Trade Effects of Digitalization

A panel data study of the effect digitalization has on services trade within the European Union

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Abstract

This essay examines the impact digitalization has on trade in services inside the European Union (EU). Furthermore, it investigates whether countries with discrepancies in the degree of digitalization have identified such trade effects to different scopes. Initially, the application method used in this study is the gravity model using panel data with a disaggregated dataset from The Organisation for Economic Co-operation and Development (OECD) with 19 exporting countries and 28 importing countries between 2015 and 2018. The dataset is divided into three subcategories - *Blue collar services, White collar services,* and *Other services.* An array of econometric estimation methods are tested and the fixed-effect method is found to be the most accurate estimator. The key finding of this paper is that some dimensions of the level of digitalization in the exporting country have a positive and significant effect on services trade. To our knowledge, no earlier studies have investigated the effects of trade on digitalization, hence there is room for further research.

Key words: trade effects, digitalization, gravity model, European digital single market

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1. Introduction

One could say that digitalization is one of the things that distinguishes our modern society from our past. Digitalization is an ever-developing phenomenon, and it has been integrated into almost every level of European society and Europeans everyday life. In addition, digitalization is an element already affecting the economy in depth immensely. International trade is a field that similarly has not been left untouched by digitalization. Digitalization facilitates the process of purchasing goods or services, nowadays this can be done from your own home with the help of a computer, the internet, and e-banking. Digitalization further facilitates the process of filling out forms online to ship traded goods or register a service transaction across borders. This process is timesaving in comparison with ordering physical forms, filling them out, and then sending them with the post. In many companies, time is money. In contrast to digitalization, trade is something which has existed since people started to travel the earth. Despite this fact, trade in services, compared to trade in goods, has until recently been disregarded by international economists (Hoekman & Braga, 1997), and segments of services have traditionally been viewed as domestic activities which do not extend to the application of theories and instruments related to trade policy (WTO, 2013). Services are nevertheless essential for the functioning of an economy. The National Board of Trade, a Swedish government agency, wrote in their literature review (2015) that services constitute approximately 70 percent of the EU production but solely 20 percent of EU trade. Although, the share of exported services have grown within the world economy (Loungani et al. 2017). In 1970, exported services as a share of total exported goods and services were at 9 % compared to 20 % in 2014, the figure has thus more than doubled (ibid). One of the most instrumental causes for this drive up was technological advances (Loungani et al. 2017).

Trade in services and digitalization are both in themselves two rather unexplored fields within international economics. Continuously, from the reasoning above it seems reasonable to argue that the two subjects are not foreign to each other. For a lot of services, digitalization is even a precondition to be produced or traded. The level of digitalization in the exporting country could hence potentially work as a competitive advantage which facilitates the production of services and makes it less cumbersome to sell services across borders due to satellite networks. If the digital skill of the population as well as business digitalization in the importing country is well developed, consumers in the importing country could be better equipped to search for and purchase services online. If the level of digitalization among companies in the importing country is less developed than such in the exporting country, consumers might prefer to buy services through exports. Hence, both the level of digitalization in the exporting country as well as the level of digitalization in the importing country is of interest and could potentially have an effect on trade in services. This essay continuously aims at investigating this relationship, e.g. the effect digitalization might have on services trade. Accordingly, the principal purpose of this essay is to answer the question:

> *Does the level of digitalization in the exporting and/or importing country have an effect on trade in services, within the European Union?*

Copenhagen Economics (2010) concluded that if European firms would have been better at utilising the advances in information and communication technologies (ICT) and digital technologies in 2004, the GDP of EU15[1] would have been 3.2 percent higher. They further concluded that the creation of a Digital Single Market inside the EU could be a part of the solution to this. A couple of years has now gone by since 2004, and the European Digital Single Market (DSMS) has become a reality with the 2014-2019 act of the European Commission (European Commission, 2020). Through this initiative the importance of digitalization became more pronounced inside the EU which further sparked our interest in looking solely at the relation between digitalization and trade in services within the integrated area. DSMS is built on three grounding pillars extending it into three major objectives: (1) Access: ameliorate the access for consumers and businesses to digital goods and services throughout Europe, (2) Environment: creating the right infrastructure and conditions for digital networks and innovative services to flourish, and, (3) Economy & Society: maximizing the growth potential of the digital economy. The first two of these objectives have in their definition aims to facilitate the access to supplied services through the development of digitalization, hence trade in services will consequently be affected. By maximizing the growth potential of the digital economy, it will become easier to conduct business through markets online which, in turn, will facilitate transactions across borders because large distances will not be as great of a hurdle as it previously has been. This will as a consequence facilitate trade in services that thanks to the technical innovation today can be produced and stored, further described in section 2.1. The initiative is further based on one of

[1] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom (OECD, 2007).

the European Commission's six political objectives, to strengthen people with a new wave of technologies (European Commission, 2020).

The disposition of the essay is the following. Section 2 presents the framework and information of necessity for this essay. Section 3 demonstrates a limited amount of previous empirical studies. Section 4 and 5 describes methods and data applied in the study, respectively. The results presented and robustness checks are found in section 6. Furthermore, the results are discussed and concluded in section 7 and 8, subsequently.

2. Background

This section aims to provide the reader with some background information and definitions of the two main focuses of this essay, services and digitalization. Trade in services will consequently be described through the four modes of supply outlined in GATS and how the free movement of services is implemented inside the EU. Respectively, digitalization will be described partly as a homogenous good relating it to the scholar of economics.

2.1. Services Trade

Services constitute a vital input in the production of many industries. When it comes to international trade, services have unique attributes which separate them from manufactured products. To begin with, services are difficult to touch compared to manufactured goods. Services are hence intangible (Hoekman & Kostecki, 2009). As a consequence, trade in services is often more complicated to measure, track and tax (ibid). It is fairly easy to register a manufactured good when it crosses a border because one can see it and touch it. In comparison, it is more cumbersome to register a service transaction when it crosses a border because one cannot see when it does so. Services have hence traditionally had the characteristics of being non-storable, services are often produced and consumed at the same time making it difficult to trade across time (Hoekman & Kostecki, 2009). These characteristics likewise imply that it is more difficult to trade a service across space, one cannot simply ship it as one can with a good. These attributes have however come to change to some extent with the development of technology. Changes to production techniques and business processes have come to change due to the development of the internet and other network technologies, e.g. big data and artificial intelligence (Loungani et al. 2017). Through satellite networks, more services can be produced in one country and consumed in another.

Software, the main component of hardware systems, have given some services a physical attribute similar to goods in the sense that it can be produced and stored (ibid).The production of services is nevertheless still different compared to a manufactured product. Many services are commonly produced with some contribution from the consumer in the shape of critical information and feedback provided by the consumer, creating a joint production (Loungani et al. 2017). Hence, the productivity and effectiveness of the producer are partly determined by the consumer. As a result of how a service is produced, services are often heterogeneous and tailored to a specific customer (ibid). This indicates that what travels across international borders in terms of services have a high degree of product differentiation.

As highlighted in the introduction, trade in services is a subject which has not been as well explored as merchandised trade. The first multilateral trade agreement on services trade came into force in January 1995 as one of the main accomplishments of the Uruguay Round of trade negotiations within the World Trade Organization (WTO), called the General Agreement on Trade in Services (GATS) (WTO, 2013). This was nearly half a century after GATS equivalent in merchandised trade had come into effect in 1947, the General Agreement on Tariffs and Trade (GATT) (ibid). The countries which we focus on in this study are all affected by both of these agreements since the member states of the EU are WTO members in their own right along with the EU being a member in itself (WTO, n.d.). In the WTO, the European Commission speaks for all member states of the EU at almost every WTO meeting (ibid).

The GATS consist of four main components. Firstly, it is a set of rules and concepts which are applicable to all parts affecting services trade (Hoekman & Kostecki, 2009). Secondly, it includes commitments which are specifically applied to sectors and subsectors within the services field and are in turn listed in member's schedule (ibid). Thirdly, negotiation will continuously be held to progressively liberalize trade in services (Hoekman & Kostecki, 2009). Lastly, it contains a set of attachments and protocols which determines sector-specific disciplines and decisions at ministerial level, in turn, related to the implementation of GATS (ibid.)

GATS does not define what a service is, it instead defines a list consisting of 12 services. The list is constructed based on the UN central Product Classification (Hoekman & Kostecki, 2009). Trade in services is subsequently covered by GATS Article I:2 to consist of four modes of supply which depend on the geographic location of the producer and the consumer when a transaction is made (WTO, 2013). Mode 1 includes Cross-border trade, a service transaction from the territory of one member country into the territory of another (ibid). Mode 2 is defined as Consumption abroad which is when services are supplied in the territory of one Member country to consumers of another Member (WTO, 2013). Mode 3 describes Commercial presence that is when services are supplied by a supplier from one Member country through a commercial presence in the territory of another Member (ibid). Mode 4 lastly includes the Presence of natural persons, this is when a service is supplied by a supplier of one Member country, through the presence of a natural person who is a citizen of this country inside the borders of any other Member country (WTO, 2013).

In the EU, the single market for services allows for the free movement of services inside the union (The National Board of Trade, 2015). It further includes two kinds of general cross-border relationships, the possibility for EU members to freely supply services across borders and the right to set up an affiliate or a business abroad in the territory of another member country (ibid). This is in line with the modes of supply in GATS. Barriers to services trade inside the union have traditionally been found behind the borders with regards to national regulations (The National Board of Trade, 2015). Consequently, members of the union are allowed to implement regulations of national character in order to protect consumers and the environment and to further guarantee specific quality levels (ibid). These regulations cannot discriminate against foreign service suppliers, hence the same rules should be applied to domestic providers. This applies to both formally discriminatory regulations and practically discriminatory regulations (The National Board of Trade, 2015). Nevertheless, it has been difficult to supply services across borders due to these national regulations. The free movement of services has also been politically sensitive due to many services being a part of a country's fundamental structure, e.g. healthcare, education, and infrastructure (ibid).

2.2. Digitalization & Digitization

So far digitalization has exclusively been described as taking one form, however, the label is multidimensional. An introduction to “digitization” needs to be stressed as ”digitalization” aligned with ”digitization” has multiple dimensions and implications depending on the area and sector of interest. The two forms of interchanging analogue information are important to distinguish in this essay for a broader understanding of how it might affect trade.

Both digitalization and digitization are mutually associated in a great range of different disciplines, and are regularly separated from each other. According to the Oxford English Dictionary (OED) ”digitization”, in a broad sense, refers to the conversion of analogue data, e.g. images, videos, and text, into digital form, hence a matter of material process. The cross-disciplinary term of “digitization” refers to a technical process of changing streams of analog information into binary strings with discrete and discontinuous values. The binary segment of the values taken have only two possible values minimizing errors or disturbances and helps to produce more accurate signals. In contrast ”digitalization” is the maintenance or increase in use of digital or computer technology by an industry, country or organization. Thus, it is a method in many areas of how social life is restructured around digital communication and media infrastructures (Brennen & Kreiss, 2016). In a broader perspective digitalization can be examined as a competitive good, differentiating countries ability to perform in different areas of interest where digitization processes are present. Within the economic field networks are, in their own character, defined as homogenous goods, however the speed and reliability diverge across different networks. Hence, this discrepancy in distribution of networks across countries and sectors is a field this study partly investigates, and how it could likely affect services trade. Shy (2002) categorizes these discrepancies between network markets into four brackets, such as: (1) Complementarity, Compatibility & Standards, (2) Consumption Externalities, (3) Switching Costs and Lock-in, (4) Significant Economies of Scale (Vogelsang, 2010). The first aspect relates to the universal standards for the network hardware such as software and cables. The second characteristic describes the utility of a consumer using a network increasingly when more users access the network, whereas the third applies to the costs of switching networks - if it is high the users are “locked” with their current network. Ultimately the fourth aspect represents the marginal costs as the average costs decline when a greater number of users attend the network (ibid).

3. Previous Empirical Studies

The following section presents leading research of importance for this study. First, earlier studies on how well the gravity equation performs with services trade are presented, thenceforth a limited overview of research assessing the effects of digitalization. As previously mentioned, in the introduction, the number of earlier studies within the subject is narrow, considering the novelty of the field. To our knowledge, no earlier studies have investigated the effects of trade on digitalization. Regardless, this section aims to provide the reader with a framework on the methods previously applied and the results achieved by earlier studies already executed within the field.

3.1. Services Trade & Gravity Model

The gravity model has been extensively used analyzing merchandised trade, however services trade have not been studied to the same extent. One of the very first approaches in analyzing services trade applying the gravity model (Lejour & Verheijden, 2004), was in a study written by Lejour & Verheijden (2004). It investigates how to explain bilateral trade patterns of services trade using two-panel data sets. One between 1997 and 1999 for provinces in Canada, and the other between 1999 and 2001 for OECD countries focusing on EU member states. The main objective of the study was to question whether services trade can also be explained by the traditional gravity model variables. The second aim was being able to conclude something on the potential of the internal market for services within the EU. The variables used, explaining services trade, were the Gross Domestic Product (GDP) in the origin and destination country, the distance between the observed countries, cultural differences, common membership of a Free Trade Agreement (FTA), and the level of economic institutions. Since two separate cross-border data sets were applied, two conclusions could be drawn. The first conclusion was that the level of services trade is determined by the size of the market, measured by the GDP, of the origin country to a larger degree than by that of the destination country, taking the sub-sector Hotels & Restaurants as an exemption (Lejour & Verheijden, 2004). More conclusively, the distance between provinces in Canada resulted in being important for goods trade, mutually being the same for services trade (ibid). However, the results for services such as Communication, Finance, and Private education, distance had no relevance having more relevance for sectors such as Wholesale margins and Transport (Lejour & Verheijden, 2004). The second conclusion being drawn from the second dataset diverged from those on services trade within Canada, where some coefficients were being more important. For the EU, the size of the market of the destination country seemed to be more important for services trade than that of the origin country. For goods, it was the opposite as it was for Other Commercial Services, but the size of the market was concluded being less important than it was for the Canadian data. In addition, distance seemed to be of less importance for trade in services than for trade in goods within the EU (Lejour & Verheijden, 2004).

The comprehensive results, based on the gravity equation, distance was found to be less important for services compared to goods. Concluding for their second object, the potential of the internal EU market, the authors argue that variables such as differences in language and culture are ignored, isolating the trade potential for the EU if the internal market would have the same characteristics as the Canadian market for intra-regional services trade (Lejour & Verheijden, 2004). One might assume that the study might be questioned considering the differences in their respective sizes, hence the importance of population density needed to be controlled for. This issue is, however, discussed, noting that a better benchmark for the intra-regional trade comparison would be with the U.S due to higher population density, however, data from federal trade in services were not provided from the U.S (Lejour & Verheijen, 2004). Controlling for whether differences in the size of the variables matters, they applied a Chow test under the null hypothesis that there is no structural break between the observations of the Canadian and EU data which was rejected (ibid).

Kimura & Lee (2006) similarly discusses in their study the resemblances and differences between bilateral trade in services between different OECD members and goods trade in terms of their determinants. Nonetheless, the dataset is more heterogeneous as it involves countries outside of the EU. The study was comparative as they compared the exports and imports of goods being dependent variables, with the respective exports and imports of services trade as the dependent variables. The result was a higher adjusted R-square, coefficient of determination, for services trade as opposed to goods trade. Moreover, this involved the gravity equation performing better with trade in services than with trade in goods.

However, opposed to the Lejour & Verheijden (2004) study, the distance variable resulted in being negatively significant (Kimura & Lee, 2006). Similarities in both studies mentioned was the positively significant variable common language, however only for the sub-sector Transport in the Lejour & Verheijden (2004) as opposed to in Kimura & Lee (2006) being significant in all specifications.

3.2. Trade Effects & Digitalization

As earlier mentioned, to our knowledge, no earlier studies have applied digitalization to the gravity model explaining the effects on services trade. However, in a paper using panel data based on OECD countries, Mammadli & Klivak (2020) studied the impact of digitalization on the economy, specifically on GDP in a frame of nine years. More specifically, this analysis is divided into two parts, first focusing on creating a synthetic index reflecting the state of digitalization at the country level. Secondly, the study validates the synthetic index using GDP in previous years as the dependent variable. Creating a structure for their synthetic index, inspiration methods were drawn from the paper by Raul F. Katz et al. (2014), and methodology for how to weigh different indicators was chosen from the German Digitalization report (Mammadli & Klivak, 2020). The model was dynamic, letting the dependent variable GDP being lagged, controlling for time effects instead of applying time dummies to show differences in time which consequently resulted in a higher adjusted R-square coefficient, hence the model fitted the data well (Mammadli & Klivak, 2020).

As digitalization is yet troublesome to measure, digitalization could be concluded to contribute to innovation or being the main component in perceiving how technology transforms the economy (Mammadli & Klivak, 2020). Similarly to our reasoning, digitalization is not yet finally determined, thus a solid quantitative approach of measuring digitalization is ambiguous and room for further research is present.

4. Methodology

In the section below, the methodology used for the study performed in this essay will be presented. The traditional gravity model will be described together with some of its extensions, and a description of the gravity model with disaggregated data will be provided. The measurement of digitalization used in this study will further be described in this section.

4.1. The Gravity Model

The gravity model has been widely used when modelling international trade and has undergone improvements, extensions, and modifications during the years. The first and traditional form of the gravity equation was recognized by Jan Tinbergen in 1962 (Feenstra, 2016). This equation was similar to Newton's universal law of gravitation which describes how the force of gravity between two objects depends on the mass of each of these objects and the distance between them. The larger the objects are, or the smaller the distance is between them, the greater the force of gravity is (ibid). Similarly, Tinbergen's equation explains how the value of bilateral trade is a function of the product size of each of the two economies, often measured as the GDP, and the distance between these two countries (Gomez-Herrera et al. 2014). Hence, just like in the Newtonian theory the gravity equation shows that bilateral trade is in proportion to the respective size of the economies and the proximity between them (Bacchetta et al. 2012).

As the traditional equation simply relates to countries trading in proportion to their gross domestic products, extensions have been made as previously mentioned. Later studies have questioned the traditional form of the equation, thus structural forms have been applied or complemented using other variables or forms of the equation.

The structural form of the gravity model has facilitated the delivery of tractable structures for trade policy analysis in an environment where multi-countries are present (Yotov et al., 2016). As the traditional form was frictionless, the structural form captures the multilateral resistance terms, making one able to calculate the impact of changes in trade cost (Head & Mayer, 2014). A frictionless world involves each good having the same price everywhere (Tinbergen, 2011). For applied economic analysis Anderson (1979) introduced a more theoretical economic scholar for the gravity equation on the basis of product differentiation by place of origin and constant elasticity of substitution expenditures (CES). Closely following, Bergstrand (1985) applied a Heckscher-Ohlin framework (Yotov et al., 2016). Even though Anderson, along with other studies, was seen as a pioneer in the approach of applied economic analysis, the model had difficulties gaining impact in the profession of trade until the late 1900s and 2000s (ibid). According to WTO, the most influential structural gravity models in the field of economics are Eaton & Kortum (2002) implementing a Ricardian structure, and Anderson & Van Wincoop (2003) further developing the Armington-CES model of the earlier mentioned Anderson (1979) model initializing the effects of trade costs (Yotov et.al, 2016). The existence of trade costs and barriers will consequently be stressed in 4.1.2.

The importance of regional trade agreements (RTAs) has been shown to be an appropriate estimation method lowering the risk of parameter inconsistency and has partly been shown by Greenaway & Milner (2002). The conclusion of the study was the importance of the inclusion of regionalism for applied analysis with a more expanded panel data set (Greenaway &

Milner, 2002). As regional trade agreements, such as NAFTA and EU have been established, in the 20th century the decomposition of regional trade effects has been noted to be included. An alternative to control these effects is the simultaneous use of RTA and non-RTA dummy variables (Greenaway & Milner, 2002). Hamilton & Winters (1992) earlier investigated this issue in a study predicting ”out-of-sample” trade flows for Central and Eastern European countries, noting the importance of intra- and extra-European inclusion in the data set.

4.1.1. Gravity Model with Disaggregated Data

Aggregation is encapsulated in the gravity model, considering its main insight from the approach, as earlier mentioned, is that bilateral trade depends on relative trade barriers (Salvatici, 2013). Thus, the treatment of flows has constantly been implemented as an aggregate, e.g. trade in goods (ibid). This implies that varying costs and elasticities across sectors are hard to identify using the traditional form of the equation involving an aggregation bias (Tinbergen, 2011). Introduction to disaggregated data is probably more applicable today in models of international trade as it allows for some firms in a country to export a partial set of products to a partial set of countries in the world, implying that trade barriers do move around (Salvatici, 2013). Our main purpose of applying a disaggregated dataset of trade in services depicts from capturing effects that might be lost in a larger aggregated data set. Furthermore, services trade flows enable one to capture sectoral effects in our sample - a solution as our sample mainly contains homogenous country-pairs when it comes to digitalization. Additionally, the development of micro-foundations of the gravity model is the introduction of a larger set of applications to other bilateral flows rather than simply trade in goods (Head & Mayer, 2014), enabling us to use services trade as our dependent variable, accordingly.

More recently less traditional approaches have been highlighted in order to illustrate trade flows - dynamic gravity modelling. Simply, as different types of dataset consequently differ, estimation methods have been illustrated more as a toolkit approach to enact robustness since one estimator may be favored for one type of dataset, accordingly (Head & Mayer, 2014). As policies diverge across sectors, the effects of trade policy should by that means be allowed to vary by each sector (Yotov et.al, 2016). From here the methodology differs depending on one of the questions of interest, the estimates of the trade policy variables can either be sector-specific or constrained estimates to be universal across sectors (ibid).

Larch & Yotov (2016) have marked the importance and accessibility of the separability implications of the model. Trade separability enables one to focus solely on inference about costs distributed from the pattern of distribution of goods excluding having to explain, at the same time, what disposes the total supplies of goods to all locations (Tinbergen, 2011).

Likewise, the importance of practicing panel data when analyzing services trade, rather than simply using a cross-sectional data set, has been marked as being helpful in isolating endogeneity. The traditional form of the equation is simply structured for cross-country analysis of international trade flows and the econometric issue of endogeneity is frequently being present as trade policy, such as Free Trade Agreements (FTA), is not an exogenous variable. The argument for using panel data originates from finding that, on average, two FTA member's bilateral trade doubles ten years after the commencement of the agreement (Baier & Bergstrand, 2007). However, even though infeasible computations might occur due to a larger number of resulting dummy variables using panel data, adopting country fixed effects solving the challenge of many estimates (Head & Mayer, 2014). The fixed effect accounts for overstated trade flows to and from countries and can consequently control for this (ibid).

4.1.2. Multilateral Resistance

As the gravity model explains bilateral trade flows, several extensions and approaches of the trade model have been made to capture trade costs using different methods. Separating the size term, representing the level of frictionless trade, from the trade cost term makes it possible to capture the total effects of trade costs which further is decomposed to bilateral trade costs, inward multilateral resistance and outward multilateral resistance (Yotov et.al, 2016). Resistance takes the intuition, all else equal, that two countries will exchange trade flows with each other the more remote they are from the remaining countries (Larch & Yotov, 2016). However, estimating the multilateral resistance variable has not yet been directly observed and is yet observed as a theoretical term, simply (Yotov et.al, 2016). Anderson & Van Wincoop (2003) stressed multilateral resistance weighing the importance of the average trade barrier affecting countries to be more or less resistant to trade combining the gravity equation aiming at gaining more unbiased coefficients. They found that trade flows were not only dependent on the size of the trading countries, but also the average barrier towards other countries. They suggested that the multilateral resistance variable being equal to the set of price indices in the respective country since they are dependent on bilateral resistance, evolving a gravity model as a function of price indices. Even before the Anderson & Van Wincoop (2003) study, the discourse of trade unions has been applied by McCallums (1995) testing for implications of trade agreements to a before borderless, frictionless, gravity model equation. The estimation involved applying a dummy variable taking the value of one if intra-bloc trade is present and zero otherwise (McCallums, 1995). Hence, extending the structural model is an example of how it naturally seems plausible to use multilateral terms for generating efficient coefficients. This is further explained in the section below.

4.1.3. The Fixed Effects Method

Panel data sets are generally acquainted with large samples, hence controlling for country-specific effects using single dummy variables could be cumbersome to complete for every country. If a dummy variable is included for every country-pair in the sample, and an intercept is included as well, one would end up in the dummy variable trap where the model suffers from multicollinearity (Dougherty, 2016). Applying a fixed effect method would similarly favor country-pair specific effects, thus allowing these effects to be heterogeneous. The advantage in using the country-pair fixed effect is that the heterogeneity in a panel can be controlled for (Bacchetta et al., 2016). The constant term holds all discrepancies among the units that are not previously captured by the already incorporated explanatory variables (Bergstrand & Baier, 2007). However, the disadvantage of including country-pair dummies in the model is that bilateral time-invariant coefficients will be included in the fixed effects (Bacchetta et al. 2016). Then the model will suffer from perfect multicollinearity (ibid). In the case of disaggregated data, where the panel id is specified to country-pair-sector relations and year, then heterogeneity will be controlled for by country-pair-sectoral fixed effects. Then, the fixed effects will capture time-invariant effects within the country-pair-sector relation. To control for the use of fixed effects rather than random effects, the Hausman test can be used to test if the model instead should be estimated with the random effect model[2] (Bacchetta et al., 2016).

When having a sample with data that is pooled across service sectors, the appropriate method of handling multilateral resistance is to include country fixed effects that are interacted with

[2] See 6.2.2 for results from the Hausman test.

sectoral dummy variables (Bacchetta et al., 2016). Since the multilateral resistance terms are constant across the years covered in this study, these terms will be presumed to be included in the fixed effects. Consequently the occurrence of omitted variable-bias is hence dodged. More specifically, a fixed time effect catches the effect of all, observed and unobserved, terms that are time-invariant over the individual units (Verbeek, 2005). This especially applies to our multilateral resistance terms as a partial set of these terms are unobservable. Head & Mayer (2014) identify that exporter and importer fixed effects should be time-varying in the case of pooled data over a number of industries. Time-varying importer and exporter fixed effects take into account that multilateral resistance may change over time (Bacchetta et al., 2016). In the study conducted in this essay we have chosen to handle multilateral resistance by having exporter-sector and importer-sector fixed effects separated from time-fixed effects, captured by time dummies for each year. Applying this approach makes one able to control for country-sector specific effects which could capture barriers to services trade in terms of national regulations behind the borders. The exporter-sector fixed effect will further capture the outward multilateral resistance of a sector, while the importer-sector fixed effect will account for inward multilateral resistance (Yotov et al. 2016).

4.2. Gravity Model & Digitalization

The gravity model has not previously been used to estimate the effect digitalization might have on bilateral services trade. This section, therefore, has the intention of describing the measure of digitalization used as a variable in the gravity model further specified in section 5.3. For the purpose of this essay the gravity model generates conclusions regarding the expected impact on trade and of a transition in trade costs.

4.2.1. Classifying Digitalization

The specification of digitalization[3] is vital for our causal relationship between trade in services and digitalization, and hence the inference of the study. As digitalization is a new field of study, the core definition is differing concerning different areas of interest which one has to keep in mind as presented in the background. As the definition of digitalization deviates across sectors, the terminology of the measurement is therefore not constant and measurements taking the form as indices diverge for different concepts (Vogelsang, 2010).

[3] For detailed description, see section 2.2.

The measure of digitalization applied in this essay is the Digital Economy and Society Index (DESI), which is an official index of digitalization that summarizes variables on Europe's digital performance. Additionally, it tracks the increased or decreased performance of EU countries regarding their digital competitiveness and covers the performance from 2014 (European Commission, 2020).

Naturally, the use of an index covering the digital performance for all of our observations in the EU, choosing DESI as a measurement of digitalization seems to be convenient for our study. The index is divided into five main dimensions: Connectivity (desi_1_conn), Human Capital (desi_2_hc), Use of Internet (desi_3_ui), Integration of Digital Technology (desi_4_idt), Digital Public Services (desi_5_dps), each reflecting the EU's digital policy priorities (European Commission, 2020). The comprehensive notation of the DESI is named as the DESI overall index and is calculated as the weighted average of the five main DESI dimensions above as follows: Connectivity (25%), Human Capital (25%), Use of Internet (15%), Integration of Digital Technology (20%) and Digital Public Services (15%). The weight depends on the relevance and importance in comparison with the others, hence a higher weight denotes a higher relevance (European Commission, 2018). The dimensions are then divided into sub-dimensions with their respective weighted averages, where the number of sub-dimensions differs for each dimension. At last, the sub-dimensions are divided into their respective individual indicators, where the number of individual indicators for each sub-dimension differ accordingly (European Commission, 2020).

Focusing on trade in services, with a composition of disaggregated data, we have chosen to study how the Use of Internet, Integration of Digital Technology and Digital Public Services dimensions could potentially have an effect on trade in services for the importing/exporting country. Additionally, in order to capture potential sectoral effects of our sub-categories summarized in table 5.1, the definition of digitalization is applied using these three dimensions[4] of the DESI. As earlier mentioned, our dataset is disaggregated, hence it seems plausible to disaggregate our index connecting each dimension to one sub-category to capture the effects digitalization has on services trade. The reasoning is as follows, first, Use of Internet could potentially have an effect on the subcategory *Other services*, as a representation of a higher level of personal internet application could affect the trade in the

[4] See appendix 2 for a summary and structure for the three chosen dimensions of the DESI.

telecommunication and information services positively, such as ameliorating skills in the ICT sector. Secondly, Integration of Digital Technology could potentially capture effects in the subcategory *White collar services* as one of the dimensions is business digitisation. This comes from a higher representation of business digitisation level, individual indicator for Integration of Digital Technology, could have an effect on financial services and other businesses, scoped by the same sub-category, facilitating processes within the sector. This relates to many businesses that are found to be aiming towards higher levels of automatization processes, thus digitisation processes. This dimension could further work as a comparative advantage, the higher level of digitalization a company has, the more likely it is to be engaged in exports compared to companies with a lower level of digitalization. The fifth dimension, Digital Public Services could potentially, similarly as for the fourth dimension, have an effect on *White collar services* as digital public services of businesses, an individual indicator of Digital Public Services, could potentially affect Other businesses, a sub dimension of *White collar services*. Additionally, the fifth dimension could facilitate the business process of a company which in turn might facilitate the process of trading services.

Regarding the dimension Integration of Technology, one would think that the last indicator, Selling Online Cross Border[5], would potentially interfere with the dependent variable of the study, the value of exported services, but the two measure different things. Selling Online Cross-border measures the percentage of enterprises which have made electronic sales to other EU countries in the last calendar year, where enterprises that have between 10-249 employees are included (Digital Agenda Data, 2020). Electronic sales is further defined as a sale being released via a computer network, where computer networks include websites, EDI-type systems and other methods of electronic data transfer. Here manually typed emails are excluded (ibid).

4.3. The Issue of Zero Trade Flow & Missing Data

The occurrence of zero trade flow between two countries in a given year is an issue of estimation as well as an issue of measurement that affects the method of using most of the existing gravity models (Bacchetta et al., 2016). The issue gets more pronounced when handling disaggregated trade data, and especially with regards to services trade because of the extent consumption is localized and production is specialized (Yotov et al., 2016). The main

[5] Again, see appendix 2 for a detailed summary of each dimension of the DESI.

problem with zero trade flow is that the standard gravity model is estimated in a log-linear version. When one takes the logarithms of a variable consisting of zeros, the zeros will be dropped out of the estimation, treated as missing variables (Bacchetta et al., 2016). That happens because the log of zeros is not defined. How to handle zero trade flows is a matter of judgement, and depends on if the reported zero trade flow really is zero or if it is a reporting error (ibid).

One of the alternative procedures when handling zero trade flow is to abridge the sample by dropping observations of zero trade (Bacchetta et al., 2016). This is correct if the observations are randomly distributed, that is when the zeros are caused by a random rounding error or if they are random missing data. These zeros can be dropped because they are not informative (ibid). The same reasoning can be applied to missing data, where not even zeros have been recorded. Observations of zero trade between a country pair can continuously be dropped without losing any information if the zero reflects the fact that neither of the countries produces the good or service in question (Bacchetta et al. 2016). In these cases, the Ordinary Least Square (OLS) method can be used, and the zeros will automatically be dropped when the value of bilateral trade is transformed into logarithmic form (Yotov et al., 2016).

Another method that has been frequently used, but is theoretically inconsistent, is to replace zero trade flows with a small and random value (Yotov et al., 2016). This method, however, yields inconsistent estimates when estimated with the OLS method, because it is not guaranteed that the substituted value reflects the underlying expected value (Bacchetta et al. 2016). When using this method, one can no longer interpret the coefficients as elasticities and the results depend on the unit of measurement (Head & Mayer, 2014). Hence, this method should be avoided and have been so in the study conducted in this essay.

If the occurrence of zero trade country pairs is frequent throughout the sample, the zeroes are most likely informative and can reflect restrictive transport costs because of disproportionate distances or the size of the economies involved, if these are extensively small (Bacchetta et al. 2016). In this case, one approach is to use a Tobit estimator with left-censoring at zero on the log of bilateral trade with a constant added or the Pseudo Poisson Maximum Likelihood (PPML) estimator (ibid). The Tobit model applies to a scenario when small values of bilateral trade are rounded to zero or if zero trade, in fact, reflects trade that is negative (Bacchetta et al., 2016). The use of this model can be justified for trade data reported from countries with a low degree of accuracy in reporting (ibid). When the study is demarcated to the EU, one can assume that the degree of accuracy is quite high when reporting trade flows due to the lack of incentive to “improve" trade data. The PPML method, on the other hand, can be estimated directly in the non-linear form of the gravity model, hence applicable to the levels of trade (Bacchetta et al., 2016). Thus, one can avoid dropping zero trade. When the sample used in a study suffers from heteroscedasticity, the PPML is a robust line of action (Santos Silva & Tenreyro, 2006). Santos Silva and Tenreyro (2006) consequently conclude that the performance of PPML is good when no rounding error is present and then biases tend to be small.

5. Data

This section will present the data used in the study conducted in this essay together with a description of the variables included in the traditional gravity model which is the base of this study. The empirical specification of the model that will be estimated will consequently be presented below.

5.1. Gravity Variables

The basis for our empirical specification and hence study, presented further down in this section, is the traditional form of the gravity equation. As earlier stressed in 4.2, the traditional form consists of a mass of labor or other elements of production supplied at province i,(Y_i) being drawn to a mass demand for goods or labor at destination j, (E_j) but the potential flow is reduced by the distances between the masses (d_{ij}). The following equation gives the anticipated movement of good or labor between countries i and j (X_{ij}) (Tinbergen, 2011):

$$X_{ij} = Y_i E_j / d_{ij}^2$$

Furthermore, this is also the basis for the extended forms of the structural forms of the gravity model.

5.2. Sample

The statistical study conducted in this essay uses panel data that is demarcated to include member countries of the EU between the years 2015-2018. The reason for choosing panel data for the study is that it improves the estimation efficiency (Yotov et al., 2016). The sample include data at the sectoral level for 19 exporting countries[6] and 28 importing countries[7]. The reason for including only 19 exporting countries in the sample instead of including all EU members is because data on the value of exported services is collected from the OECD. Not all EU members are, in turn, members of the OECD and therefore the data do not cover the entire EU. We have in addition chosen to exclude Luxembourg, Portugal, Spain and the United Kingdom as exporters because of the extent data were missing for these countries. The sample is limited to the years 2015, 2016, 2017, and 2018 because the variable capturing digitalization, the DESI, first recorded the digital performance of countries inside the union in 2015. 2018 is the most recent year where data on trade in services can be found and to be reliable.

This study furthermore focuses on export flows of trade in services as it is a more trustworthy measure of trade flow as a result of stronger incentive to report for exporting firms (Anderson et al. 2015). The data on bilateral services trade by sector from the exporting country is collected from a dataset called "EBOPS 2010 - Trade in services by partner economy" from the OECD Statistics. EBOPS stands for Extended Balance of Payments Services Classification, and EBOPS 2010 is a disaggregated substructure of the Sixth edition of the Balance of Payments and International Investment Position Manual (BPM6) services classification (Department of Economic and Social Affairs, 2012). This study includes 11 of the 12 components of BPM6, listed in table 5.1. The service category *Government goods and services not included elsewhere (n.i.e.)* is excluded from the sample. The reason for this is that it is not included in GATS (ibid). BPM6 services components cover mode1, mode 2, and mode 4 of supplies defined by GATS while mode 3 of supply is not covered by this measurement (Department of Economic and Social Affairs, 2012), all modes of supply are

[6] Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Republic of Ireland, Republic of Slovenia, Slovak Republic, and Sweden.

[7] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg Netherlands, Poland, Portugal, Republic of Ireland, Republic of Malta, Republic of Slovenia, Romania, Slovak Republic, Spain, Sweden, and United Kingdom.

described in section 2.1. For that reason, mode 3 of supply will not be covered by the sample used in this study, and the relationship between the commercial presence of a supplier from one country in the territory of another and digitalization will therefore not be explored.

The dataset consists of 22.572 observations, 4.250 observations of these are missing, and an additional 21 observations contain zero trade flow. The statistical analysis will be estimated using OLS fixed effects estimation method which can be used under the assumption that these zeros are not informative, described in section 4.3. Since the model is estimated in a log-linear form, the zeros will be regarded as missing variables. However, as a robustness measure the same regressions for subcategory *White collar services* will be estimated with the PPML estimator in order to control for this assumption being robust. The dataset is furthermore divided into three subcategories based on the BPM6 services classification it contains, these subcategories are described by table 5.1. When one uses an aggregated dataset, potential positive and negative effects could take out each other. This will thus be avoided with a disaggregated dataset. Additional reasons for choosing a disaggregated dataset is described in section 4.1.1.

Table 5.1: List of included services sectors and how they are distributed into sub-categories.

Blue collar services	**White collar services**	**Other services**
Transport	Other business	Travel
Manufacturing services on physical inputs owned by others	Charges for the use of intellectual property n.i.e.	Personal, cultural and recreational services
Maintenance and repair services n.i.e.	Financial services	Telecommunication, computer and information services
Construction	Insurance & pension services	
Observations: 8208	**Observations: 8208**	**Observations: 6156**
Missing values: 1965	**Missing values: 1491**	**Missing values: 773**
Number of zeros: 0	**Number of zeros: 21**	**Number of zeros: 0**

As previously mentioned, data on exported services trade was collected from the OECD Statistics, and are measured by the nominal value in US dollars. Data on GDP for the exporting and importing country is collected from the World Bank, also measured by the nominal value in US dollars. Data on the bilateral distance and common language between the exporting and importing country is collected from Centre d'Etudes Prospectives et d'Informations Internationales (Institute for Research on the International Economy) (CEPII). Common language is defined as the official or national language and languages spoken by at least 20 percent of the population in common for both the exporting and importing country (Mayer & Zignago, 2011). Bilateral distance is calculated by the great circle formula that uses latitudes and longitudes of the most crucial cities/agglomerations in terms of population in the two countries, where internal distance based on areas is incorporated (ibid). The measurement of digitalization is described in section 4.2.1, and the data is collected from a database provided by the European Commission called “Data & Visualisation Tool”. Data from the index is primarily collected by the European Commission services (e.g. Directorate-General for Communication Network, Content and Technology and Eurostat) and by provisional studies launched by the Commission services (European Commission, 2018). The framework for developing the index is based on recommendations in the OECD’s “Handbook on Constructing Composite Indicators: Methodology and User Guide” (ibid).

5.3. Empirical Specification

The empirical specification of the gravity model that constitutes the basis for the statistical analysis is in log-linear form. The coefficients obtained are therefore estimated as elasticities (Bacchetta et al. 2016), i.e. the coefficient is interpreted as the percentage change in the exported value of services trade from *i* to *j* from sector *k* at time *t* if the explanatory variable increased by one percent. The dummy variable, common language denoted *Lang*, in the model is though not logged. The coefficient of the dummy variable is hence semi-elasticity, consequently reflecting one percentage change in the exported value of services trade from *i* to *j* from sector *k* at time *t* if the dummy variable experiences an absolute change.

The empirical specification of the gravity equation is divided into three separate equations, for all three subcategories. The first equation aims at capturing the effect the level of digitalization in the exporting country has on exported services.

$$lnEXP_{ijkt} = \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnDist_{ij} + \beta_4 Lang_{ij} + \beta_5 lnDigit_{it} + \sum_l \beta_l Exp\_Sector_{dummy_l} + \sum_m \beta_m Imp\_Sector_{dummy_m} + \sum_t \beta_t Year_{dummy_t} + u_{ijkt} \quad (1)$$

The second equation aims at capturing a similar effect but with the level of digitalization in the importing country.

$$lnEXP_{ijkt} = \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnDist_{ij} + \beta_4 Lang_{ij} + \beta_5 lnDigit_{jt} + \sum_l \beta_l Exp\_Sector_{dummy_l} + \sum_m \beta_m Imp\_Sector_{dummy_m} + \sum_t \beta_t Year_{dummy_t} + u_{ijkt} \quad (2)$$

The third equation incorporates both countries' levels of digitalization in order to see if one could yield a different effect if both levels are accounted for in the same regression.

$$lnEXP_{ijkt} = \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnDist_{ij} + \beta_4 Lang_{ij} + \beta_5 lnDigit_{it} + \beta_5 lnDigit_{jt} + \sum_l \beta_l Exp\_Sector_{dummy_l} + \sum_m \beta_m Imp\_Sector_{dummy_m} + \sum_t \beta_t Year_{dummy_t} + u_{ijkt} \quad (3)$$

In these equations no constant term is included because it should not be included in the presence of fixed effects (Yotov et al. 2016). $lnEXP_{ijkt}$ is the logged nominal value of bilateral exported services. *i* is the exporting country, *j* is the importing country, *k* is the service sector, and *t* is time defined by the year in which the value was recorded. *l* is defined for a category capturing the exporter-sector relation, and *m* is defined for a category capturing the importer-sector relation. $lnGDP_{it}$ is the logged value of the nominal GDP for country *i* at time *t*, and $lnGDP_{jt}$ is the logged value of the nominal GDP for the country *j* at time *t*. is the $lnDist_{ij}$ logged value of the distance between country *i* and *j*. $Lang_{ij}$ is a dummy variable equal to one if country *i* and *j* have one or more languages in common. $lnDigit_{it}$ is the level of digitalization in country *i* at time *t*, where digitalization is either measured by DESI3[8], DESI4[9] or DESI5[10]. $lnDigit_{jt}$ is the level of digitalization in country *j* at time *t*, where digitalization is either measured by DESI3, DESI4 or DESI5. $Exp\_Sector_{dummy_l}$ and

[8] Use of Internet
[9] Integration of Digital Technology
[10] Digital Public Services

$Imp\_Sector_{dummy_m}$ are country-sectoral fixed effects, and $Year_{dummy_t}$ is time fixed effects. Lastly, u_{ijkt} is the error term.

According to theory, the determinants of the economic size of the two economies, $lnGDP_{it}$ and $lnGDP_{jt}$, is believed to have a positive impact on bilateral services trade, where the economic size of the importing country should have a higher importance than the economic size of the exporting country. Similarly, $lnDist_{ij}$ is expected to have a negative impact on services trade. Although, distance is assumed to have a lower relevant impact on services trade in the subcategory *White collar services* and *Other services* than in *Blue collar services*. The level of digitalization in exporting country, $lnDigit_{it}$, is expected to have a positive effect on exported services from all of the three subcategories. Similarly, $Lang_{ij}$ is expected to have a positive effect according to theory. The level of digitalization in the importing country, $lnDigit_{jt}$, can be expected to have both a positive and a negative effect depending on which DESI-variable that constitute digitalization in the regression. DESI4, which is a variable including the effects of business digitalization and e-commerce, in the importing country could be expected to have a negative effect on exported services from the exporting country. The intuition behind this is that a low level of digitalization, in terms of DESI4, in the importing country could result in services being purchased through imports from a foreign market rather than from the domestic market due to comparative advantages of the exporting country if their level of DESI4 would be higher. If the level of DESI4 then would increase in the importing country, the demand might turn towards the domestic market instead of the foreign market, and hence lead to a decrease in exported services to this country. The effect of DESI5, which captures the level of e-governance, can be connected to the effect of DESI4 because a high level of e-governance could facilitate the establishment and conduction of regular business operations. DESI3 in the importing country is expected to have a positive effect on exported service. If the importing country has a high level of DESI3, which captures the use of the internet, consumers in the importing country could be better equipped to search for and purchase services online from a foreign market.

6. Results

This section will present the results of the estimated gravity models which have been specified in section 5.3. The results of the three specifications will be presented along with a section aimed at controlling the robustness of these results.

6.1. Results of the Three Gravity Equations

The first gravity equation includes the level of digitalization for the exporting country and is presented as *Model (1)* in the tables provided in this section. The second equation includes the level of digitalization for the importing country and is presented as *Model (2)*. The third equation incorporates both countries' level of digitalization and is presented as *Model (3).* The level of digitalization has been captured by either DESI3, DESI4, or DESI5 separately. Hence, nine regressions have been generated for each subcategory to provide these results. The variables of interest for this study is *lnDESI3_EXP*, *lnDESI3_IMP*, *lnDESI4_EXP*, *lnDESI4_IMP*, *lnDESI5_EXP*, and *lnDESI5_IMP*. Consequently, these are the variables that will be in focus when the results are presented and later discussed.

Table 6.1: Results from *Blue collar services* for DESI3

VARIABLES	(1) Model (1) - OLS Fe	(2) Model (2) - OLS Fe	(3) Model (3) - OLS Fe
lnGDP_EXP	0.360	0.372	0.359
	(0.780)	(0.781)	(0.780)
lnGDP_IMP	0.111	0.181	0.178
	(0.533)	(0.547)	(0.547)
lnDist	-0.760***	-0.759***	-0.760***
	(0.036)	(0.036)	(0.036)
lang	0.326***	0.327***	0.325***
	(0.093)	(0.093)	(0.093)
lnDESI3_EXP	0.033		0.033
	(0.021)		(0.021)
lnDESI3_IMP		-0.361	-0.359
		(0.535)	(0.535)
Observations	6,243	6,243	6,243
R-squared	0.738	0.738	0.738

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6.2: Results from *Blue collar services* for DESI4

VARIABLES	(1) Model (1) - OLS Fe	(2) Model (2) - OLS Fe	(3) Model (3) - OLS Fe
lnGDP_EXP	0.138	0.374	0.135
	(0.793)	(0.781)	(0.793)
lnGDP_IMP	0.120	0.121	0.128
	(0.532)	(0.535)	(0.535)
lnDist	-0.759***	-0.759***	-0.759***
	(0.036)	(0.036)	(0.036)
lang	0.328***	0.328***	0.328***
	(0.093)	(0.093)	(0.093)
lnDESI4_EXP	0.419		0.427
	(0.427)		(0.429)
lnDESI4_IMP		0.195	0.209
		(0.393)	(0.394)
Observations	6,243	6,243	6,243
R-squared	0.738	0.738	0.738

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6.3: Results from *Blue collar services* for DESI5

VARIABLES	(1) Model (1) - OLS Fe	(2) Model (2) - OLS Fe	(3) Model (3) - OLS Fe
lnGDP_EXP	0.312	0.367	0.307
	(0.783)	(0.780)	(0.782)
lnGDP_IMP	0.127	0.143	0.154
	(0.533)	(0.535)	(0.535)
lnDist	-0.761***	-0.759***	-0.761***
	(0.036)	(0.036)	(0.036)
lang	0.327***	0.328***	0.327***
	(0.093)	(0.093)	(0.093)
lnDESI5_EXP	0.401*		0.395*
	(0.237)		(0.238)
lnDESI5_IMP		-0.205	-0.190
		(0.251)	(0.252)
Observations	6,243	6,243	6,243
R-squared	0.738	0.738	0.738

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In the subcategory *Blue collar services*, only *lnDESI5_EXP* is statistically significant. The coefficient is positive which implies that if the level of digitalization captured by DESI5, Digital Public Services, would increase with one percent in the exporting country, the exported services would increase with around 0.401 percent. The other measurements of digitalization for both the exporting and importing countries were continuously insignificant. The bilateral distance, *lnDist*, has a negative coefficient according to the expectations described in section 5.3 and is significant at a level of one percent. A common language, *lang*, has a positive coefficient which also was predicted, and is significant at a level of one percent. Finally, our coefficient of determination, R-square, is relatively high considering the high number of explanatory variables inserted in our models.

Table 6.4: Results from *White collar services* for DESI3

VARIABLES	(1) Model (1) - OLS Fe	(2) Model (2) - OLS Fe	(3) Model (3) - OLS Fe
lnGDP_EXP	0.580	0.585	0.583
	(0.741)	(0.741)	(0.741)
lnGDP_IMP	0.975**	1.139**	1.139**
	(0.482)	(0.502)	(0.502)
lnDist	-0.761***	-0.761***	-0.761***
	(0.033)	(0.034)	(0.034)
lang	0.165*	0.166*	0.166*
	(0.087)	(0.087)	(0.087)
lnDESI3_EXP	0.003		0.004
	(0.021)		(0.021)
lnDESI3_IMP		-0.799	-0.799
		(0.503)	(0.503)
Observations	6,673	6,673	6,673
R-squared	0.769	0.769	0.769

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6.5: Results from *White collar services* for DESI4

VARIABLES	(1) Model (1) - OLS Fe	(2) Model (2) - OLS Fe	(3) Model (3) - OLS Fe
lnGDP_EXP	0.562	0.590	0.566
	(0.752)	(0.742)	(0.752)
lnGDP_IMP	0.976**	0.991**	0.993**
	(0.483)	(0.485)	(0.486)
lnDist	-0.761***	-0.761***	-0.761***
	(0.034)	(0.034)	(0.034)
lang	0.166*	0.165*	0.166*
	(0.087)	(0.087)	(0.087)
lnDESI4_EXP	0.041		0.050
	(0.402)		(0.403)
lnDESI4_IMP		0.286	0.287
		(0.381)	(0.383)
Observations	6,673	6,673	6,673
R-squared	0.769	0.769	0.769

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6.6: Results from *White collar services* for DESI5

VARIABLES	(1) Model (1) - OLS Fe	(2) Model (2) - OLS Fe	(3) Model (3) - OLS Fe
lnGDP_EXP	0.513	0.573	0.505
	(0.740)	(0.741)	(0.740)
lnGDP_IMP	0.975**	0.992**	0.991**
	(0.483)	(0.483)	(0.483)
lnDist	-0.764***	-0.761***	-0.764***
	(0.034)	(0.034)	(0.034)
lang	0.164*	0.165*	0.164*
	(0.087)	(0.087)	(0.087)
lnDESI5_EXP	0.376*		0.374*
	(0.219)		(0.219)
lnDESI5_IMP		-0.195	-0.190
		(0.226)	(0.226)
Observations	6,673	6,673	6,673
R-squared	0.769	0.769	0.769

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The subcategory *White collar services* show similar results as was presented for *Blue collar services.* In this subcategory, *lnDESI5_EXP* is again positively significant. This implies that digital public services, as captured by DESI5, has a positive effect on exported services provided from the sectors belonging to this subcategory as well as the categories belonging to *Blue collar services*. Neither one of the other DESI-variables was significant within this category, neither for the exporting nor the importing country. However, both *lnDist* and *lang* followed their expected signs. Worth noticing is that in this category the GDP of the importing country, *lnGDP_IMP*, is positively significant which was not the case in the subcategory *Blue collar services.* This implies that the economic size of the importing country is more important for exported services from the sectors included in the subcategory *White collar services* than from the sectors included in *Blue collar services*. Finally, our coefficient of determination, R-square, is relatively high with similar implications as for *Blue collar services*, thus a higher number of explanatory variables could explain the value of the coefficient.

Table 6.7: Results from *Other services* for DESI3

	(1)	(2)	(3)
VARIABLES	Model (1) - OLS Fe	Model (2) - OLS Fe	Model (3) - OLS Fe
lnGDP_EXP	0.432	0.449	0.433
	(0.660)	(0.660)	(0.660)
lnGDP_IMP	0.391	0.427	0.425
	(0.454)	(0.472)	(0.473)
lnDist	-0.707***	-0.705***	-0.706***
	(0.034)	(0.034)	(0.034)
lang	0.393***	0.395***	0.393***
	(0.092)	(0.092)	(0.092)
lnDESI3_EXP	0.031*		0.031*
	(0.018)		(0.018)
lnDESI3_IMP		-0.176	-0.177
		(0.468)	(0.468)
Observations	5,383	5,383	5,383
R-squared	0.831	0.831	0.831

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6.8: Results from *Other services* for DESI4

VARIABLES	(1) Model (1) - OLS Fe	(2) Model (2) - OLS Fe	(3) Model (3) - OLS Fe
lnGDP_EXP	0.588	0.447	0.584
	(0.662)	(0.660)	(0.662)
lnGDP_IMP	0.392	0.402	0.401
	(0.454)	(0.456)	(0.456)
lnDist	-0.705***	-0.706***	-0.706***
	(0.034)	(0.034)	(0.034)
lang	0.395***	0.395***	0.395***
	(0.092)	(0.092)	(0.092)
lnDESI4_EXP	-0.239		-0.233
	(0.368)		(0.369)
lnDESI4_IMP		0.302	0.298
		(0.349)	(0.350)
Observations	5,383	5,383	5,383
R-squared	0.831	0.831	0.831

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6.9: Results from *Other services* for DESI5

VARIABLES	(1) Model (1) - OLS Fe	(2) Model (2) - OLS Fe	(3) Model (3) - OLS Fe
lnGDP_EXP	0.462	0.442	0.456
	(0.659)	(0.660)	(0.659)
lnGDP_IMP	0.397	0.412	0.415
	(0.454)	(0.454)	(0.455)
lnDist	-0.707***	-0.706***	-0.707***
	(0.034)	(0.034)	(0.034)
lang	0.394***	0.395***	0.394***
	(0.092)	(0.092)	(0.092)
lnDESI5_EXP	0.240		0.233
	(0.197)		(0.197)
lnDESI5_IMP		-0.257	-0.249
		(0.204)	(0.205)
Observations	5,383	5,383	5,383
R-squared	0.831	0.831	0.831

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The results presented for the subcategory *Other services* differs a bit from the results provided for the other two categories. In this category, *lnDESI5_EXP* was not significant like it was in the other two. Instead, *lnDESI3_EXP* was significant and had a positive coefficient. This implies that digital public services, as covered by DESI5, is not as important for the sectors included in the *Other services* category as it is for the sectors included in *Blue collar services* and *White collar services.* Furthermore, use of the internet, captured by DESI3, in the exporting country seems to be of higher importance for the sectors included in *Other services* and hence has a positive effect on exported services from these sectors. Similarly to the other two subcategories, the bilateral distance, *lnDist,* and a common language, *lang,* has the signs as predicted in section 5.3. Finally, our coefficient of determination, R-square, is relatively high considering the high number of explanatory variables inserted in our models. Hence, the same implications as for the other two categories *White collar services* and *Blue collar services.*

6.2. Robustness Measures

The following sections describe econometric issues that may arise and countermeasures undertaken in order to account for such. Furthermore, different estimation methods will be presented that have been tested as a robustness measure to the fixed effects OLS regression which have been used to generate the results described in 6.1. Lastly, alternatively specifications of the model that have been tested will be provided. Yotov et al. (2016) advanced trade policy guide published by the WTO, written by experts within the field of international economics, is primarily used when applying the structural gravity equation in this study. Additionally, common robustness checks that have been conducted in the guide are referred to, as their specifications apply to our specifications accordingly.

6.2.1. Econometric Issues

Robust standard errors should be used systematically when one applies the gravity equation because it often deals with observations that may be heterogeneous, and hence the assumption of homoscedastic error terms are likely to be violated (Bacchetta et al. 2016). The presence of heteroscedasticity will result in biased and inconsistent estimates when the gravity model is estimated in log-linear form with the OLS estimator (Yotov et al. 2016). Potential heteroscedasticity is consequently accounted for in this study by the systematic use of robust standard errors.

When looking at the correlation tables[11] one can see that the correlation between the explanatory variables are not high. If the correlation among the explanatory variables were deemed to be high it could cause the coefficients of the model to have an unsatisfactory level of precision and the model would suffer from multicollinearity (Doughert, 2016). Although, in a model with more than two explanatory variables, like the one presented in this study, multicollinearity could be caused by an approximately linear relationship between the explanatory variables which do not result in a high pairwise correlation among the variables (ibid). The effect of multicollinearity, in this case, is however not serious if the number of observations in the sample is large, which the sample used in this study can be deemed to be.

6.2.2. Fixed Effect versus Random Effect Method

When a model uses panel data two main approaches are known, the fixed effects regression and the random effects regression (Dougherty, 2016). The extensive literature existing on the application of the gravity model advocates for the use of the fixed effects regression but to be sure of which of these two approaches were most suitable for our model the Hausman test was used. The result of the Hausman test indicated that the fixed effects regression was a suitable approach to fit the model used in this study, in alignment with existing literature. Under the null-hypothesis for the Hausman test, the random effect model is appropriate, our p-values for the regression was at 0 percent indicating that the null could be rejected, and clarified us to apply the fixed effects model. Hence, this is the method that has been applied to generate the results described in section 6.1.

6.2.3. Instrumental Variables

A common problem when estimating the effect of trade policy, e.g. the effect of a free trade agreement, on trade with the gravity model is that the variable capturing trade policy might be endogenous. To account for the possibility of $lnDigit_{it}$ or $lnDigit_{jt}$ being endogenous in a similar manner, this has been tested for. Earlier attempts of using instrumental variables in the context of the gravity equation have, however, been mixed due to the lack of reliable instruments (Yotov et al., 2016). An instrument should be correlated, and preferably highly correlated, with the explanatory variable being instrumented (Dougherty, 2016). The instrument should not be correlated with the disturbance term and it should not in itself be an

[11] See the correlation tables in appendix 4.

explanatory variable (ibid). When running the Two-Stage Least Square regression separately for each empirical specification and each DESI-variable, the DESI-variable was instrumented with the other two dimensions of DESI that have not been presented in the results, dimension one and two of DESI. The reason for using these two is that, as described in section 6.2.5, they had no explanatory power in themselves. After running the Two-Stage Least Square regressions a test for endogeneity was performed. The null hypothesis that was tested for was whether the variables are exogenous. In all of the tests, within all of the three subcategories, both the Durbin score statistic, as well as the Wu-Hausman statistic, generated p-values over 5 per cent which indicates that the null hypothesis can be rejected, and the variables are hence exogenous. The results of these tests for the exporting country can be found in appendix 5. The results for the DESI-variables of the importing country showed similar results and will therefore not be presented.

6.2.4. Pseudo Poisson Maximum Likelihood

In the sample used in order to conduct this study, few zeros were recorded. As previously mentioned, there were only 21 zeros out of 22.572 observations which indicates that the problem of zero trade flows should not be a problem when estimating the gravity model in log-linear form with the OLS fixed effects method. However, in order to test if the zero trade flows recorded in subcategory *White collar services* was informative, the gravity equation for this subcategory has been estimated in a non-linear form with the PPML method as a robustness measure. With this estimation method, all of the five DESI-variables were tested for both the exporting and importing country in separate regressions. Regressions with a DESI-value for both the exporting and the importing country included in the same regression was also applied. However, neither of these regressions generated a significant coefficient for the variables $lnDigit_{it}$ nor $lnDigit_{jt}$.

6.2.5. Alternative Specifications Tested For

Besides the specification provided in 5.3, different specifications of the gravity model have been tested. A gravity model with two dummy variables capturing the effect of countries being a part of the euro area has been tested and dismissed. One of the dummies captured the effects of when one of the countries in the observations is a part of the euro area. The other dummy captured the effect if both countries in the observation are a part of the euro area.

This model did not improve the results that have been presented and could consequently be dismissed.

Besides having the described DESI-variables as a representation of digitalization, Human Capital (desi_2_hc) and Connectivity (desi_1_conn) have in addition been tested in the model as well. These variables did not yield significant results, for neither the exporting nor the importing country, and have therefore not been included or studied further in this essay.

A single indicator of the fourth dimension of DESI has consequently been tested as a measurement of digitalization. This indicator captured the percentage of enterprises with a high level of digital intensity, where a high level of digital intensity was defined as using seven out of twelve defined digital technologies. These digital technologies include, among other things, access to ICT specialist skills, and the use of Enterprise Resource Planning (ERP) software. This measurement of digitalization did not generate a significant result and will therefore not be presented further.

A model without the traditional gravity variables like GDP, bilateral distance, and common language have consequently been tested. In this model, fixed effects were instead included to capture the effects of the excluded variables. One exporter-sector-year dummy variable and one importer-sector-year dummy variable were included to capture the time-varying fixed effect. To capture time-invariant variables, such as the bilateral distance and common language, a country-pair dummy variable was included in addition to the other two. This model did not generate a preferable result because the variable capturing the level of digitization was also included in the time-varying fixed effects and was therefore omitted from the regression.

7. Discussion

The results presented in section 6.1 support to some extent the hypothesis presented in the introduction but did not yield as straightforward results as was expected. One reason might be the fact that digitalization and trade in services is already integrated to a large degree, as discussed in the introduction, and therefore clear results could not be distinguished. One would think that the fourth dimension of DESI, Integration of Digital Technology, would have a significant effect on traded services because it captures business digitalization and e-commerce which seems like a precondition for services being traded across borders in the modern society of today. This could paradoxically be the reason for it not yielding significant results because the level of business digitalization and e-commerce could be what distinguishes services suppliers from trading on the local market and services suppliers engaging in the export market. Hence, the level of business digitalization and e-commerce could be a source of productivity for firms which is a part of the export cutoff productivity, the productivity level which separates firms on the domestic market and firms extending their business to the exporting market. Because the dependent variable captures the value of exported services, all the firms contributing to this value might have a homogenous and high level of digitalization and therefore does not yield significant results. Another reason for the lack of significant results for the variables capturing digitalization might be that the EU is a homogenous group when it comes to digitalization, and that the level of digitalization does not differ enough between the countries to capture discrepancies when it comes to trade in services. The study could potentially generate better results if it was focused on countries with more distinct differences in the level of digitalization, potentially focusing on countries with larger differences in terms of development as a whole would generate clearer results. Then, the problem of the lack of reported and trustworthy data for services trade and digitalization would be more pronounced which could further affect the study conducted in this essay. The DESI is a rather new index which aims at capturing the level of digitalization which is a wide phenomenon that is, in turn, hard to assign a value to. The DESI, however, does this well but is fairly new and could potentially be a better estimation of digitalization after being utilized during more years.

As already mentioned a quantitative approach in measuring digitalization is still a new field of study, hence a scarce range of indices to compare diverging countries with each other was difficult to find and was hence an additional reason for choosing to limit the study to the DSMS and to better capture effects within the economically integrated area. In addition, a larger range of missing values could potentially have an effect on the results. Furthermore, a lower value of exported services, or even missing data could be explained by a higher locally consumed aggregation for sectoral consumption. Specialization in production directed to consumers in the same country could relate to services being closer to the consumer, thus explaining the higher rate of local consumption compared to traded goods. Continuously, data on services trade is difficult to collect because, as discussed in section 2.1, services are harder to record when they are traded across borders and this could also be a reason for missing data.

8. Conclusion

The aim of this essay was to answer the question regarding if the level of digitalization in the exporting and/or importing country had a significant effect on trade in services within the EU. The results of the study performed using data from 19 exporting countries and 28 importing OECD countries between 2015 and 2018, concluded that the third and fifth dimension of DESI, Use of Internet and Digital Public Services, in the exporting country had a positive and significant effect on exported services. The fourth dimension of DESI, Integration of Digital Technology, could however, be a precondition for firms engaging in the export market and hence have not generated significant results. The level of digitalization in the importing country has not generated significant results but does not have to be disregarded as a factor of importance for trade in services. Applying other specifications, however did not ameliorate our estimations, strengthening the argument for applying panel data and increasing the number of observations and capturing country-sectoral specific effects. However, facilitating the process in collecting data in the future as well as ameliorating the quality of data on services trade in terms of lessening the amount of missing data could enhance the results of similar future studies. In addition, this study identifies the need for an extension outside of the EU for the measurement of digitalization as it is an important factor of trade in the modern world but has not yet been explored to the extent it should be.

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10. Appendix

10.1. Appendix 1

Table A.1: Countries included in the sample.

Countries included in the sample			
Exporting countries:	Abbr:	Importing countries:	Abbr:
Austria	AUT	Austria	AUT
Belgium	BEL	Belgium	BEL
Czech Republic	CZE	Bulgaria	BGR
Denmark	DNK	Croatia	HRV
Estonia	EST	Cyprus	CYP
Finland	FIN	Czech Republic	CZE
France	FRA	Denmark	DNK
Germany	DEU	Estonia	EST
Greece	GRC	Finland	FIN
Hungary	HUN	France	FRA
Italy	ITA	Germany	DEU
Latvia	LVA	Greece	GRC
Lithuania	LTU	Hungary	HUN
Netherlands	NLD	Italy	ITA
Poland	POL	Latvia	LVA
Republic of Ireland	IRL	Lithuania	LTU
Republic of Slovenia	SVN	Luxembourg	LUX
Slovak Republic	SVK	Netherlands	NLD
Sweden	SWE	Poland	POL
		Portugal	PRT

Republic of Ireland	IRL
Republic of Malta	MLT
Republic of Slovenia	SVN
Romania	ROM
Slovak Republic	SVK
Spain	ESP
Sweden	SWE
United Kingdom	GBR

10.2 Appendix 2

Table A.2.1: Summary and structure of dimension 3 of DESI

Category	Subdimension	Weight of subdimension	Individual indicator	Weight of individual indicator
desi_3_ui	Internet Use	25%	People who never used the internet	50%
desi_3_ui	Internet Use	25%	Internet users	50%
desi_3_ui	Activities online	50%	News	16.6%
desi_3_ui	Activities online	50%	Music, videos & games	16.6%
desi_3_ui	Activities online	50%	Video on demand	16.6%
desi_3_ui	Activities online	50%	Video calls	16.6%
desi_3_ui	Activities online	50%	Social networks	16.6%
desi_3_ui	Activities online	50%	Doing and online course	16.6%
desi_3_ui	Transactions	25%	Banking	33%
desi_3_ui	Transactions	25%	Shopping	33%
desi_3_ui	Transactions	25%	Selling online	33%

Table A.2.2: Summary and structure of dimension 4 of DESI

Category	Subdimension	Weight of subdimension	Individual indicator	Weight of individual indicator
desi_4_idt	Business digitisation	60%	Electronic information sharing	16,70%
desi_4_idt	Business digitisation	60%	Social media	16,70%
desi_4_idt	Business digitisation	60%	Big data	33,30%
desi_4_idt	Business digitisation	60%	Cloud	33,30%
desi_4_idt	e-Commerce	40%	SMEs selling online	33%
desi_4_idt	e-Commerce	40%	e-Commerce turnover	33%
desi_4_idt	e-Commerce	40%	Selling online cross-boarder	33%

Table A.2.3: Summary and structure of dimension 5 of DESI

Category	Subdimension	Weight of subdimension	Individual indicator	Weight of individual indicator
desi_5_dps	e-Government	100%	e-Government users	20%
desi_5_dps	e-Government	100%	Pre-filled forms	20%
desi_5_dps	e-Government	100%	Online service completion	20%
desi_5_dps	e-Government	100%	Digital public services for businesses	20%
desi_5_dps	e-Government	100%	Open data	20%

10.3. Appendix 3

Table A.3.1: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.306	1.000				
(3) lnGDP_IMP	0.378	-0.031	1.000			
(4) lnDist	-0.182	-0.014	-0.101	1.000		
(5) comlang_off	0.181	0.109	0.048	-0.288	1.000	
(6) lnDESI3_EXP	-0.024	0.045	0.003	0.024	0.006	1.000

Table A.3.2: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.306	1.000				
(3) lnGDP_IMP	0.378	-0.031	1.000			
(4) lnDist	-0.182	-0.014	-0.101	1.000		
(5) comlang_off	0.181	0.109	0.048	-0.288	1.000	
(6) lnDESI3_IMP	0.182	0.014	0.093	-0.161	0.102	1.000

Table A.3.3: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lnServices_EXP_V	1.000						
(2) lnGDP_EXP	0.374	1.000					
(3) lnGDP_IMP	0.427	-0.031	1.000				
(4) lnDist	-0.210	-0.014	-0.101	1.000			
(5) comlang_off	0.190	0.109	0.048	-0.288	1.000		
(6) lnDESI3_EXP	0.032	0.045	0.003	0.024	0.006	1.000	
(7) lnDESI3_IMP	0.159	0.014	0.093	-0.161	0.102	0.011	1.000

Table A.3.4: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.306	1.000				
(3) lnGDP_IMP	0.378	-0.031	1.000			
(4) lnDist	-0.182	-0.014	-0.101	1.000		
(5) comlang_off	0.181	0.109	0.048	-0.288	1.000	
(6) lnDESI4_EXP	0.045	0.192	0.008	0.024	0.101	1.000

Table A.3.5: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.306	1.000				
(3) lnGDP_IMP	0.378	-0.031	1.000			
(4) lnDist	-0.182	-0.014	-0.101	1.000		
(5) comlang_off	0.181	0.109	0.048	-0.288	1.000	
(6) lnDESI4_IMP	0.171	0.007	0.233	-0.047	0.071	1.000

Table A.3.6: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

/ariables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1) lnServices_EXP_V	1.000						
2) lnGDP_EXP	0.306	1.000					
3) lnGDP_IMP	0.378	-0.031	1.000				
4) lnDist	-0.182	-0.014	-0.101	1.000			
5) comlang_off	0.181	0.109	0.048	-0.288	1.000		
6) lnDESI4_EXP	0.045	0.192	0.008	0.024	0.101	1.000	
7) lnDESI4_IMP	0.171	0.007	0.233	-0.047	0.071	0.046	1.000

Table A.3.7: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.306	1.000				
(3) lnGDP_IMP	0.378	-0.031	1.000			
(4) lnDist	-0.182	-0.014	-0.101	1.000		
(5) comlang_off	0.181	0.109	0.048	-0.288	1.000	
(6) lnDESI5_EXP	0.032	-0.030	0.016	0.035	0.037	1.000

Table A.3.8: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.306	1.000				
(3) lnGDP_IMP	0.378	-0.031	1.000			
(4) lnDist	-0.182	-0.014	-0.101	1.000		
(5) comlang_off	0.181	0.109	0.048	-0.288	1.000	
(6) lnDESI5_IMP	0.100	0.017	0.039	0.053	0.030	1.000

Table A.3.9: A display of the pairwise correlation coefficient between the variables in the subcategory *Blue collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lnServices_EXP_V	1.000						
(2) lnGDP_EXP	0.306	1.000					
(3) lnGDP_IMP	0.378	-0.031	1.000				
(4) lnDist	-0.182	-0.014	-0.101	1.000			
(5) comlang_off	0.181	0.109	0.048	-0.288	1.000		
(6) lnDESI5_EXP	0.032	-0.030	0.016	0.035	0.037	1.000	
(7) lnDESI5_IMP	0.100	0.017	0.039	0.053	0.030	0.056	1.000

Table A.3.10: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

/ariables	(1)	(2)	(3)	(4)	(5)	(6)
1) lnServices_EXP_V	1.000					
2) lnGDP_EXP	0.411	1.000				
3) lnGDP_IMP	0.377	-0.031	1.000			
4) lnDist	-0.178	-0.014	-0.101	1.000		
5) comlang_off	0.212	0.109	0.048	-0.288	1.000	
6) lnDESI3_EXP	0.017	0.045	0.003	0.024	0.006	1.000

Table A.3.11: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

/ariables	(1)	(2)	(3)	(4)	(5)	(6)
1) lnServices_EXP_V	1.000					
2) lnGDP_EXP	0.411	1.000				
3) lnGDP_IMP	0.377	-0.031	1.000			
4) lnDist	-0.178	-0.014	-0.101	1.000		
5) comlang_off	0.212	0.109	0.048	-0.288	1.000	
6) lnDESI3_IMP	0.147	0.014	0.093	-0.161	0.102	1.000

Table A.3.12: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lnServices_EXP_V	1.000						
(2) lnGDP_EXP	0.411	1.000					
(3) lnGDP_IMP	0.377	-0.031	1.000				
(4) lnDist	-0.178	-0.014	-0.101	1.000			
(5) comlang_off	0.212	0.109	0.048	-0.288	1.000		
(6) lnDESI3_EXP	0.017	0.045	0.003	0.024	0.006	1.000	
(7) lnDESI3_IMP	0.147	0.014	0.093	-0.161	0.102	0.011	1.000

Table A.3.13: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.411	1.000				
(3) lnGDP_IMP	0.377	-0.031	1.000			
(4) lnDist	-0.178	-0.014	-0.101	1.000		
(5) comlang_off	0.212	0.109	0.048	-0.288	1.000	
(6) lnDESI4_EXP	0.140	0.192	0.008	0.024	0.101	1.000

Table A.3.14: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.411	1.000				
(3) lnGDP_IMP	0.377	-0.031	1.000			
(4) lnDist	-0.178	-0.014	-0.101	1.000		
(5) comlang_off	0.212	0.109	0.048	-0.288	1.000	
(6) lnDESI4_IMP	0.152	0.007	0.233	-0.047	0.071	1.000

Table A.3.15: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lnServices_EXP_V	1.000						
(2) lnGDP_EXP	0.411	1.000					
(3) lnGDP_IMP	0.377	-0.031	1.000				
(4) lnDist	-0.178	-0.014	-0.101	1.000			
(5) comlang_off	0.212	0.109	0.048	-0.288	1.000		
(6) lnDESI4_EXP	0.140	0.192	0.008	0.024	0.101	1.000	
(7) lnDESI4_IMP	0.152	0.007	0.233	-0.047	0.071	0.046	1.000

Table A.3.16: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.411	1.000				
(3) lnGDP_IMP	0.377	-0.031	1.000			
(4) lnDist	-0.178	-0.014	-0.101	1.000		
(5) comlang_off	0.212	0.109	0.048	-0.288	1.000	
(6) lnDESI5_EXP	0.096	-0.030	0.016	0.035	0.037	1.000

Table A.3.17: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.411	1.000				
(3) lnGDP_IMP	0.377	-0.031	1.000			
(4) lnDist	-0.178	-0.014	-0.101	1.000		
(5) comlang_off	0.212	0.109	0.048	-0.288	1.000	
(6) lnDESI5_IMP	0.054	0.017	0.039	0.053	0.030	1.000

Table A.3.18: A display of the pairwise correlation coefficient between the variables in the subcategory *White collar services*.

Pairwise correlations

/ariables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1) lnServices_EXP_V	1.000						
2) lnGDP_EXP	0.411	1.000					
3) lnGDP_IMP	0.377	-0.031	1.000				
4) lnDist	-0.178	-0.014	-0.101	1.000			
5) comlang_off	0.212	0.109	0.048	-0.288	1.000		
6) lnDESI5_EXP	0.096	-0.030	0.016	0.035	0.037	1.000	
7) lnDESI5_IMP	0.054	0.017	0.039	0.053	0.030	0.056	1.000

Table A.3.19: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

/ariables	(1)	(2)	(3)	(4)	(5)	(6)
1) lnServices_EXP_V	1.000					
2) lnGDP_EXP	0.374	1.000				
3) lnGDP_IMP	0.427	-0.031	1.000			
4) lnDist	-0.210	-0.014	-0.101	1.000		
5) comlang_off	0.190	0.109	0.048	-0.288	1.000	
6) lnDESI3_EXP	0.032	0.045	0.003	0.024	0.006	1.000

Table A.3.20: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

/ariables	(1)	(2)	(3)	(4)	(5)	(6)
1) lnServices_EXP_V	1.000					
2) lnGDP_EXP	0.374	1.000				
3) lnGDP_IMP	0.427	-0.031	1.000			
4) lnDist	-0.210	-0.014	-0.101	1.000		
5) comlang_off	0.190	0.109	0.048	-0.288	1.000	
6) lnDESI3_IMP	0.159	0.014	0.093	-0.161	0.102	1.000

Table A.3.21: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lnServices_EXP_V	1.000						
(2) lnGDP_EXP	0.374	1.000					
(3) lnGDP_IMP	0.427	-0.031	1.000				
(4) lnDist	-0.210	-0.014	-0.101	1.000			
(5) comlang_off	0.190	0.109	0.048	-0.288	1.000		
(6) lnDESI3_EXP	0.032	0.045	0.003	0.024	0.006	1.000	
(7) lnDESI3_IMP	0.159	0.014	0.093	-0.161	0.102	0.011	1.000

Table A.3.22: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.374	1.000				
(3) lnGDP_IMP	0.427	-0.031	1.000			
(4) lnDist	-0.210	-0.014	-0.101	1.000		
(5) comlang_off	0.190	0.109	0.048	-0.288	1.000	
(6) lnDESI4_EXP	0.072	0.192	0.008	0.024	0.101	1.000

Table A.3.23: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.374	1.000				
(3) lnGDP_IMP	0.427	-0.031	1.000			
(4) lnDist	-0.210	-0.014	-0.101	1.000		
(5) comlang_off	0.190	0.109	0.048	-0.288	1.000	
(6) lnDESI4_IMP	0.162	0.007	0.233	-0.047	0.071	1.000

Table A.3.24: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1) lnServices_EXP_V	1.000						
2) lnGDP_EXP	0.374	1.000					
3) lnGDP_IMP	0.427	-0.031	1.000				
4) lnDist	-0.210	-0.014	-0.101	1.000			
5) comlang_off	0.190	0.109	0.048	-0.288	1.000		
6) lnDESI4_EXP	0.072	0.192	0.008	0.024	0.101	1.000	
7) lnDESI4_IMP	0.162	0.007	0.233	-0.047	0.071	0.046	1.000

Table A.3.25: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.374	1.000				
(3) lnGDP_IMP	0.427	-0.031	1.000			
(4) lnDist	-0.210	-0.014	-0.101	1.000		
(5) comlang_off	0.190	0.109	0.048	-0.288	1.000	
(6) lnDESI5_EXP	0.007	-0.030	0.016	0.035	0.037	1.000

Table A.3.26: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lnServices_EXP_V	1.000					
(2) lnGDP_EXP	0.374	1.000				
(3) lnGDP_IMP	0.427	-0.031	1.000			
(4) lnDist	-0.210	-0.014	-0.101	1.000		
(5) comlang_off	0.190	0.109	0.048	-0.288	1.000	
(6) lnDESI5_IMP	0.088	0.017	0.039	0.053	0.030	1.000

Table A.3.27: A display of the pairwise correlation coefficient between the variables in the subcategory *Other services*.

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lnServices_EXP_V	1.000						
(2) lnGDP_EXP	0.374	1.000					
(3) lnGDP_IMP	0.427	-0.031	1.000				
(4) lnDist	-0.210	-0.014	-0.101	1.000			
(5) comlang_off	0.190	0.109	0.048	-0.288	1.000		
(6) lnDESI5_EXP	0.007	-0.030	0.016	0.035	0.037	1.000	
(7) lnDESI5_IMP	0.088	0.017	0.039	0.053	0.030	0.056	1.000

10.4 Appendix 4

Table A.4.1: The test for exogenous variables in subcategory *Blue collar services* where *lnDESI3_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = .366609 (p = 0.5449)
Robust regression F (1,6050) = .355322 (p = 0.5511)

Table A.4.2: The test for exogenous variables in subcategory *Blue collar services* where *lnDESI4_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = .010309 (p = 0.9191)
Robust regression F (1,6050) = .009989 (p = 0.9204)

Table A.4.3: The test for exogenous variables in subcategory *Blue collar services* where *lnDESI5_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = .711216 (p = 0.3990)
Robust regression F (1,6050) = .689249 (p = 0.4065)

Table A.4.4: The test for exogenous variables in subcategory *White collar services* where *lnDESI3_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = .512215 (p = 0.4742)
Robust regression F (1,6480) = .497526 (p = 0.4806)

Table A.4.5: The test for exogenous variables in subcategory *White collar services* where *lnDESI4_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = 3.46097 (p = 0.0628)
Robust regression F (1,6480) = 3.36617 (p = 0.0666)

Table A.4.6: The test for exogenous variables in subcategory *White collar services* where *lnDESI5_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = .486727 (p = 0.4854)
Robust regression F (1,6480) = .472973 (p = 0.4916)

Table A.4.7: The test for exogenous variables in subcategory *Other services* where *lnDESI3_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = 1.12748 (p = 0.2883)
Robust regression F (1,5236) = 1.09755 (p = 0.2949)

Table A.4.8: The test for exogenous variables in subcategory *Other services* where *lnDESI4_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = .807947 (p = 0.3687)
Robust regression F (1,5236) = .786149 (p = 0.3753)

Table A.4.9: The test for exogenous variables in subcategory *Other services* where *lnDESI5_Exp* is instrumented.

Tests of endogeneity
Ho: variables are exogenous

Robust score chi2(1) = .035068 (p = 0.8515)
Robust regression F (1,5236) = .034111 (p = 0.8535)