$

The first model (Model 1) to be analyzed is the basic Gravity Model. β_1 stands for the mean percentage (expressed as per-unit) ceteris paribus effect of increasing Spanish GDP by one US$ on the predicted value of Spanish imports of the product in matter. β_2 is the mean ceteris paribus percentage variation in the predicted value of Spanish imports of the considered product when the GDP of Spain's trading partner is increased by 1%. β_3 represents the mean percentage change in the predicted value of Spanish imports of the product analyzed, when distance between Spain and the exporting country increases by 1%, other things equal.

Based on the theoretical background of the Gravity Model, coefficients β_1 and β_2 are expected to be positive in every case. In fact, the larger the size of the economy of the countries participating in trade, the larger the value of trade between them is expected to be. By contrast, β_3 is anticipated to be negative, since the greater the distance between two countries, the larger the trade costs are foreseen to be and, thus, the smaller the trade flows between them. The coefficients and their respective p-values for Model 1, regarding Spanish imports of medical goods, are presented in Table 3 below.

Concerning Model 1 in Table 3, the sign of the coefficients for GDP_j and D_{ij} is the expected one in every case. β_2 and β_3 are significant at a 1% significance level for all the dependent variables considered, except for the β_2 related to imports of HS 3003 medicines, which is only significant at a 5% significance level. In contrast, the coefficient for Spanish GDP does not have the expected sign neither for total medicine imports nor for HS heading 3002 and 3004 imports but, given that it is not possible to state at a 10% significance level that β_1 is different from zero for none of the dependent variables, it will not be taken into account. Furthermore, including the variable GDP_i in the model causes the data matrix to be close to singularity. Thus, GDP_i has been excluded from Model 2.

Table 3
Estimations for Model 1 and Model 2 with 2016 cross-sectional data

Ind. v./ Dep. v.	Model 1 Medicines Total[HC]	3002	3003	3004	PPE	Model 2 Medicines Total[HC]	3002	3003	3004[HC]	PPE
Constant	4.96E+15	7.43E+16	-9.63E+14	5.01E+15	-5.51E+14	-2.28E+00	-20.8841**	1.37E+01	-1.88E-01	-5.29E+00
p-value	0.2044	0.4023	0.5514	0.1311	0.7932	0.641	0.0364	0.1798	0.9781	0.213
GDPi	-3392.63	-50832.2	658.408	-3429.95	377.179					
p-value	0.2044	0.4023	0.5514	0.1311	0.7932					
l_GDPj	1.3001***	1.8063***	0.8443**	1.5328***	1.2918***	1.3811***	1.8158***	0.8359**	1.4644***	1.2906***
p-value	2.73E-08	1.04E-05	0.0347	2.77E-07	1.13E-09	8.11E-10	8.15E-06	0.0336	3.87E-07	6.44E-10
l_Dij	-1.1490***	-1.9491***	-2.9223***	-2.7072***	-1.7048***	-2.2279***	-1.7407**	-2.9526***	-2.8402***	-1.7341***
p-value	1.36E-08	0.0087	0.0005	4.11E-06	5.97E-06	5.74E-06	0.0113	0.0004	2.76E-06	1.06E-06
Adj. R^2	0.6769	0.4529	0.3672	0.6212	0.7081	0.7035	0.4577	0.3839	0.6259	0.7163

*[HC]Heteroskedasticity corrected; ***p-value<0.01, **p-value <0.05, *p-value<0.1*
Source: Own compilation based on data from Gretl.

$$l\_IM_{ij} = \alpha + \beta_1 l\_GDP_j + \beta_2 l\_D_{ij} + u_{ij} \qquad \text{(Model 2)}$$

Regarding Model 2, β_1 is expected to be positive and β_2 to be negative because of the aforementioned reasons. The coefficients and their respective p-values for Model 2, regarding Spanish imports of medical goods, are displayed in Table 3 above. The conclusions drawn for the coefficients of GDP_j and D_{ij} in Model 2 are identical to those described for Model 1, except for the β_2 corresponding to imports of HS 3002 medicines, which is now significant at a 5% significance level.

$$l\_IM_{ij} = \alpha + \beta_1 l\_GDP_j + \beta_2 l\_D_{ij} + \beta_3 EU_j + u_{ij} \quad \text{(Model 3)}$$

The variable named EU is introduced in Model 3, aimed at measuring the effect of barriers to trade on Spanish imports of medical products. As previously mentioned, the latest MFN tariff applied by the EU on medicines and PPE is 0% and 3.9%, respectively (World Trade Organization, 2020a). Moreover, non-tariff barriers, such as technical barriers, affect world trade in medical goods. The existence of barriers to trade is expected to lead to higher imports from EU Member Countries than from the rest of the world, especially in the case of PPE, as higher tariffs to imports from extra-EU countries are applied. β_3 denotes the mean ceteris paribus percentage change (expressed as per-unit) in the predicted value of Spanish imports of the goods in matter caused by EU membership by the exporting country, and it is expected to be positive. The coefficients obtained and the p-values associated to them for Model 3, regarding Spanish imports of medical goods, are presented in Table 4.

Table 4
Estimations for Model 3 and Model 4 with 2016 cross-sectional data

Ind. v./ Dep. v.	Model 3					Model 4				
	Medicines					Medicines				
	Total^{HC}	**3002**	**3003**	**3004**	**PPE^{HC}**	**Total**	**3002**	**3003**	**3004**	**PPE**
Constant	-6.95E+00	-32.6064**	-1.41E+01	-9.44E+00	-7.9554*	-11.3045*	-39.3261***	-27.1829**	-1.03E+01	-19.3024***
p-value	0.3202	0.0131	0.2554	0.3046	0.0859	0.0756	0.0055	0.0486	0.2369	0.0006
l_GDPj	1.4135***	1.9800***	1.3391***	1.5986***	1.2138***	1.5430***	2.1565***	1.5881***	1.6974***	1.5853***
p-value	2.48E-08	4.08E-06	0.0009	6.25E-07	1.56E-11	1.11E-09	2.12E-06	0.0003	8.97E-08	6.98E-12
l_Dij	-1.8351***	-0.9798	-1.4882*	-2.1879***	-1.2282***	-1.9724***	-1.1040	-0.6907	-2.7343***	-1.0921***
p-value	7.00E-04	2.44E-01	0.0616	1.10E-03	2.00E-04	4.00E-04	2.79E-01	0.4224	4.00E-04	8.80E-03
EUj	1.1987*	2.179	4.4569***	0.7214	1.3205**	1.2118	3.211*	6.0792***	0.8032	2.7333***
p-value	0.0965	0.1564	0.0038	0.5208	0.025	0.1267	0.0557	0.0009	0.459	0.0002
RDj						0.0005***	0.0005*	-0.0002	0.0006***	-0.0002*
p-value						0.0023	0.088	0.405	0.0053	0.099
Adj. R^2	0.6683	0.4758	0.5565	0.5980	0.8082	0.8022	0.5900	0.5799	0.7368	0.8419

*^{HC}Heteroskedasticity corrected; ***p-value<0.01, **p-value <0.05, *p-value<0.1*
Source: Own compilation based on data from Gretl.

Adding the regressor EU to Model 2 leads to having a positive and significant (1% significance level) coefficient regarding GDP_j for every dependent variable considered. Moreover, the D_{ij} coefficient for dependent variable "HS 3002 imports" loses statistical significance and that for "HS 3003 imports" is now significant only at a 10% significance level. The coefficient for the regressor EU is positive as expected, while it is only significant for total imports of medicines, and for imports of HS 3003 medicines and PPE, at a 10%, 1% and 5% significance levels, respectively. It is plausible to associate this result with the presence of tariff barriers to trade on PPE. As for medicine imports, this may be due to the existence of more developed technical harmonization inside the EU for these products, as compared to those with extra-EU countries.

$$l\_IM_{ij} = \alpha + \beta_1 l\_GDP_j + \beta_2 l\_D_{ij} + \beta_3 EU_j + \beta_4 RD_j + u_{ij} \quad \text{(Model 4)}$$

Model 4 adds the variable RD, so as to proxy the R&D activity of the countries considered. Changes in this variable are expected to be positively correlated with the value of Spanish imports of medicines, given the importance of R&D on the manufacturing of these goods. In contrast, it is predicted to have no effect or to be negatively correlated with imports of PPE, as their production, generally, does not require a high R&D activity. β_4 represents the mean percentage (expressed as per-unit) ceteris paribus effect on the predicted value of Spanish imports of the product in matter, of increasing the number of researchers in the exporting country in one person. Thus, β_4 is expected to be positive for medicine imports and negative or not statistically significant for PPE imports. The coefficients and their corresponding p-values, regarding Spanish imports of medical goods, are summarized in Table 4 above.

The conclusions drawn in Model 3 for the coefficients of the regressor GDP_j still hold in Model 4. Regarding D_{ij}, all the coefficients have the expected negative sign, but that corresponding to HS 3003 medicine imports is no longer statistically significant. The coefficient for EU is still positive and significant for imports of HS 3003 medicines and for imports of PPE, whereas both coefficients are significant at a 1% significance level in Model 4. Moreover, β_3 is now significant at a 10% significance level for imports of HS 3002 medicines, while it is not possible to state at a 10% significance level that it is different from zero in the case of total medicine imports.

A one person increase in the exporting country's number of researchers seems to affect positively total medicine imports (1% significance level) and imports of medicines under HS headings 3002 (10% significance level) and 3004 (1% significance level). Furthermore, this variable appears to be negatively correlated with the expected value of Spanish imports of PPE (10% significance level), while it appears sensible to associate it with the low R&D activity required, in general, for manufacturing PPE. Nevertheless, the size of β_4 is very small in every case.

$$l\_IM_{ij} = \alpha + \beta_1 l\_GDP_j + \beta_2 l\_D_{ij} + \beta_3 EU_j + \beta_4 RD_j + \beta_5 HTEX_j + u_{ij} \quad \text{(Model 5)}$$

Model 5 adds the variable HTEX to Model 4. This regressor represents the share of high-technology exports of Spain's trading partners, and seeks to proxy the relative abundance of knowledge in the latter. Since the pharmaceutical sector is classified as a high-technology manufacturing industry, increases in the share of high-technology exports by countries are expected to lead to a higher value of Spanish imports of medicines. However, they are foreseen to have no effect or be negatively correlated with imports of PPE, as the latter are considered medium-low and low technology products (OECD Directorate for Science, Technology and Industry, 2011). β_5 measures the ceteris paribus mean percentage (expressed as per-unit) change in the predicted value of Spanish imports of the product in matter, when the share of high-technology exports of its trading partner is increased in one unit. Therefore, β_5 is expected to have a positive sign for imports of medicines and to have a negative sign or not be statistically significant for imports of PPE. The results obtained when running Model 5 in Gretl are displayed in Table 5.

Table 5
Estimations for Model 5 with 2016 cross-sectional data

	Model 5				
	Medicines				
Ind. v./ Dep. v.	**Total**	**3002**	**3003**	**3004**	**PPE**
Constant	-1.01E+01	-37.1206***	-2.02E+01	-9.92E+00	-19.0145***
p-value	0.1063	0.007	0.1014	0.2672	0.0009
l_GDPj	1.5132***	2.1027***	1.4300***	1.6879***	1.5779***
p-value	1.98E-09	2.41E-06	0.0003	2.01E-07	2.27E-11
l_Dij	-2.0984***	-1.4020	-1.1965	-2.7745***	-1.1234***
p-value	2.00E-04	1.66E-01	0.1378	5.00E-04	9.40E-03
EUj	1.2732	3.3621**	5.7618***	0.8227	2.7485***
p-value	0.1043	0.0402	0.0005	0.4575	0.0002
RDj	0.0004**	0.0003	-0.0005*	0.0006**	-0.0002*
p-value	0.0108	0.2579	0.0676	0.0122	0.0973
HTEXj	0.0523	0.1284	0.1571**	0.0167	0.0130
p-value	0.1764	0.1145	0.0213	0.7612	0.6818
Adj. R^2	0.8094	0.6170	0.6724	0.7269	0.8365

*[HC]Heteroskedasticity corrected; ***p-value<0.01, **p-value <0.05, *p-value<0.1*
Source: Own compilation based on data from Gretl.

Model 4 and Model 5 lead to identical conclusions regarding regressors GDP_{j}, and D_{ij}. For regressor EU, the results found in Model 4 still hold, except in the case of HS 3002 medicines, which is now significant at a 5% significance level. Moreover, Spanish imports of PPE still seem to be negatively correlated with the number of researchers in the exporting country at a 10% significance level. This also holds for imports of HS 3003 medicines, which appears counterintuitive. Furthermore, β_4 is still positive for total medicine imports and imports of HS 3004 products, but only at a 5% significance level, while that for HS 3002 imports has lost statistical significance. Nevertheless, the size of these coefficients is rather small yet. Interestingly, it is only possible to state that a one unit increase in the regressor HTEX affects positively Spanish imports of HS 3003 medicines, at a 5% significance level. A sensible explanation may be that R&D intensity is higher in the production of HS 3003 heading medicines.

Subsequently, the mean ceteris paribus percentage variation in the predicted value of Spanish imports of the medical goods considered, when the value of Spanish exports of the same product is increased by 1%, has been analyzed. Moreover, the mean ceteris paribus percentage change in the predicted value of Spanish imports of medical goods when the value of the real effective exchange rate index of the exporting country is increased in 1% has been studied. However, it is not possible to state at a 10% significance level that the effect of these regressors on Spanish imports of either of the medical goods considered is different from zero. Moreover, a dummy variable for contiguity between Spain and the exporting country has initially been included but, since the results obtained do not appear to have economic sense, as contiguity seems to affect Spanish imports of medical goods negatively, it has been removed from the models.

Results

The model selection criteria will be Adjusted R^2, which is an improvement of R^2, as it penalizes the introduction of new regressors and enables the comparation of models including a different number of independent variables (Wooldridge, 2008). The higher the Adjusted R^2, the better is the variation of the dependent variable explained by the regressors included in the model and, therefore, the better the model. Accordingly, evidence in Tables 3, 4 and 5 suggests that Model 4 is the best model for explaining Spanish imports of medicines falling into HS heading 3004 (0.7368) and of those of PPE (0.8419), while Model 5 is the preeminent model for describing total imports of medicines (0.8094) and imports of medicines under HS headings 3002 (0.6170) and 3003 (0.6724).

Concerning Spanish imports of PPE, their predicted value seems to increase by 1.59% on average when the GDP of the exporting country rises by 1%, ceteris paribus. If the exporting country is a Member State to the EU, the predicted value of imports of PPE is 273% higher in mean than if it is an extra-EU country, keeping other variables unchanged. Other things equal, a 1% increase in the distance between Spain and its trading partner leads to a 1.09% decrease in the predicted value of imports of the goods in matter, while the latter decreases on average by 0.02% if the number of researchers in the exporting country is increased in one person. Variations in these regressors explain 84.19% of the variations in the predicted value of Spanish imports of PPE.

Regarding total Spanish medicine imports, other things equal, they seem to increase by 1.51% on average when the exporting country's GDP is increased by 1%, and by 0.04% if the number of researchers in its trading partner rises in one person. In contrast, a 1% increase in the distance between Spain and the country of origin, ceteris paribus, leads to an average 2.1% decrease in the predicted value of Spanish imports of medicines. It is not possible to state at a 10% significance level that EU membership by the exporting country and the share of high-technology exports of the latter affect the value of total Spanish imports of medicines. Variations in these regressors explain 80.94% of the changes in the predicted value of total medicine imports by Spain.

A higher R&D activity associated with the pharmaceutical industry, as compared to PPE production in general, may explain why increases in the number of researchers in the exporting country affect total Spanish imports of medicines and PPE oppositely. Likewise, the higher MFN average tariff applied by the EU on PPE with respect to that applied on medicines, as well as the existence of non-tariff barriers to trade, may explain why EU membership by Spain's trading partner appears to affect only PPE imports by Spain. Interestingly, some of the variables affecting the imports of various medicines also seem to diverge, as evidenced by the paragraphs that follow.

With respect to Spanish imports of medicines under HS heading 3002, a ceteris paribus 1% increase in the GDP of the exporting country seems to increase their predicted value by 2.1%, on average. Moreover, if the exporting country belongs to the EU, the predicted value of Spanish imports of HS 3002 medicines is expected to be 336% higher on average, other things equal, than if the exporting economy is an extra-EU state. Interestingly, it is not possible to claim at a 10% significance level that the distance between Spain and its trading partner, and the number of researchers and share of high technology exports in the latter, affect Spanish imports of the medicines under analysis. These variables explain 61.70% of the changes in the value of Spanish imports of products belonging to HS heading 3002.

As for Spanish imports of HS 3003 medicines, other things equal, their predicted value appears to increase by 1.43% in mean when the GDP of the exporting country rises by 1%, and by 16% if the share of high technology exports by Spain's trading partner increases in one unit. When the exporting country is an EU Member State, the value of imports of these medicines by Spain is 576% higher in mean, as compared to the case at which the exporting economy is an extra-EU country, ceteris paribus. Counterintuitively, the value of Spanish imports of HS 3003 medicines seems to decrease on average by 0.05% if the number of researchers in the exporting country increases in one person, other things equal. It is not possible to state at a 10% significance level that increases in the distance between Spain and its trading partners affect the predicted value of Spanish imports of the products in matter. These regressors explain 67.24% of variations in the value of Spanish imports of HS 3003 medicines.

With regard to Spanish imports of medicines belonging to HS group 3004, their predicted value is found to increase by 1.7% on average when the GDP of its trading partner is augmented by 1%, ceteris paribus. Likewise, other things equal, their value seems to increase by 0.06% in mean if the number of researchers in the exporting country is augmented in one person. By contrast, a 1% increase in the distance between Spain and the country of origin decreases the predicted value of imports of the product in matter by 2.73%, ceteris paribus. Besides, it is not possible to claim, at a 10% significance level, that EU membership by the exporting country affects Spanish imports the cited goods. Changes in these variables explain 73.68% of the variations in imports of medicines belonging to HS group 3004.

6.3. Panel data analysis for 2007-2017

A model for Spanish imports of medical goods in the period 2007-2017 is constructed in this section. Although a larger period of time was initially considered, the lack of data concerning relevant variables to the study for years before 2007 and after 2017 has led to a reduction in the time span analyzed. Models are based on the insights gained from the analysis performed in Section 6.2. Likewise, the software employed to that end is Gretl.

The aim of this section is to determine whether the variables found as explicating Spanish imports of medical goods from OECD countries and China in 2016, do also explain variations in these trade flows during a period of time. Moreover, variables that are not found to affect Spanish imports of medical goods in 2016 are incorporated, so as to see if they affect trade over time. For this purpose, a panel data database has been constructed, consisting of thirty-six cross-sectional units, eight variables and eleven time periods (2007-2017). The thirty-five OECD countries (excluding Spain) and China are referred to as cross-sectional units, while the variables included are specified in the following subsection.

6.3.1. Variables

In addition to the regressors considered in the previous section, two new variables have been included: (i) The annual Real Effective Exchange Rate (REER) index (base year 2010) and

(ii) Spanish exports of medical goods to OECD countries and to China. The former has been added because changes in competitiveness may affect trade over time, whereas the latter may be of interest to the present analysis given the aforementioned intra-industry nature of trade in medicines. Regarding the cross-sectional data analysis for 2016, it is not possible to state at a 10% significance level that the effect of these regressors on Spanish imports of either of the medical goods considered is different from zero. Thus, they are included so as to check whether they affect variations in the value of Spanish imports of medical products over time.

Data regarding Spanish exports of medical goods to OECD countries and to China, denoted as "EX", has been obtained from *DataComex*. Since the unit of measurement in the database is current US$, they have been transformed into 2010 US$ by means of the Spanish GDP deflator retrieved from the World Development Indicators by *World Bank*.

The REER index, which is denoted as "REER" and which has been retrieved from the International Financial Statistics database by the *International Monetary Fund*, is computed by dividing the nominal effective exchange rate (NEER) by a price deflator or cost index. The introduction of the annual REER, instead of considering the REER as of 31st December of the corresponding year, is due to the fact that it has been considered to be a better approximation to the values taken by the variable over the course of the year.

6.3.2. Variable transformation and method

Variables are checked for normality, with the purpose of including in the model variables with normally distributed errors. The Jarque-Bera (JB) Test is employed for this purpose. As previously explained, those variables reporting a p-value smaller than 0.05 in the JB Test are not considered to be normally distributed. The p-values resulting from the JB Test are presented in Table 4A in Annex 2 to the present study. According to the JB Test, imports and exports of medical goods, the GDP of Spain's trading partners, the distance between Spain and the exporting country, the number of researchers in the country of origin, the share of high-technology exports in the latter, and the REER index regarding the exporting country do not follow a normal distribution. Thus, these variables will be included in logarithmic form in the models.

Moreover, analyzing panel data involves a greater complexity that doing so with cross-sectional data, as the former combines both cross-sectional and time series data. The most popular approaches for carrying analyses with this type of data are (i) Pooled OLS regression, (ii) Fixed effects model (FEM), and (iii) Random effects model (REM). Pooled OLS estimation refers to simple linear regression models employed for panel data, which do not consider the effects over individuals and time (Gil-García & Puron-Cid, 2014). In contrast, FEM and REM take into account individual effects over time. Regarding FEM, it assumes that unobserved individual effects for each country are correlated with the independent variables included, while REM presumes that the unobserved individual heterogeneity is uncorrelated with explanatory variables (Wooldridge, 2008).

By means of the Joint Significance and Breusch-Pagan Tests, it has been found out that both FEM and REM are preferred over the Pooled OLS approach for analyzing the models in this section. The null hypothesis in both tests, which claims that Pooled OLS regression is the preeminent approach, has been rejected at a 1% significance level for Model 6 and Model 7, regarding all the different dependent variables, as shown in Table 6. Moreover, there is evidence supporting that the expected value of the unobserved effect contained in the error, given the explanatory variables, is constant. In fact, the null hypothesis in the Hausman Test states that the covariance between the explanatory variables and the error term is close to zero, which implies that REM is preferred over FEM. Given that, as evidenced in Table 6, it is not possible to reject the null hypothesis regarding this test at a 1% significance level in any case, neither for Model 6 nor for Model 7, the REM will be the one employed.

Furthermore, the following assumptions are made: (i) No perfect linear relationship between regressors exists; (ii) the variance of the idiosyncratic error given the independent variables and the unobservable effect is constant; (iii) the variance of the individual effects given all regressors is constant; and (iv) the idiosyncratic errors, given independent variables and individual effects, are uncorrelated (Wooldridge, 2008).

6.3.3. Analysis of Spanish imports of medical products in the period 2007-2017

$$l\_IM_{ijt} = \alpha + \beta_1 l\_GDP_{jt} + \beta_2 l\_D_{ij} + \beta_3 EU_{jt} + \beta_4 l\_RD_{jt} + \beta_5 l\_HTEX_{jt} + \beta_6 l\_REER_{jt} + u_{ijt} \quad \text{(Model 6)}$$

Model 6 is built on the basis of Model 5. According to the International Monetary Fund (2020), an increase in REER "indicates a loss in trade competitiveness". β_6 represents the mean ceteris paribus percentage variation in the predicted value of Spanish imports of the medical good in matter, when the value of the REER index of Spain's trading partner is increased by 1%. Given that, an increase in the REER index of the exporting country would lead to more expensive imports by Spain, β_6 is awaited to be negative.

The interpretation of β_1, β_2 and β_3 is identical to that provided for Model 3. As for β_4, it denotes the ceteris paribus mean percentage change in the predicted value of Spanish imports of the medical goods considered, when the number of researchers in Spain's trading partner increases by 1%. Similarly, β_5 stands for the average percentage variation in the predicted value of Spanish imports of medical products, caused by a ceteris paribus 1% increase in the value of the share of high-technology exports in the exporting country. From the reasonings provided in section 6.2.3, the following statements are straightforward: β_1 is expected to be positive, β_2 is expected to be negative, β_3 is expected to be positive, β_4 is expected to be positive, and β_5 is expected to be positive. Table 6 below provides the coefficients obtained when running Model 6 in Gretl, their respective p-values, and the p-value related to the Joint Significance, Breusch-Pagan and Hausman tests.

Table 6

Estimation of Model 6 and 7 with 2007-2017 panel data (Random effects; Joint Significance, Breusch Pagan and Hausman tests)

Ind. V./ Dep. v.	**Model 6**					**Model 7**				
	Medicines				**PPE**	**Medicines**				**PPE**
	Total	**3002**	**3003**	**3004**		**Total**	**3002**	**3003**	**3004**	
Constant	-31.711***	-53.5748***	-23.7475*	-27.8427***	-8.0957	-26.9806***	-54.1209***	-15.2694	-26.5729***	-7.8651
p-value	0.0001	6.93E-05	0.0859	0.0027	0.1528	0.0012	5.53E-05	0.2775	0.0043	0.1474
l_GDPjt	1.3561***	1.8519***	1.1370***	1.3087***	1.2136***	0.9062***	1.8287***	0.7212**	1.1185***	1.0698***
p-value	4.96E-11	1.97E-11	1.48E-05	4.59E-09	1.56E-19	1.00E-04	3.36E-10	1.18E-02	5.94E-06	3.34E-13
l_Dij	-1.6197***	-1.2049*	-2.0224***	-1.7725***	-1.0413***	-1.4306**	-1.1804*	-1.8122**	-1.6653***	-0.8837**
p-value	0.0043	0.0903	0.0098	0.0034	0.0042	0.0116	0.0961	0.0207	0.0063	0.0117
EUjt	0.9179	2.0712	1.004	0.6555	1.6096**	0.8266	2.0202	-0.234	0.6309	1.4213**
p-value	0.37	0.1084	0.4176	0.5485	0.0143	0.4181	0.1162	0.8565	0.5644	0.0229
l_RDjt	1.0993***	0.8384*	0.425	1.127***	-0.2453	1.0717***	0.8378*	0.3992	1.1656***	-0.2483
p-value	0.0002	0.093	0.4036	0.0009	0.2374	0.0002	0.092	0.4311	0.0006	0.2169
l_HTEXjt	1.4719***	0.4343	1.1764*	1.1214***	0.1795	1.5043***	0.3838	1.0722*	1.1124***	0.1574
p-value	4.52E-09	0.4786	0.0674	0.0003	0.3387	8.53E-10	0.5317	0.0958	0.0003	0.3976
l_REERjt	2.5887***	3.8609**	3.2045*	2.4109***	-0.0113	2.4263***	3.9644**	2.6893	2.2967***	-0.0385
p-value	3.97E-05	0.0203	0.0632	0.0017	0.9812	8.01E-05	0.0186	0.1309	0.0027	0.9361
l_EXijt						0.374***	0.0415	0.3371***	0.1816*	0.1734**
p-value						8.97E-05	0.5564	0.0008	0.0701	0.0367
Joint Sig.	1.87E-31	1.45E-13	1.89E-07	2.50E-20	2.29E-22	5.00E-35	2.69E-13	2.87E-08	2.23E-20	5.30E-26
Breusch-P.	1.11E-145	1.19E-50	3.16E-23	6.57E-120	1.61E-110	2.60E-153	2.85E-50	8.48E-22	2.75E-124	8.95E-106
Hausman	0.5705	0.6659	0.0274	0.6244	0.1420	0.742	0.4999	0.0208	0.8223	0.0678

****p-value<0.01, **p-value <0.05, *p-value<0.1*

Source: own compilation based on data from Gretl.

Model 6 in Table 6 evidences that a 1% ceteris paribus increment in the GDP of Spain's trading partners increases the predicted value of Spanish imports of the all the medical goods considered, at a 1% significance level. With respect to a 1% increase in distance between Spain and the exporting country, other things equal, it causes negative changes in the predicted value of imports of all the medical goods. This effect is significant at a 10% significance level for imports of HS 3002 medicines, and at a 1% significance level in all other cases. Moreover, it is only possible to state that EU membership by the exporting country increases the predicted value of Spanish imports of PPE, at a 5% significance level.

A 1% increase in the number of researchers in the exporting country, ceteris paribus, causes an increase in the predicted value of total Spanish medicine imports (1% significance level), and of imports of medicines under HS headings 3002 (10% significance level) and 3004 (1% significance level). Likewise, a ceteris paribus 1% increment in the value of the share of high-technology exports of the exporting county leads to increases in the predicted value of total Spanish imports of medicines and HS 3004 medicine imports (1% significance level), and of that of HS 3003 drugs (10% significance level).

Increasing the value of the REER index of the exporting country by 1% appears to bring increases in the predicted value of total medicine imports (1% significance level) and of imports of medicines falling into HS 3002 (5% significance level), 3003 (10% significance level) and 3004 (1% significance level) headings. However, contrary to expectations, this effect is positive, meaning that a ceteris paribus 1% increase in the price of Spanish imports leads to a higher value of the latter. This may be explained by the low price-elasticity of demand of medicines in developed countries (Scherer, 2000; Otero García-Castrillón, 2006).

$$l\_IM_{ijt} = \alpha + \beta_1 l\_GDP_{jt} + \beta_2 l\_D_{ij} + \beta_3 EU_{jt} + \beta_4 l\_RD_{jt} + \beta_5 l\_HTEX_{jt} + \beta_6 l\_REER_{jt} + \beta_7 l\_EX_{ijt} + u_{ijt}$$

(Model 7)

Model 7 adds Spanish exports of medical goods to OECD countries and China. β_7 represents the ceteris paribus mean percentage variation in the predicted value of Spanish imports of medical products, caused by increasing the value of Spanish exports of the same medical good in 1%. β_7 is expected to have a positive sign regarding Spanish medicine and PPE imports, because of the aforementioned intra-industry trade present in the pharmaceutical sector in the case of the former, and because it has been found that some of the most relevant trading partners of Spain coincide regarding imports and exports of PPE. The results obtained when running Model 7 in Gretl, including the coefficients, their respective p-values, and the p-value related to the Joint Significance, Breusch-Pagan and Hausman tests are displayed in Table 6 above.

The conclusions for β_1 in Model 7 are identical to those drawn in Model 6, except for that corresponding to imports of HS 3003 medicines, which has decreased its significance level to 5%. Table 6 suggests that a ceteris paribus 1% increase in the distance between Spain and its trading partners still leads to decreases in the predicted value of Spanish imports of medical goods, although statistical significance levels for the coefficients have changed: 10% for HS 3002 imports, 5% for total medicine imports and HS 3003 and PPE imports, and 1% for HS 3004 imports. The conclusions regarding the coefficients related to the regressors EU, logarithm of RD and logarithm of HTEX are the same as those provided in Model 6.

A 1% increase in the value of the REER index of the exporting country seems to increase the predicted value of total medicine imports (1% significance level) and of imports of medicines belonging to HS group 3002 (5% significance level) and 3004 (1% significance level). Nevertheless, it is not possible to state at a 10% significance level that the effect of the aforementioned increase on the predicted value of Spanish imports of HS 3003 medicines and PPE is different from zero.

Increasing the value of total Spanish exports of medicines, of HS 3003 and HS 3004 medicines and of those of PPE by 1%, ceteris paribus, seems to cause increases in the predicted value of Spanish imports of the same products. This effect is statistically significant at a 10% significance level for imports of HS 3004 medicines, at a 5% significance level for imports of PPE, and at a 1% significance level for total medicine imports and imports of HS 3003 medicines. These results seem to support the view that intra-industry trade takes place regarding the pharmaceutical sector, except for HS 3002 medicines. Moreover, it may be plausible to explain bilateral flows of PPE by the existing Regional Trade Agreements between Spain and other countries[18] considered in the analysis.

Results

With regard to the predicted value of Spanish imports of PPE, it increases by 1.07% in mean when the GDP of the exporting country grows in 1%, ceteris paribus. Moreover, imports of PPE seem to be 142% higher on average if Spain's trading partner is an EU member, other things equal. Interestingly, a 1% increment of the value of Spanish exports of PPE to the considered countries, causes a 0.17% growth in the predicted value of Spanish imports of the same products, ceteris paribus. Distance between Spain and the exporting country appears to negatively affect the predicted value of Spanish imports of PPE, since the latter decreases by 0.88% when the cited distance grows in 1%, other things equal.

With respect to the predicted value of total Spanish imports of medicines, it seems to increase by 0.91% in mean when the GDP of the exporting country rises in 1%, ceteris paribus. Likewise, it appears to increase in 1.07%, 2.43% and 0.37% when, other things equal, the number of researchers in the exporting country, the value of the REER index of the latter, or the Spanish exports of medicines are increased by 1%, respectively. Besides, a 1% increase in the value of the share of high-technology exports in Spain's trading partner is found to lead to an average 1.5% increase in the predicted value of total medicine imports, ceteris

[18] EC Treaty, EU-Canada, EU-Chile, EU-Iceland, EU-Israel, EU-Japan, EU-Republic of Korea, EU-Mexico, EU-Norway, EU-Switzerland-Liechtenstein, EU-Turkey and EEA (World Trade Organization, 2020e).

paribus. By contrast, increasing the distance between Spain and its trading partner in 1%, other things equal, results in an average 1.43% decrease of the predicted value of Spanish imports of medicines.

The fact that EU membership by the exporting country appears to only affect, positively, the predicted value of Spanish imports of PPE, may be explained by the presence of non-tariff barriers to trade, as well as by the 0% and 3.9% latest average MFN tariffs applied by the EU on medicines and PPE, respectively (World Trade Organization, 2020a). Presumably due to the low price elasticity of demand of medicines in developed countries (Scherer, 2000; Otero García-Castrillón, 2006), losses in trade competitiveness by the exporting country appear to increase only the forecasted value of Spanish medicine imports. Besides, the higher R&D activity and intensity attributed to the pharmaceutical industry, as compared to PPE production in general, may justify why increases in the number of researchers and in the value of the share of high-technology exports in the exporting country, seem to increase only the fitted value of total Spanish imports of medicines.

Concerning the predicted value of imports of HS 3002 medicines, other things equal, it increases by 1.83% on average when the GDP of the country of origin of imports rises by 1%. Increasing the number of researchers in the exporting country by 1% leads to an average 0.84% increase in the predicted value of Spanish imports, ceteris paribus. Furthermore, a 1% growth in the value of the REER index of the exporting country, ceteris paribus, rises the predicted value of Spanish imports of HS group 3002 by 3.96% on average. Augmenting the distance between Spain and its trading partners in 1%, ceteris paribus, induces an average 1.18% decrease in the predicted value of imports of these medicines.

As for the forecasted value of imports of HS 3003 medicines, it is 0.72% higher in mean if the GDP of the Spanish trading partner is increased by 1%, other things equal. Besides, a 1% increase in the value of the share of high-technology exports of the exporting country seems to rise the predicted value of HS 3003 heading imports by 1.07%, ceteris paribus. Similarly, when the value of Spanish exports of HS 3003 medicines grows by 1%, it appears to increase the value of Spanish imports of the same goods by 0.34% on average, other things equal. Moreover, a 1% ceteris paribus increase in the distance between Spain and the exporting country decreases the predicted value of Spanish imports of these medicines by 1.81%, on average.

Regarding Spanish imports of HS 3004 medicines, a ceteris paribus 1% increase in the GDP of the exporting country causes their predicted value to rise by 1.12% on average. If, other things equal, the number of researchers in Spain's trading partner goes up in 1%, or the value of the share of high-technology exports in the latter grows by 1%, the predicted value of Spanish imports of these medicines increases, on average, by 1.17% and 1.11%, respectively. Besides, a ceteris paribus 1% increase in the value of the REER index of the exporting country results in an average 2.3% increment in the forecasted value of Spanish imports. Moreover, when the value of Spanish exports of HS 3004 medicines is increased by 1%, ceteris paribus, the predicted value of Spanish imports of the same products is 0.18% higher in mean. By contrast, the predicted value of the cited imports decreases by 1.67%, on average, if the distance between Spain and the exporting country grows in 1%, ceteris paribus.

The theoretical background of the Gravity Model, as represented by changes in the GDP of the exporting country and in the distance between Spain and the latter, seems to hold for all the medical goods considered in this analysis. Furthermore, increases in the value of Spanish exports of the product in matter appear to increase the predicted value of Spanish imports of all the medical goods considered, except for those of HS 3002 medicines. This may be explained by the importance of intra-industry trade in the pharmaceutical sector, as well as by the Regional Trade Agreements in which Spain participates. Nevertheless, this analysis suggests that other variables determining total Spanish imports of medicines and PPE, as well as those of various medicines, appear to differ.

7. CONCLUSIONS

The aims of the present paper are (i) to describe the context in which international trade in medical products takes place, and (ii) to analyze the determinants of Spanish imports of these goods from OECD countries and China. Concerning medical products, pharmaceutical products and personal protective equipment (PPE) are covered.

Regarding the first objective, the pharmaceutical industry has high R&D investment rates and intensity. Intra-industry trade is very significant in this sector, while market concentration is high, as well as geographical concentration and internationalization. Besides, the demand of medicines in developed countries has a low price elasticity. Medicines have a large strategic value from the health and industrial perspectives, and they are the medical products with the lowest MFN tariff applied by WTO members. However, due to their effects on health, non-tariff barriers to trade on medicines are significant, both globally and inside the EU. As for PPE, its production involves low profit margins, and takes place mainly in Asia. Even if PPE is not as regulated as medicines, it is subject to strong regulations. Furthermore, the average MFN tariff applied by WTO members on PPE is five times greater than that on medicines.

It is worth of mention that trade in medical products has acquired considerable importance recently, due to Covid-19, as the latter has increased their global demand. In this context, some nations have applied protectionist measures to trade in medical products, while other countries have advocated for removing existing trade barriers on the cited goods.

For the second objective, two econometric analyses with 2016 cross-sectional data and 2007-2017 panel data are performed, for Spanish imports of medical goods from OECD countries and China. Both analyses suggest that certain variables explaining total Spanish imports of medicines and PPE differ, as well as those determining Spanish imports of distinct medicines. Results seem to capture differences in the market for each product.

With respect to 2016 data, it appears that Spanish imports of all the goods considered are affected positively by increases in the exporting country's GDP. Likewise, augmenting the distance between Spain and its trading partner seems to affect negatively total Spanish imports of medicines and PPE. Increases in the number of researchers in the exporting country appear to affect positively total medicine imports and negatively PPE imports by Spain. Besides, EU membership by Spain's trading partners seems to increase the predicted value of Spanish PPE imports. Concerning imports of various medicines by Spain in 2016, increases in the distance between Spain and its trading partners seem to negatively affect HS 3004 medicine imports, while EU membership by the exporting country appears to increase the value of imports of HS 3002 and 3003 medicines. Moreover, increases in the number of researchers in the exporting country seem to negatively affect imports of HS 3003 medicines and positively HS 3004 medicine imports. Finally, augmenting the share of high-technology exports of Spain's trading partner is found to affect, positively, HS 3003 medicine imports.

Results from the 2007-2017 analysis suggest that, over time, the Gravity Model holds for Spanish imports of all the goods studied. Both, total Spanish imports of medicines and PPE, seem to be affected positively by increases in the value of Spanish exports of the same goods. Moreover, EU membership by the exporting country appears to only affect Spanish imports of PPE, positively. Furthermore, increases in the number of researchers in the exporting country and in the value of the share of high-technology exports in the latter, seem to affect positively Spanish imports of medicines solely. Besides, losses in trade competitiveness by Spain's trading partners appear to positively affect Spanish medicine imports. As for Spanish imports of various medicines, increases in the number of researchers in the exporting country and losses in trade competitiveness by the latter, are found to increase the predicted value of HS 3002 and 3004 medicine imports, exclusively. Moreover, increments in the value of the share of high-technology exports by the exporting country, as well as in the value of Spanish exports of the same goods to the latter, seem to do so for Spanish imports of medicines under HS 3003 and 3004 headings.

Note that the main limitation faced by this paper is the unavailability of data for many years for central regressors to the analysis, which leads to studying a short period of time.

Additionally, a similar econometric analysis has been performed for finding out the determinants of Spanish exports of medical goods to OECD countries and China. However, it has not been included in the paper, given that the results obtained do not appear to provide insights consistent with the industry and regulatory characteristics of the cited products.

8. BIBLIOGRAPHY

Antoñanzas, F., Rodríguez, R., Sacristán, J., & Illa, R. (2005). Los medicamentos en la Unión Europea: el tándem comercio-salud. *Gaceta Sanitaria, 19*(2), 151-167.

Christel, M. (2019). Pharm Exec's Top 50 Companies 2019. *Pharmaceutical Executive, 39*(6). Retrieved from http://www.pharmexec.com/pharm-execs-top-50-companies-2019

Costa-Font, J., & Kanavos, P. (2004). Comercio Paralelo de medicamentos en la UE. *Farmacia Profesional, 18*(11), 12-19.

DataComex (2020). *Estadísticas del comercio exterior español.*

Deutsche Welle (2020). *Coronavirus: The German face mask conundrum.* Retrieved April 13, 2020, from https://p.dw.com/p/3ahIn

El País (2020). *La guerra de las mascarillas enfrenta a Europa y EE UU.* Retrieved April 10, 2020, from https://elpais.com/sociedad/2020-04-02/la-guerra-de-las-mascarillas-enfrenta-a-europa-y-eeuu.html

EUR-Lex (2020a). *Subsidiarity.* Retrieved February 14, 2020, from Glossary of summaries: https://eur-lex.europa.eu/summary/glossary/subsidiarity.html

EUR-Lex (2020b). *Regulation (EU) 2020/402 of 14 March 2020.* Retrieved 10 April, 2020, from https://eur-lex.europa.eu/eli/reg_impl/2020/402/oj

EUR-Lex (2020c). *Commission implementing Regulation (EU) 2020/568 of 23 April 2020 making the exportation of certain products subject to the production of an export authorisation.* Retrieved May 1, 2020, from https://eur-lex.europa.eu/eli/reg_impl/2020/568/oj

EUR-Lex (2020d). *Directive 2001/83/EC of the European Parliament and of the Council of 6 November 2001 on the Community code relating to medicinal products for human use.* Retrieved May 7, 2020, from https://eur-lex.europa.eu/eli/dir/2001/83/oj

European Commission (2018). *Infringement: Parallel trade of medicines: Commission closes infringement proceedings and complaints against Poland, Romania and Slovakia.* Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/IP_18_3459

European Commission (2020a). *Trade Helpdesk. EU product classification system*. Retrieved February 7, 2020, from https://trade.ec.europa.eu/tradehelp/eu-product-classification-system

European Commission (2020b). *International cooperation on pharmaceuticals.* Retrieved February 15, 2020, from https://ec.europa.eu/health/international_cooperation/pharmaceuticals_en

European Commission (2020c). *Coronavirus: Commission presents practical guidance to ensure continuous flow of goods across EU via green lanes.* Retrieved April 16, 2020, from https://ec.europa.eu/commission/presscorner/detail/en/ip_20_510

European Medicines Agency (2020). *Mutual recognition agreements (MRA).* Retrieved April 29, 2020, from https://www.ema.europa.eu/en/human-regulatory/research-development/compliance/good-manufacturing-practice/mutual-recognition-agreements-mra

European Union (2020). *Countries.* Retrieved February 28, 2020, from https://europa.eu/european-union/about-eu/countries_en

Eurostat (2020). *International trade in medicinal and pharmaceutical products.*

Financial Times (2020). *Germany accuses US of face mask piracy.* Retrieved April 10, 2020, from https://www.ft.com/content/bb52e108-a345-4278-8e72-f1c20e010cda

Gil-García, J., & Puron-Cid, G. (2014). Using panel data techniques for social science research: an illustrative case and some guidelines. *Revista Científica Multidisciplinaria de Prospectiva, 21*(3), 203-216.

González-Baizán González Lamuño, M. (2018). *Régimen jurídico e intervención administrativa del medicamento. El comercio exterior de medicamentos: Comerio paralelo de medicamentos en España.*

ICEX (2019). *El mercado de productos farmacéuticos en Canadá.*

International Monetary Fund (2020). *What is real effective exchange rate (REER)?* Retrieved April 14, 2020, from http://datahelp.imf.org/knowledgebase/articles/537472-what-is-real-effective-exchange-rate-reer

Jacobzone, S. (2000). Pharmaceutical Policies in OECD Countries: Reconciling Social and Industrial Goals. *OECD Labour Market and Social Policy Occasional Papers*(40).

Jordán Galduf, J. M., & Tamarit Escalona, C. (2013). *Economía de la Unión Europea* (7 ed.). Pamplona: Cívitas.

Krugman, P. (1980). Scale Economies, Product Differentiation and the Pattern of Trade. *The American Economic Review, 70*(5), 950-959.

Krugman, P., Obstfeld, M., & Melitz, M. (2018). *International Economics. Theory and Policy.* (11 ed.). Boston: Pearson.

Mayer, T., & Zignago, S. (2011). *Notes on CEPII's distances measures: The GeoDist database.*

Ministerio de Sanidad, Consumo y Bienestar Social (2020a). *Título Segundo de los Medicamentos. Capítulo Primero de los Medicamentos Reconocios por la Ley y sus Clases.*

Retrieved February 14, 2020, from https://www.mscbs.gob.es/profesionales/farmacia/legislacion/leyes/indice/titulo02cap1.htm

Ministerio de Sanidad, Consumo y Bienestar Social (2020b). *Nota de prensa: La partida devuelta de test rápidos defectuosos contaba con homologación europea para su compra y comercialización en todo el espacio comunitario.* Retrieved April 16, 2020, from https://www.mscbs.gob.es/gabinete/notasPrensa.do?id=4827

Montpart, E., & Martín, M. (2001). Patentes y especialidades farmacéuticas genéricas. *Offarm, 20*(10), 144-149.

OECD (2019). *Health at a Glance. OECD Indicators.*

OECD Directorate for Science, Technology and Industry (2011). *ISIC REV. 3 TECHNOLOGY INTENSITY DEFINITION. Classification of manufacturing industries into categories based on R&D intensities.*

Office of the United States Trade Representative (2020). *Industry initiatives. Pharmaceuticals.* Retrieved April 13, 2020, from https://ustr.gov/issue-areas/industry-manufacturing/industry-initiatives/pharmaceuticals

Otero García-Castrillón, C. (2006). *El Comercio Internacional de Medicamentos.* Madrid: Dykinson.

Peterson Institute for International Economics (2020a). *COVID-19: China's exports of medical supplies provide a ray of hope.* Retrieved April 10, 2020, from https://www.piie.com/blogs/trade-and-investment-policy-watch/covid-19-chinas-exports-medical-supplies-provide-ray-hope

Peterson Institute for International Economics (2020b). *EU limits on medical gear exports put poor countries and Europeans at risk.* Retrieved April 12, 2020, from https://www.piie.com/blogs/trade-and-investment-policy-watch/eu-limits-medical-gear-exports-put-poor-countries-and

Peterson Institute for International Economics (2020c). *The G20 should expand trade to help developing countries overcome COVID-19.* Retrieved April 14, 2020, from https://www.piie.com/blogs/trade-and-investment-policy-watch/g20-should-expand-trade-help-developing-countries-overcome

Priede Bergamini, T., López-Cózar Navarro, C., & Benito Hernández, S. (2009). Sector de la fabricación de productos farmacéuticos en España. Representación de las empresas de participación en la industria. *Investigaciones Europeas de Dirección y Economía de la Empresa, 15*(1), 137-147.

Scherer, F. (2000). The Pharmaceutical Industry. In A. J. Culyer, & J. P. Newhouse, *Handbook of Health Economics* (Vol. 1). Elsevier Science B. V. .

Tinbergen, J. (1962). *Shaping the world economy: Suggestions for an international economic policy.* New York: Twentieth Century Fund.

UNCTAD (2019). *World Investment Report 2019. Special Economic Zones.*

Universidad Complutense de Madrid (2013). *Regresión con datos de sección cruzada.* Retrieved from https://www.ucm.es/data/cont/docs/518-2013-10-25-Tema_5_EctrGrado.pdf

Wooldridge, J. (2008). *Introductory econometrics: A modern approach* (4 ed.). Ohio: South Western Cengage Learning.

World Bank (2020). *Data. High technology exports (% of manufactured exports).* Retrieved March 29, 2020, from https://data.worldbank.org/indicator/tx.val.tech.mf.zs

World Customs Organization (2020). *HS Nomenclature 2017 edition.* Retrieved from World Customs Organization. Nomenclature and Classification of Goods: http://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2017-edition/hs-nomenclature-2017-edition.aspx

World Health Organization (2020a). *Medical devices. Personal protective equipment.* Retrieved April 12, 2020, from https://www.who.int/medical_devices/meddev_ppe/en/

World Health Organization (2020b). *Rational use of personal protective equipment for coronavirus disease (COVID-19) and considerations during severe shortages. Interim guidance.*

World Trade Organization (2011). *Current issues in SPS*. Retrieved from World Trade Organization: https://www.wto.org/english/tratop_e/sps_e/sps_issues_e.htm

World Trade Organization (2020a). *Trade in medical goods in the context of tackling Covid-19.*

World Trade Organization (2020b). *Technical barriers to trade.* Retrieved February 29, 2020, from https://www.wto.org/english/tratop_e/tbt_e/tbt_e.htm

World Trade Organization (2020c). *Overview: the TRIPS Agreement.* Retrieved February 20, 2020, from https://www.wto.org/english/tratop_e/trips_e/intel2_e.htm

World Trade Organization (2020d). *COVID-19 and world trade. Trade and trade-related Measures (As of 1 May 2020).* Retrieved from https://www.wto.org/english/tratop_e/covid19_e/trade_related_goods_measure_e.htm

World Trade Organization (2020e). *Regional Trade Agreements Database. Spain.* Retrieved April 29, 2020, from http://rtais.wto.org/UI/PublicSearchByMemberResult.aspx?MemberCode=724&lang=1&redirect=1

World Trade Organization (2020f). *The treatment of medical products in Regional Trade Agreements.*

9. ANNEXES

9.1. Annex 1

Table 1A

Indicators of the Structure of Pharmaceutical Industry. World largest 50 companies by sales (in billions of US$) (2018)

Rank		Country	Sales	R&D expenditure	R&D/ Sales	Market Share	Concentration index[1]
1	Pfizer	US	45302	7962	18%	6,66%	6,66%
2	Roche	Switzerland	44552	9803	22%	6,54%	13,20%
3	Novartis	Switzerland	43481	8154	19%	6,39%	19,59%
4	Johnson & Johnson	US	38815	8446	22%	5,70%	25,29%
5	Merck & Co	US	37353	7908	21%	5,49%	30,78%
6	Sanofi	France	35121	6227	18%	5,16%	35,94%
7	AbbVie	US	32067	5093	16%	4,71%	40,65%
8	GlaxoSmithKline	England	30645	4987	16%	4,50%	45,15%
9	Amgen	US	22533	3657	16%	3,31%	48,46%
10	Gilead Sciences	US	21677	3897	18%	3,18%	51,64%
11	Bristol-Myers Squibb	US	21581	5131	24%	3,17%	54,81%
12	AstraZeneca	England	20671	5266	25%	3,04%	57,85%
13	Eli Lilly	US	19580	4993	26%	2,88%	60,73%
14	Bayer	Germany	18221	3417	19%	2,68%	63,40%
15	Novo Nordisk	Denmark	17726	2347	13%	2,60%	66,01%
16	Takeda	Japan	17427	3012	17%	2,56%	68,57%
17	Celgene	US	15238	4084	27%	2,24%	70,81%
18	Shire	Ireland	14993	1608	11%	2,20%	73,01%
19	Boehringer Ingelheim	Germany	14834	3206	22%	2,18%	75,19%
20	Allergan	US	14700	1575	11%	2,16%	77,35%
21	Teva Pharma. Ind.	Israel	13122	1213	9%	1,93%	79,28%
22	Mylan	US	11144	586	5%	1,64%	80,91%
23	Astellas Pharma	Japan	11036	1909	17%	1,62%	82,53%
24	Biogen	US	10887	2587	24%	1,60%	84,13%
25	CSL	Australia	8270	724	9%	1,21%	85,35%
26	Daiichi Sankyo	Japan	7033	1888	27%	1,03%	86,38%
27	Merck KGaA	Germany	7001	1928	28%	1,03%	87,41%
28	Otsuka Holdings	Japan	5726	1863	33%	0,84%	88,25%
29	UCB	Belgium	5138	1371	27%	0,75%	89,01%
30	Les Laboratoires Servier	France	5103	N/A	0%	0,75%	89,76%
31	Bausch Health Companies	Canada	4631	413	9%	0,68%	90,44%
32	Eisai	Japan	4531	1309	29%	0,67%	91,10%
33	Abbott Laboratories	US	4422	184	4%	0,65%	91,75%
34	Fresenius	Germany	4328	631	15%	0,64%	92,39%
35	Sun Pharmaceutical Ind.	India	4222	321	8%	0,62%	93,01%
36	Grifols	Spain	4154	284	7%	0,61%	93,62%
37	Alexion Pharmaceuticals	US	4130	704	17%	0,61%	94,22%
38	Regeneron Pharmaceuticals	US	4106	2186	53%	0,60%	94,83%
39	Chugai Pharmaceutical	Japan	3649	855	23%	0,54%	95,36%
40	Sumitomo Dainippon Pharma	Japan	3543	776	22%	0,52%	95,88%
41	Menarini	Italy	3313	N/A	0%	0,49%	96,37%

42	Sino Biopharmaceutical	Hong Kong	3142	339	11%	0,46%	96,83%
43	Vertex Pharmaceuticals	US	3038	1292	43%	0,45%	97,28%
44	Endo International	Ireland	2947	141	5%	0,43%	97,71%
45	Mitsubishi Tanabe Pharma	Japan	2913	755	26%	0,43%	98,14%
46	Ipsen	France	2628	357	14%	0,39%	98,52%
47	Jiangsu Hengrui Medicine	China	2570	334	13%	0,38%	98,90%
48	Mallinckrodt	Ireland	2543	361	14%	0,37%	99,28%
49	STADA Arzneimittel	Germany	2467	85	3%	0,36%	99,64%
50	Ferring Pharmaceuticals	US	2461	357	15%	0,36%	100,00%

Source: Own compilation based on data from Christel (2019).

9.2. Annex 2

Table 2A

Results of Jarque-Bera test for normality[19] (cross-sectional data 2016)

Variable	p-value	Variable	p-value
Total medicine imports	7.31E-29	Total medicine exports	1.45E-18
3002 imports	2.90E-61	3002 exports	1.07E-75
3003 imports	1.54E-26	3003 exports	1.89E-56
3004 imports	2.07E-20	3004 exports	1.70E-69
Personal Protective Product imports	1.35E-13	Personal Protective Product exports	3.58E-18
GDP_i	-	D_{ij}	2.49E-09
GDP_j	9.25E-77	$HTEX_j$	0.642309
RD_j	0.743318		

Source: Own compilation based on data from Gretl.

Table 3A

White's test for heteroskedasticity p-values (2016 cross-sectional data)

	Medicines				Personal Protective Products
MODEL	Total	3002	3003	3004	
1	0.04155*	0.909209	0.586529	0.072221	0.0761756
2	0.0410049*	0.802539	0.360561	0.0292727*	0.0569405
3	0.0182871*	0.944398	0.252886	0.0784115	0.00149265*
4	0.800723	0.888197	0.0798163	0.543469	0.186551
5	0.946769	0.938146	0.23066	0.530572	0.114202

* Models that need to be corrected for heteroskedasticity.

Source: Own compilation based on data from Gretl.

[19] No JB Test p-value available for GDP_i.

Table 4A
Results for Jarque-Bera test for normality (panel data 2007-2017)

Variable	p-value	Variable	p-value
Total medicine imports	0	Total medicine exports	0
3002 imports	0	3002 exports	0
3003 imports	0	3003 exports	0
3004 imports	0	3004 exports	0
Personal Protective Equipment imports	0	Personal Protective Equipment Exports	0
GDP_{jt}	0	$HTEX_{jt}$	2.72E-12
D_{ij}	3.27E-207	$REER_{jt}$	1.61E-91
RD_{jt}	1.26E-06		

Source: Own compilation based on data from Gretl.