UK IN A CHANGING EUROPE

BREXIT AND SERVICES TRADE: NEW EVIDENCE FROM SYNTHETIC DIFF-IN-DIFF APPROACH

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UKICE working paper 08/2021

ABSTRACT

This paper examines the causal impact of the Brexit referendum on services exports of the UK and other major services exporters. We find long-run, contrasting effects on exports of services in the UK and Ireland in particular. While the UK experienced an annual decline in its services exports by 5.7% on average in 2016-2019, Ireland has gained during the same period 14.8% per year. There is large heterogeneity in sector effects, which highlights the most affected services exports in Transport, Travel, Insurance, Telecom and IP sectors. Adopting a novel method of synthetic difference in difference (SDID), we show that SDID outperforms more traditional difference in difference and synthetic control methods and hence is better placed to understand changes in UK services trade.

1. INTRODUCTION

The Brexit vote to leave the EU on 23 June 2016 marked the beginning of ending the forty-five years close economic integration between the UK and the EU. The crack of the EU's hyper-globalisation project could mark significant changes in the relationship between the UK, the EU and the world economy. As such disintegration happens so rarely, it is important to understand its implications. So far, beyond aggregate assessments and headlines however, the precise economic impacts of Brexit are still rare in terms of where impacts have been felt, by which sectors and when. Answering these questions would help assess the real costs of Brexit (Sampson, 2017).

This paper focuses on analysing the causal effect of Brexit Referendum on UK's services trade. Taking advantage of the unexpectedness of the Brexit vote result, we treat the 2016 Referendum as a quasi-experiment. Our analysis estimates the impact of the uncertainty over the period between 2016 and 2019 on the services exports of the UK, in comparison to that of other major services exporters. We also examine the heterogeneous effects that different sectors have experienced.

The quality of such an estimation hinges on the identification of the causal impact. Indeed, considerable challenges exist in quantifying the magnitude of the impact and modelling the mechanisms. There are largely three types of approaches adopted for this kind of assessment. First, some studies estimate the effect of Brexit by estimating the economic consequences of UK joining the EU (Crafts, 2016; Campos et al., 2019; Lawless & Morgenroth, 2019). The estimates are used in a symmetrical equivalent way to infer the effect of withdrawing from EU. These are referred to as case studies approach of joining the European Union in Sampson (2017). However, it would be inappropriate to assume all the benefits of joining the EU would be eradicated by withdrawing from it (Sampson, 2017), even though it helps to understand the areas of losses due to the disintegration.

Second, several studies rely on general equilibrium models to simulate Brexit effects at macro level (Ebell & Warren, 2016; Dhingra et al., 2017; Jackson & Shepotylo, 2018; Steinberg, 2019). They were particularly useful in the early days before any real effects could be observed. General equilibrium modelling prescribes the ways in which Brexit will affect trade costs between related partners. While being able to account for known effects, these approaches may miss unknown channels to the model, for example multinational enterprises' cross-border business relocation. Also, focusing at the macroeconomic level, these approaches generally ignore the heterogeneity in sectors, and by extension agglomeration effects (Sampson, 2017). For the UK services sector, the effect is expected to be large.

The third and a more widely adopted approach in recent literature is a reduced form estimation for the Brexit impact using a quasi-experiment approach, which relies on appropriate econometric techniques

for identification. The clear advantage of this approach lies in its capability to capture the effect of a policy exposure or change in policy on the economy that is likely to exert influence through multiple channels. In the case of Brexit, the uncertainty during the Brexit period was not just around UK's future trade policy, but a mixture of political, economic and social uncertainty. Various sources of uncertainty imply that the channels through which uncertainty might have affected the economy are less than clear. The deteriorated future trade terms inflated trade costs but may not be the only threat. Also, restricted access to skills and capital are also concerns (Deardorff and Stern, 2005; Portes and Forte, 2017). Further, the potential loss of freedom of mobility has serious implications on business travel, particularly for foreign multinationals in need of moving staff around offices in different countries while they export a lion's share of UK services (Lowe, 2021). More generally, the eroded household spending and pessimistic views of the economic outlooks affect not only exporting firms but also firms that do not rely on sales to the EU (Bank of England, 2019). Hence, firms might be motivated to move their businesses, whole or part, away from the UK. For this reason, it is important to take account of this mechanism of Brexit effect, beyond modelling direct reduction of businesses' investment and sales.

However, given that the causal inferences are hard to obtain in the absence of exogenous variations, there are different methodological approaches to connect observed data with unobserved counterfactuals. The differences of the estimation methods may lead to different estimates of the causal effect and the possible conclusions to be drawn. This itself warrants studies to investigate and compare. The most popular methods so far include Difference in Differences (DID) methods due to Card and Krueger (1994) and Abadie (2005) and applied in the Brexit case by Fernandes and Winters (2021), Synthetic Control (SC) method due to Abadie and Gardeazabal (2003) and applied in Breinlich et al (2020) and Douch and Edwards (2021). First of all, DID approach is best taken when a substantial number of units are exposed to a policy intervention. When a "parallel trends" assumption can be satisfied, then one could adequately control for selectivity of the units in a panel data setting, i.e. accounting for unit-specific and time-specific fixed effects. The shortcoming is that it does rely on the "parallel trends" assumption. In contrast, SC approach is more appropriate when only a single unit experiences the policy intervention and therefore it is not possible to construct parallel trends within observed data. It hence reconstructs such parallel trends by re-weighting the units to match the pre-intervention trends. The drawback of SC is that it is unable to draw inferences.

Building on these, the recent contribution by Arkhangelsky et al (2019) proposes a new method, namely Synthetic Difference in Differences (SDID), to re-weight and match pre-intervention trends that relaxes from the reliance on parallel trend type assumptions, and at the same time allows additive

unit-level shifts, and draws valid large-panel inference. The authors show that SDID estimators are consistent, asymptotically normal, and more efficient relative to SC and DID methods.

In this light, this paper seeks new evidence on the effect of Brexit by applying this new methodology to assess the Brexit effect on the overall services trade and heterogeneity among different sectors. The advantages of SDID approach relative to the standard difference in difference are as follows. It makes the comparison of UK trade with the counterfactual more localized - it gives more weight to units that are similar to the UK and more weight to periods that are similar to the post-Brexit. Essentially, it answers the question how the services exports of the UK changed after the Brexit referendum, rather than what is the impact of the Brexit for the whole sample. The use of weights in the difference-in-difference estimator allows us to compare UK services exports with the exports of countries that are similar to UK rather than with all countries, which makes the estimation more local and robust. In particular, the parallel trend assumption is likely to hold for SDID even if it is violated for the standard DID. It may also improve the precision of the estimation. At the same time, it has advantages over the synthetic control method because it allows us to make statistical inferences about the estimated coefficients. Synthetic control method also use weights, as the SDID does, but it does not include fixed effects and does not balance the results using the time weights. As such, SDID is robust to the violation of the parallel trend assumptions, and it optimally selects weights for the synthetic control units and time periods and produces an estimate with smaller standard errors.

We seek to make three contributions. First, we provide new evidence on the effect of Brexit in the line of enquiry drawing on the most recent methodological improvement. Our work builds on and complements the recent efforts including Dinghra et al (2017), Mulabdic et al (2017), Bloom et al (2019), Born et al (2019), Douch and Edwards (2021) and Fernandes and Winters (2021), who have adopted varied approaches. While these studies find negative effect of Brexit on the UK trade, the magnitudes estimated vary considerably and they primarily focus on trade in goods. Our analysis shows that the methodologies do matter for the specific estimate of the magnitude of Brexit impact. We demonstrate the advantages of the SDID method relative to SC and a number of DID approaches, including the modification of DID suggested by Doudchenko & Imbens (2016) and Ferman & Pinto (2019).

Our second contribution lies in the novel evidence of the Brexit effect on services trade which is remarkably limited in comparison to the abundant evidence on trade in goods. As Lawless (2018) puts it, services trade has no clear fall-back position (from the deep integration) so setting parameters of how large trade impacts could be is less obvious. Services industries generate two-third of the world's GDP. The UK is the second-largest service market in the world only after the US. Its key services

sectors, especially professional, business and financial services sectors, contribute significantly to the UK economy in terms of output, value-added generation and job creation, as well as helping maintaining UK's trade balances by a trade surplus in services to compensate the large trade deficit in goods (Douch, Du, Nduka & Shepotylo, 2020).

All these highlight that UK's disintegration from custom union and single market may have more significant impacts on services than goods in proportion, because of the distinct nature of international trade in services and the ways in which they are delivered. Services are often intangible, invisible, perishable, and the delivery of the service is usually contemporaneous with its consumption by the service recipient. There is generally a need for proximity between the producer and the consumer, implying that one party must move across a border to make the international transaction. Barriers to proximity between suppliers and consumers across borders, combined with restrictions to information flow, could potentially decimate international trading capability in services. This is particularly the case for services delivered in the mode of Cross-border (Mode 1), Presence of the natural persons (Mode 4) and possibly also for Consumption abroad (Mode 2) according to the WTO General Agreement on Trade in Services (GATS) modes of supply international services. It may also affect embodied services inputs, sometimes called "mode 5" services trade, which are manufacturing firms services delivery cross border and often high value-adding (Borchert, 2016).

In addition, it is generally more challenging to liberalize services trade than goods. The deep integration of the UK in the services networks in the EU gives reasons to expect a large fall when services restrictions are put in place as a result of the breakup. Indeed, Mulabdic et al. (2017) predict a decline in UK's bilateral trade in services with the EU to fall at least 16% in the best scenario. Hence, the UK's exit from the EU could mean that UK trade in services face more significant changes in their trading relationship than goods do.

Third, we estimate the heterogenous effect of the Brexit on different types of services, which bring new evidence of the uneven impact on heterogenous sectors. The paucity of the research on services trade is not only due to the lack of sectoral and detailed bilateral data, but also because of the general lack of research on services trade and its policy (Buckley & Majumdar, 2018; Mudambi, 2008). It is particularly challenging to study services because of the large heterogeneity of sectoral characteristics. Davies and Studnicka (2018) estimate the stock market return using price movement data and highlight the different expectations of different firms experiencing the same Brexit shock. The large variations of the impacts we identify among different service types show that it is important to look into sectoral differences in order to obtain a close picture. This helps to understand further the varying degree of the impact on different EU member countries stress the heterogeneity among the related

parties within the EU trade partners. For example, despite of compelling evidence provided in Douch and Edwards (2021) they are unable to analyze bilateral trade in services and hence couldn't separate the trade between EU and non-EU, let alone the variations of the effects among EU countries.

The structure of the paper is as follows. Section 2 provides a brief account of the context. Section 3 discusses data and stylized facts on the services exports. Section 3 outlines the methodology, followed by results in Section 5. Section 6 provides further discussion of findings and Section 7 concludes.

2. BACKGROUND

A unique background of the analysis on the impact of the economic disintegration in the case of Brexit is that Britain did not leave the EU right away. What followed the 2016 Brexit Referendum was a long four-and-half-year period of uncertainty about how the UK would leave the EU.

Up to 29 March 2017, the uncertainty facing the UK services sector was primarily about when the UK government would formally trigger the Article 50 and start the exit process. Throughout the next two years and a half, there was continuous high level of uncertainty of the extension of the Article 50, due to uncertainties regarding the precise form Brexit would take. This political uncertainty was reduced with the election victory of the UK Prime Minister Boris Johnson at the end of 2019, which set course of its formal withdraw from the EU single market and customs union on 31 January 2020, but the economic uncertainties with regards to the future relationship with the EU continued. Despite of the excessive economic uncertainty throughout this period, it continued during the Brexit transition beyond this point as the UK and the EU sought to agree the precise terms of the Brexit trade deal between the two parties.

The final agreement was reached on 24 December 2020. As a result, the prolonged period of persistent and widespread uncertainty in many aspects of the EU-UK relationships caused harms to the UK economy as a whole, by dampening investment, weakening business financial conditions and household spending (Bank of England, 2019).

3. DATA AND SUMMARY STATISTICS

Services trade data are not as readily available as data for goods trade. The inherent complexity of recording services, especially when delivered in digital form (OECD, 2019) results in only a handful of countries publishing (some) bilateral trade in services statistics, with asymmetric reporting by partner countries and service categories. This has made the analysis of the services trade challenging. Only in

recent years, to mitigate these problems, the OECD and the WTO have developed a global dataset of coherent bilateral trade in services statistics according to the main services categories, building upon the WTO-UNCTAD Trade in Services Database. In this paper, we draw on the latest edition of the OECD-WTO Balanced Trade in Services dataset (BaTIS), which is currently the most comprehensive, consistent and balanced data on trade in services. The advantages of this database lie in the fact that efforts have been made to resolve the unbalanced and missing services trade flows in the data, which enhances the data quality considerably (Liberatore and Wettstein, 2021). In this analysis we choose the period of 2012-2019, to deliberately exclude the financial crisis period of 2008-2009 and the European debt crisis in 2010-2011. The included period allows us to compare the period of 2016-2019 in the post-Brexit Referendum with the previous four-year period.

3.1 Overall summary statistics

Table 1 Panel A presents summary statistics of the services exports for the major services exporters in 2019 and the changes in market shares among the exporters in 2005-2019. The UK is the second largest services exporter, with 419.1 bln USD of exports in 2019. However, the UK's market share has reduced before Brexit from 8.86% in 2005 to 6.99% in 2019. Ireland, on the other hand, has been rapidly increasing its market share from 2.16% in 205 to 3.48% in 2019, reaching the all-time high 208.6 bln USD of exports in 2019. Another EU country which performed well is the Netherlands, who exported 286.2 bln USD of services in 2019, increasing its market share from 3.98% to 4.78% in 2019. During the same period, the decline in the market share was common for the other major EU economies, including Germany, France, Spain, and Italy, whose combined market share declined from 18.3% in 2005 to 14.97% in 2019.

The structural changes in the global services exports market were not only geographical, but also sectoral. Table 1 Panel B depicts a decline of the traditional services sectors, such as Transport and Travel, whose combined share in the total services exports declined from 48.77% in 2005 to 41.97% in 2019. The share of Insurance and Finance has been stagnant during the period, with the share in total staying relatively stable around 10%. At the same time, Intellectual Property, Telecom and IT, and Business services have been rising rapidly. It is not surprising that Ireland, who is specialized in IT and Business services, have been rapidly growing its trade in these services at an even faster pace than the global average. The Netherlands strongly benefited from its specialization in Intellectual Property. The UK has been also very successful in developing its business services exports but failed to keep up with the global trend in Telecom and IT and Intellectual Property services. At the same time, the UK other

sectors of comparative advantage – Insurance and Finance – were developing slowly in the UK and globally.

Table 1: Top 20 services exporters and sector level statistics

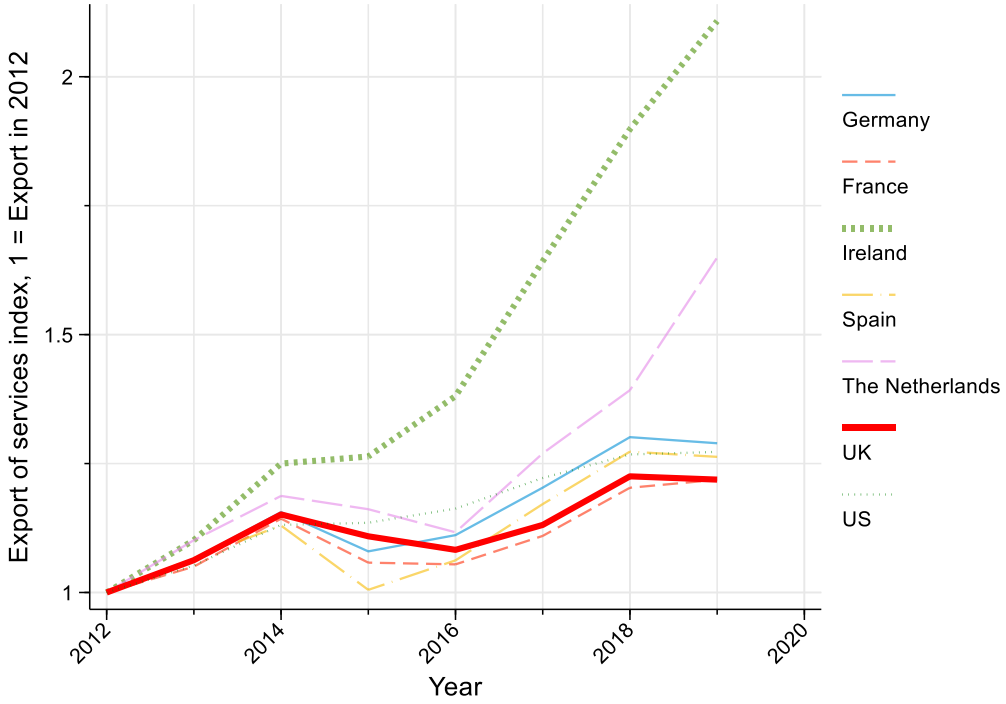
Country Name	Services export in 2019, bln USD	Share of global export of services, %		
		2005	2010	2019
A: By country:				
USA	895.6	14.89	15.25	14.95
United Kingdom	419.1	8.86	7.61	6.99
Germany	350.5	6.45	6.19	5.85
Netherlands	286.2	3.98	3.99	4.78
France	266.4	5.39	4.78	4.44
China	251.3	3.32	3.99	4.19
Ireland	208.6	2.16	2.2	3.48
Japan	191.6	3.52	3.17	3.2
Singapore	171.5	1.91	2.34	2.86
Hong Kong	153.4	1.97	2.29	2.56
Spain	150.7	3.29	2.74	2.51
India	147.1	1.38	2.07	2.45
Switzerland	145.9	2.75	2.77	2.43
Italy	129.9	3.2	2.57	2.17
Belgium	104.5	1.92	2.06	1.74
Canada	91.9	2.06	1.82	1.53
Bermuda	91.7	1.1	1.57	1.53
Republic of Korea	90.4	1.53	1.73	1.51
Luxembourg	87.8	1.28	1.37	1.46
Australia	74.6	1.25	1.37	1.25
B: By services sector:				
Travel (SD)	1408	25.63	23.48	23.49
Transport (SC)	1108	23.14	22.55	18.48
Business (SJ)	1409	19.60	20.94	23.51
Intellectual Property (SH)	447	6.81	6.81	7.45
Financial (SG)	415	6.78	7.15	6.93
Telecom (SI)	521	5.81	6.66	8.70
Construction (SE)	108	1.79	2.14	1.81
Insurance (SF)	176	3.15	3.55	2.93
Manufacturing (SA)	117	2.35	2.13	1.95
Cultural (SK)	86	1.19	1.24	1.44
Maintenance and Repair (SB)	104	1.15	1.15	1.74

Source: BaTIS.

3.2 Comparable statistics of the UK with its peers

To understand better the UK performance of services trade, we further draw statistics of the UK with its peers. Figure 1 focuses on growth performance in exported services of the UK since 2012 next to France, Germany, the Netherlands, Ireland, Spain and the US. It is noticeable that the UK was on par with other growing services exporters in 2012 By 2013, it has been outperformed by Ireland and the Netherlands in the global competition for services trade expansion, when it was surpassed (in relative terms). The differences in services export growth between Ireland and the UK have been amplified and reinforced since 2016. A slowing trend between 2014 and 2016 followed by growth period between 2016 and 2018 were shared by most countries. The exception is Ireland that has shown a growing trend, especially at a rate of 11.2% per year over 2015-2019. However, over the period the UK appeared to have lost its headway, most apparently after 2016. By the end of 2019, Irish services exports were 68.6% higher than in 2014, while the UK's services exports grew only by 5.8%. The UK's growth has also been outperformed by Germany, the US, and the Netherlands.

Figure 1: International comparison of the UK services export (OECD BATIS 2019)



What may explain such stunning success of Ireland as a services exporter, next to the rather moderate performance of the UK especially after 2015? A reasonable hypothesis is that the UK's Brexit referendum might have triggered diversion of services from the UK to Ireland, which we will test in this paper. The fact that the decoupling of the Ireland services export growth from the UK has started in 2015 does not contradict this hypothesis, since the European Referendum Bill was unveiled in the

Queen's speech on May 27, 2015, after the Conservative party won a general election with the promise to renegotiate the UK's relationship with the EU and give the British people the "simple choice" between staying in the EU or leaving the EU. These events have generated substantial trade policy uncertainty, which has an important role in determining services trade flows (Graziano et al 2020) . Moreover, as the graph shows, the UK trend has continued to deteriorate further in 2016, while the other EU countries have started to grow. At the same time, export of service from US and Ireland has been growing for the whole period in 2015-2019, which reflects insulation of the US economy from the EU shocks and strong ties of the Irish economy with the US corporate giants. Importantly, the second best-performing EU country since 2016 was the Netherlands, whose export of services has skyrocketed since 2016.

4. IDENTIFICATION

The empirical analysis involves modeling the effect of the Brexit referendum, which we refer to as the policy or treatment, on the bilateral services exports of the UK since 2016. Our variables of interest are bilateral services exports from country i to country j at time t, denoted as y_(ij,t); and aggregate services exports from country i at time t, Y_it . Unlike several related papers that exploit the Brexit as a natural experiment (Crowley et al., 2018), we argue that Brexit is far from the randomized policy experiment, neither in terms of affected units nor in terms of the timing. There was a long build up in favor of the policy change caused by the popular discontent with the economic performance of the UK since 2008 (Sampson, 2017, Fetzer, 2019). To construct the measure of the Brexit impact with causal interpretation, we focus on the modelling the unobserved counterfactual with observed data using the SDID estimator (Archangelskiy et al. 2019).

4.1 SYNTHETIC DIFFERENCE IN DIFFERENCE (SDID) ESTIMATOR

SDID combines advantages of the synthetic control method (SC) (Abadie and Gardeazabal, 2003; Abadie, 2020) and the **difference** in difference (DID) method. SC usually performs well when the number of treated units is small and there are no or few comparable non-treated units. At the same time, it is poorly suited to draw statistical inferences about the properties of the estimator. DID, on the other hand, allows to estimate the treatment effect within a standard linear model with two-way fixed effects, but requires the treated and non-treated units to follow parallel pre-trends. DID works well when the number of treated units is large. Further, SDID relaxes the parallel trend requirements, works robustly

when the number of treated units is small, and more importantly allows drawing statistical inferences within the usual regression framework. It also typically produces estimates with smaller standard errors than DID, because weights emphasize units and time periods which are more similar to the treated units (Arkhangelsky et al, 2019). In other words, SDID is a robust and efficient method of estimating the treatment effects in settings where the conventional estimators perform poorly.

There are other works that are related to SDID advances. Doudchenko & Imbens (2016) developed a generalization of SC and Ferman & Pinto (2019) derived inference for DID with few treated and many control units. Arkhangelsky et al. (2019) pointed out that computationally these two methods are identical and denoted it as DIFP estimator. We compare the performance of DIFP estimator against the other methods.

SDID is well suited to estimate the casual Brexit effect on services exports, since the treatment occurred simultaneously for all treated units, the number of the treated units is small (1 unit for aggregate trade flows and 201 units for bilateral trade flows). It may be argued that the treatment is primarily applied to the bilateral trade of the UK with its EU partners rather than with the rest of the world. It is a plausible hypothesis which we explore as well.

More formally, we observe services trade for T period for a balanced panel of IJ uints. Without loss of generality, first IJ_c units are never exposed to a treatment. The remaining $IJ_{tr} = IJ - IJ_c$ units are exposed to the treatment after time T_{pre}. We assume that the data is generated by the latent factor model (Xu, 2017)

$$\boldsymbol{y} = \boldsymbol{L} + \boldsymbol{B} \circ \boldsymbol{\tau} + \boldsymbol{E}$$

where τ is a vector of potentially heterogenous treatment effects, B is the matrix of treatment indicators, which follows a so-called block assignment $B_{ij,t} = 1, \forall\, ij > IJ_c, t > T_{pre}$. $(\boldsymbol{B} \circ \boldsymbol{\tau})_{it} = B_{ij,t}\tau_{ij,t}$ is the variable of interest. L is the systematic component, which can be decomposed as a factor model $\boldsymbol{L} = \boldsymbol{\Gamma}\boldsymbol{\Upsilon}^{\boldsymbol{T}}$, with an element of L can be presented as the product of R-dimensional vectors $\gamma_i v_t^T$. Finally, E is the error matrix. The identifying assumption is that the treatment assignment does not depend on the error term, but may be correlated with the elements of L. The elements of E are independent across units but may be serially correlated across periods.

The assumption for the SDID to be a consistent and unbiased estimate of Brexit requires that the ratio of signal to noise in the data was high, so it works better for aggregate flows rather than bilateral ones. Moreover, $\boldsymbol{\Gamma}$ should be stable over time.

The SDID estimator constructs the doppelganger synthetic control from the pool of never treated units using weights $\hat{\omega}_{ij}^{sdid}$ that trace the actual outcome of the treated group before T_{pre}.[1] It also selects time weights $\hat{\lambda}_t^{sdid}$ to balance pre-treatment and post-treatment time periods. Their role is to remove the bias stemming from comparing the post-treatment periods with the pretreatment periods that are very different for the whole sample of control units. The time and pair-specific weights are further applied to the standard difference-in-difference estimator in a two-way panel as follows

$$(\hat{\tau}^{sdid}, \hat{\mu}_1, \hat{\alpha}_1, \hat{\beta}_1) = \arg\min_{\tau,\mu,\alpha,\beta} \left(\sum_{ij=1}^{IJ} \sum_{t=1}^{T} (y_{ij,t} - \mu - \alpha_{ij} - \beta_t - B_{ij,t}\tau)^2 \hat{\omega}_{ij}^{sdid} \hat{\lambda}_t^{sdid} \right)$$

At this point, it is useful to compare it with the standard DID estimator, which can be presented as

$$(\hat{\tau}^{did}, \hat{\mu}_2, \hat{\alpha}_2, \hat{\beta}_2) = \arg\min_{\tau,\mu,\alpha,\beta} \left(\sum_{ij=1}^{IJ} \sum_{t=1}^{T} (y_{ij,t} - \mu - \alpha_{ij} - \beta_t - B_{ij,t}\tau)^2 \right).$$

$$(\hat{\tau}^{sc}, \hat{\mu}_3, \hat{\beta}_3) = \arg\min_{\tau,\mu,\alpha,\beta} \left(\sum_{ij=1}^{IJ} \sum_{t=1}^{T} (y_{ij,t} - \mu - \beta_t - B_{ij,t}\tau)^2 \hat{\omega}_{ij}^{sc} \right)$$

4.2 Weights

SDID use weights to emphasize units and time periods that are comparable to the treated units in the post-treatment period. The weights are selected for the synthetic control to follow closely the pre-treatment trend of the treated units. In addition, the penalty is imposed on using too many units for comparison. The unit weights are estimated as the outcomes of the following optimization problem

$$\left(\omega_0, \hat{\omega}^{sdid}\right) = \arg\min_{\omega_o \in R_1, \omega \in \Omega} \sum_{t=1}^{T_{pre}} \left(\omega_0 + \sum_{ij=1}^{IJ_c} \omega_{ij} y_{ij,t} - \frac{1}{N_{tr}} \sum_{ij=IJc+1}^{IJ} y_{ij,t} \right)^2 + \xi^2 T_{pre} ||\omega||_2^2,$$

where

$$\Omega = \{\omega \in R_+^{IJ} : \sum_{i=1}^{IJ_c} \omega_{ij} = 1, \omega_{ij} = \frac{1}{IJ_{tr}} \; for \; all \; ij = IJ_c + 1, \ldots, IJ\}$$

This specification differs from the standard SC in two important regards. First, it introduces a constant term, meaning that the SC counterfactual and the treated group outcomes of interest do not have to match exactly, but can just move in parallel. Second, following Doudchenko & Imbens (2016), the last

[1] A more detailed description of the methodology is given in Archangelsky et al (2019).

term introduces a penalty for using too many weights and is served as the regularization parameter. Following Archangelsky et al. (2021), the regularization parameter is given by

$$\xi = \left(N_{tr}T_{post}\right)^{0.25}\hat{\sigma},$$

where

$$\hat{\sigma}^2 = \frac{1}{IJ_c(T_{pre}-1)}\sum_{ij=1}^{IJ_c}\sum_{t=1}^{T_{pre}-1}\left(\Delta_{ij,t}-\overline{\Delta}\right)^2$$

and

$$\Delta_{ij,t} = y_{ij,t+1} - y_{ij,t}$$

$$\overline{\Delta} = \frac{1}{IJ_c(T_{pre}-1)}\sum_{i=1}^{IJ_c}\sum_{t=1}^{T_{pre}-1}\Delta_{it}.$$

The time weights are optimally chosen by solving

$$\left(\lambda_0, \hat{\lambda}^{sdid}\right) = \arg\min_{\lambda_o \in R_1, \lambda \in \Lambda} \sum_{ij=1}^{IJ_c}\left(\lambda_0 + \sum_{t=1}^{T_{pre}}\lambda_t y_{ij,t} - \frac{1}{T_{post}}\sum_{t=T_{pre}+1}^{T} y_{ij,t}\right)^2,$$

where

$$\Lambda = \{\lambda \in R_+^T : \sum_{t=1}^{T_{pre}}\lambda_t = 1, \lambda_t = \frac{1}{T_{post}} \; for\; all\; t = T_{pre}+1, \ldots, T\}.$$

5. RESULTS

5.1 AGGREGATE ANALYSIS OF UK SERVICES TRADE

We start with the analysis of the UK aggregate trade flows. The unit of analysis in this section is total export of all services sectors of country i at time t. The estimated equation is given by

$$Y_{it} = \gamma_i + \upsilon_t + B_{it} \times \tau_{it}^0 + \epsilon_{it} \quad (1)$$

where Y_{it} is the aggregate exports of services from country i at time t, B_{it} is the policy indicator, which is equal to 1 for the UK from 2016 on, and zero otherwise. To obtain comparative statistics, we consider three methods of estimation: Difference in difference (DID), Synthetic control (SC), and Synthetic difference in difference (SDID). In addition, we also consider DIFP estimator, and SC with regularization and DIFP with regularization.

The results of the DID, SC, SDID, and DIFP to estimate the causal impact of Brexit on aggregate services exports are presented in Table 2. The reported standard errors are estimated using the placebo method

discussed in Archangelsky et al (2019). The standard DID estimator report a positive and significant effect of the Brexit referendum at 1%. However, as reported by the parallel pre-trend assumption test, the estimator is likely to be biased, since the UK aggregate exports did not move in parallel to the comparison group before 2016. Once we move to the SC estimator, which does not rely on the parallel trend, we find a negative, but not significant effect of Brexit, as the SC standard errors are very large. Our preferred result, the SDID method reported in the column (3), estimates the impact of Brexit to be negative and similar in magnitude to the SC estimate. At the same time, it improves considerably on the precision of the estimation, which results in the negative and significant estimate of the effect of Brexit on the aggregate services exports at 0.1% significance level. We also report the DIFP estimator, which is closely related to SDID. It gives us similar estimates as SDID estimator. Finally, in columns (5) and (6) we present modifications of SC and DIFP that add regularization to the SC and DIFP methods and make them sharper and even more similar to the SDID.

Overall, we consider the estimate in column (3) as the most robust estimate of the impact of Brexit on the aggregate services exports of the UK. The magnitude is negative, large and significant at 0.1%. The decision to exit the EU has resulted in US$23.7/£18.5 bln[2] lower services exports relative to what it would have been, had the UK not exited from the EU. It translates into 5.7% lower services exports than the 2019 aggregate UK services exports.[3]

We further consider the impact of Brexit on services exports of Ireland in panel B of Table 2, as it has seen unprecedented surge in services exports starting 2015-2016. The estimated equation is SDID estimator of the causal effect generates a positive and significant effect at 0.01% level. In 2016-2019 Ireland experienced US$30.8/£24 bln higher aggregate services exports annually, which is 14.8% of its 2019 services exports. As in the case of the UK, the DID estimate is not consistent due to the violation of the parallel trend assumption and differs considerably from the other estimates. SC and SC REG estimates are similar in magnitude to SDID estimate but have large standard errors. DIFP and DIFP REG produce estimates that a close to SDID, but with slightly higher standard errors.

[2] The conversion rate is the average exchange rate of 2019, 1GBP=USD1.2766 according to the Bank of England.

[3] Du and Shepotylo (2021), using SC method for a pool of OECD countries and constructing the synthetic control based on the pre-trend log of services exports, GDP, and GDP per capita estimated the effect of Brexit to be 9.2%. Applying SDID to the natural log of bilateral services export among the top services exporters give an estimated effect of 10.5 percent lower bilateral trade (available upon request), which is consistent with our SC estimator in the previous paper. Our current estimates represent a more conservative approach, as we do not restrict the pool of potential donors and do not restrict it to the countries of similar size and similar level of development. Among other things, the difference in the aggregate and bilateral SDID results indicates that the effect is heterogeneous across country pairs and is lower for the trade with largest UK partners.

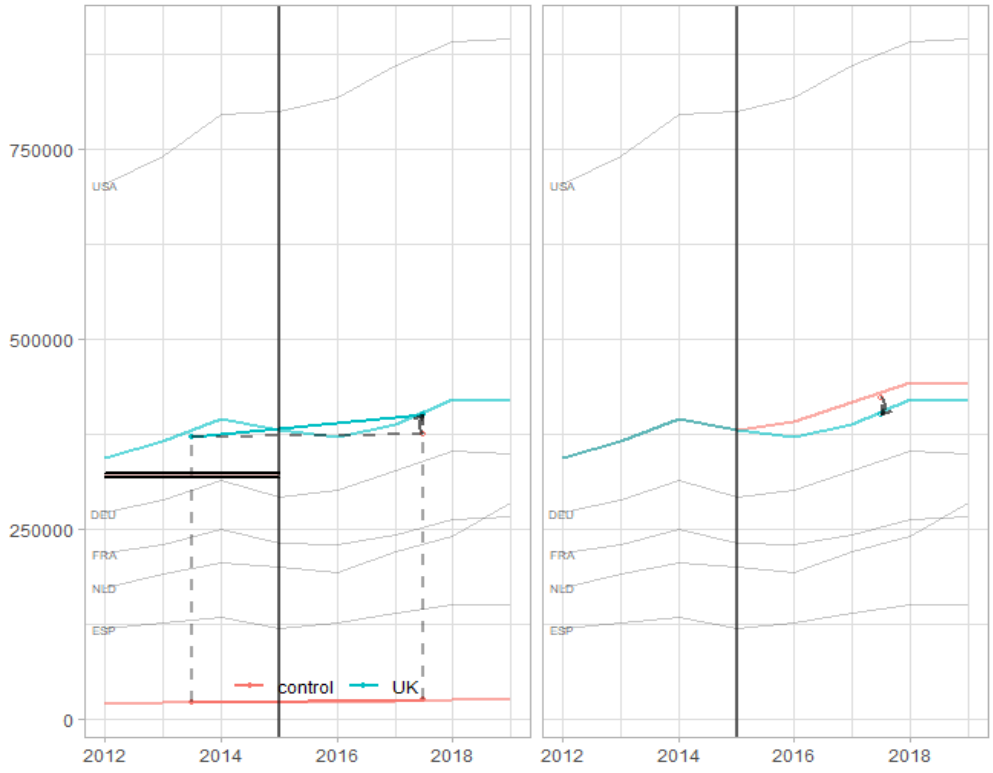
Table 2: Main results for aggregate services exports

	(1) DID	(2) SC	(3) SDID	(4) DIFP	(5) SC REG	(6) DIFP REG
A: Brexit and UK aggregate services export						
Brexit=1 # After=1	25436**	-23493	-23677***	-	-21199	-
	(9779)	(37829)	(4930)	(6365)	(37776)	(5886)
Parallel trend test, F(1,	3626					
p value	0.000					
N	1608	1608	1608	1608	1608	1608
B: Brexit and Ireland aggregate services export						
Ireland=1 # After=1	56526***	39041	30762***	27868***	37374	30326***
	(9027)	(33032)	(5926)	(6946)	(33039)	(6517)
Parallel trend test, F(1,	1354					
p value	0.000					
N	1608	1608	1608	1608	1608	1608

Note: Outcome variable is value of aggregate services export in mln USD. **Brexit** is a dummy variable which is equal to 1 for the UK and zero otherwise, **After** is a dummy variable which is equal to 1 for time periods after 2015 and zero otherwise Brexit=1 # After=1 is an interaction term of Brexit=1 and After=1, capturing the difference in difference impact of Brexit on the aggregate services exports. In panel B, **Ireland** is a dummy variable which is equal to 1 for Ireland and zero otherwise. Placebo standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figures 2-4 are important tools for further analysis of the impact of Brexit on the UK services exports. The left panel of Figure 2 presents DID results, while the right panel shows SC results. The SDID results are presented in Figure 3. First, they illustrate the main differences in the estimation across DID, SC, and SDID approaches. The red curves present the trajectory of the control group, while the blue curves present the UK actual services exports. The red and blue lines present the average trends within the studied period. The dashed line is parallel to the red line trend, while the curved arrow shows direction and size of τ for the corresponding method. For the DID method, the difference is positive, which is shown by the upward arrow, while for the SC and SDID estimates it is negative, as shown by the downward arrow. The transparent lines in Figure 2 represent the trajectories of services exports in the countries with highest weights used to construct SDID estimator. They are Germany, France, the Netherlands, Spain, and USA. Notice that Ireland is not used by the SC or SDID methods as a country to construct the counterfactual, as its performance is very different from the UK.

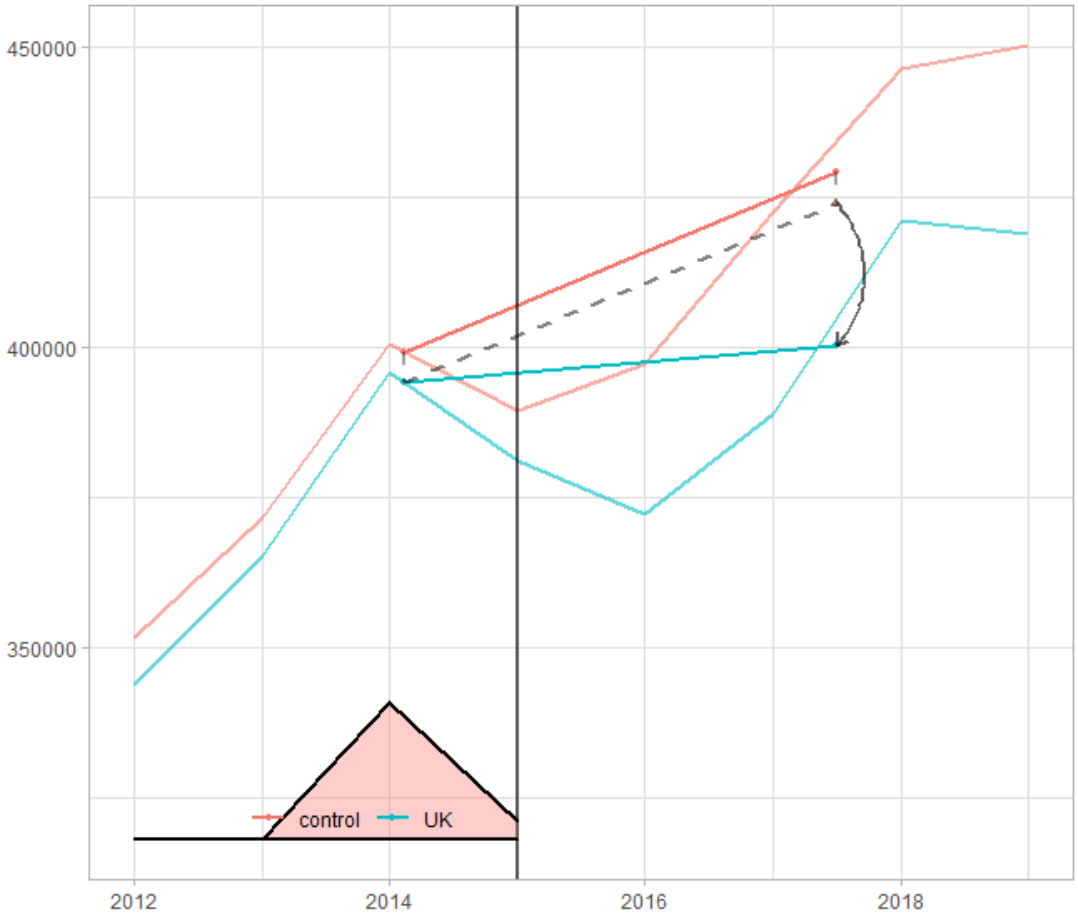
Figure 2: DID and SC plots for aggregate UK services exports



Note: Left panel present DID results, while right panel shows SC results. The red curve presents the trajectory of the control group, while the blue curve presents the UK actual services exports. The red and blue lines present the average trends within the studied period. The dashed line is parallel to the red line trend, while the curved arrow shows direction and size of τ for the corresponding method. Finally, the transparent lines represent the trajectories of services exports in the countries with highest weights used to construct SDID estimator.

According to Figure 3, the UK services exports plunged after 2015 and recovered only in 2018, but not high enough to catch up with the counterfactual in which the UK remained a member of the EU. As shown by the small histogram at the lower left corner of Figure 3, years 2014 and 2015 were used to construct the counterfactual, as they are most similar to the years since 2016, while services exports in 2012 and 2013 behaved very differently and were discarded by SDID.

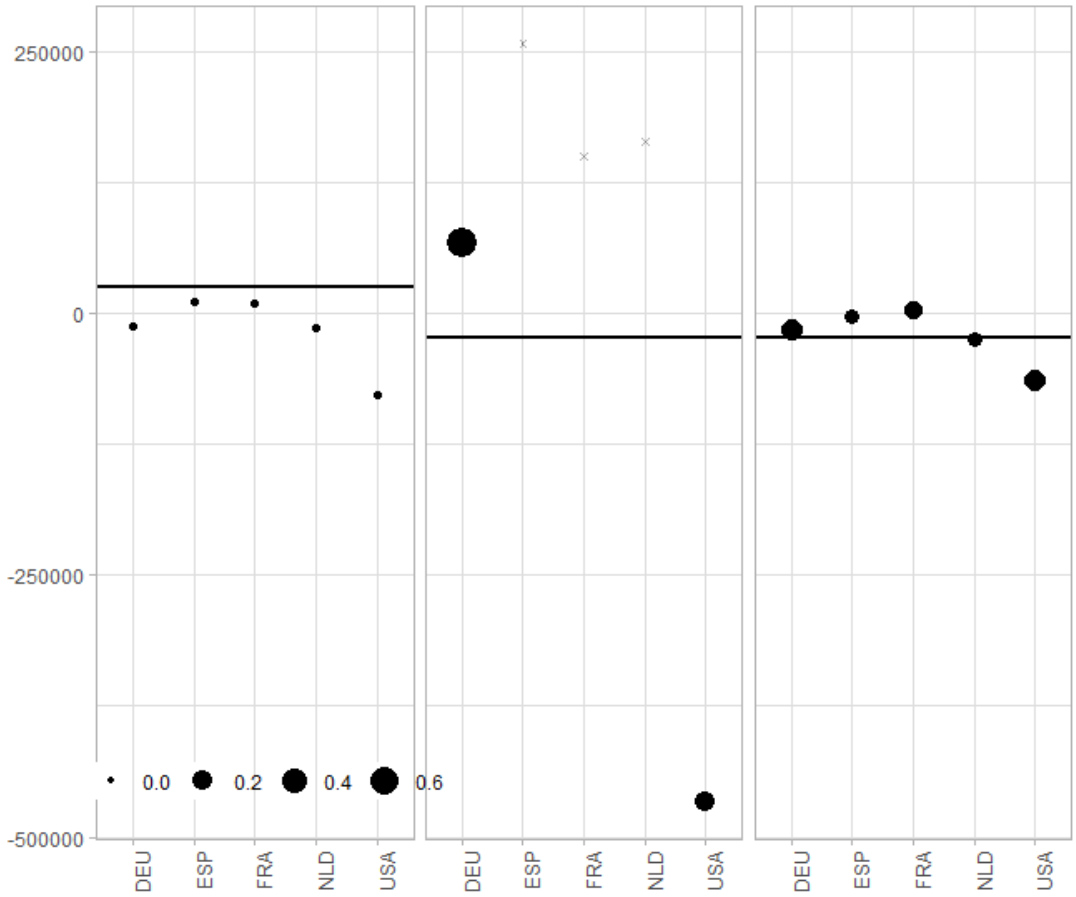
Figure 3: SDID plot for aggregate UK services exports



Note: The red curve presents the trajectory of the control group, while the blue curve presents the UK actual services exports. The red and blue lines present the average trends within the studied period. The dashed line is parallel to the red line trend, while the curved arrow shows direction and size of $\hat{\tau}_{SDID}$. Time weights used in the SDID estimation are shown at the lower left corner of the figure.

Figure 4 gives detailed information on weights used by SC and SDID methods. The figure shows the largest five w_i used for DID method, central for SC method, and right for SDID method. The size of the dot is proportional to the weight. The solid horizontal line shows the method specific $\hat{\tau}$ for the UK, while the height of a dot represents the country-by-country adjusted outcome difference between the UK and the corresponding country, $\widehat{\delta}_{tr} - \widehat{\delta}_{i}$. According to the figure, the US has performed better than its counterfactual self in the absence of Brexit (the dot is below the horizontal line), while Germany, France and Spain were performing slightly worse. We will present more precise inferences on the performance of European countries in the following sections.

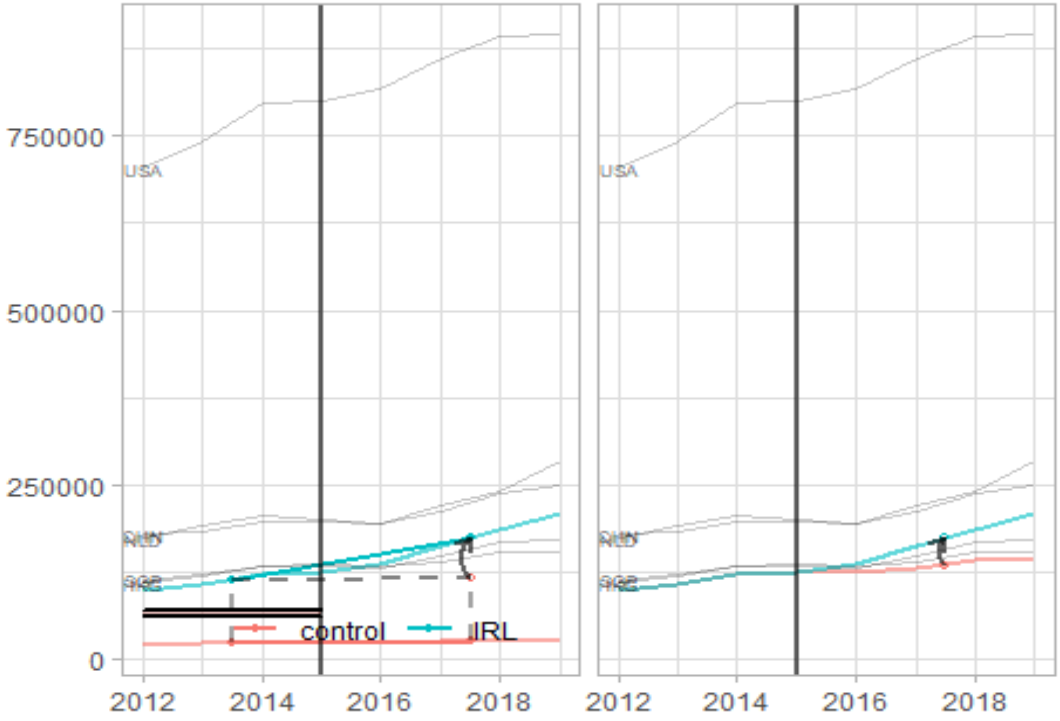
Figure 4: Weight plots for DID, SC, and SDID for aggregate UK services export



Note: The figure shows the largest five w_i used for DID method on the left, SC method in the middle, and right for SDID method. The size of the dot is proportional to the weight. The solid horizontal line shows the method specific $\hat{\tau}$ for the UK, while the height of a dot represents the country-by-country adjusted outcome difference between the UK and the corresponding country, $\hat{\delta}_{tr} - \hat{\delta}_i$.

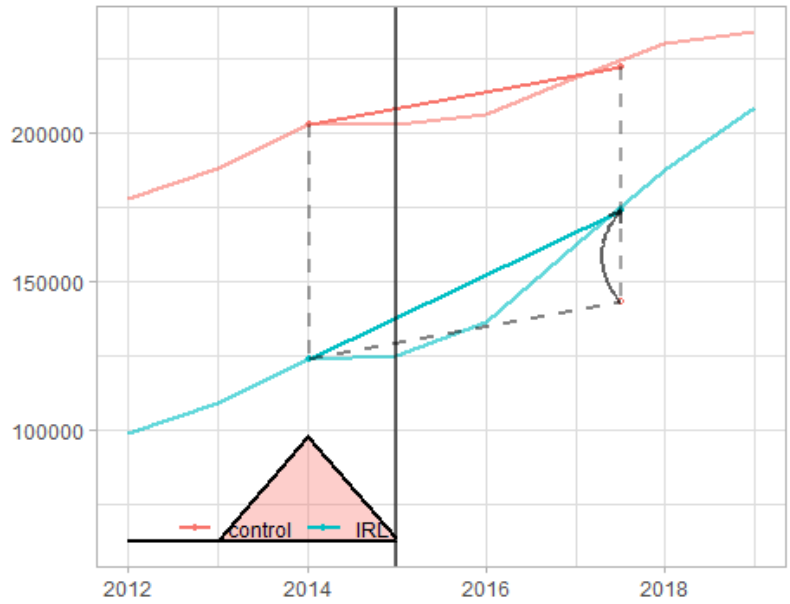
Turning to the results for Ireland, Figures 5-7 provide additional information about the quality and robustness of our results and compare the different estimators in more detail. First, all three methods point out towards the positive effect of Brexit on the Irish services exports. The main countries to construct the Ireland counterfactual are China, Hong Kong, the Netherlands, Singapore, and US. It points that Ireland has decoupled from the EU markets and performed more outwardly, similar to developments in the North America and South East Asia. As for the UK, SDID used 2014 and 2015 when computing the effect and discarded 2012 and 2013.

Figure 5: DID and SC plots for aggregate Irish services exports



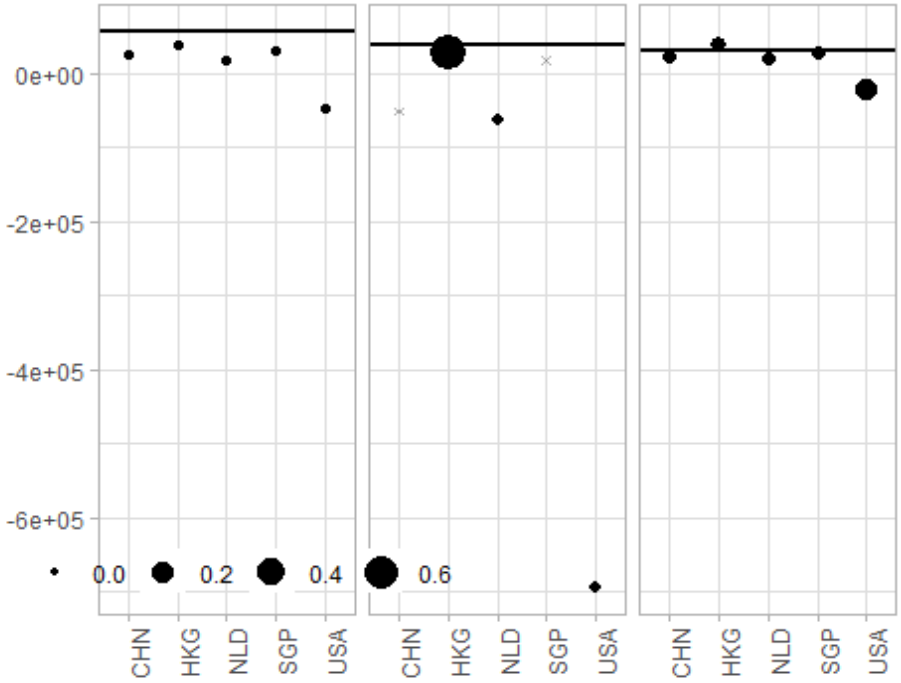
Note: Left panel present DID results, while right panel shows SC results. The red curve presents the trajectory of the control group, while the blue curve presents the Irish actual services exports. The red and blue lines present the average trends within the studied period. The dashed line is parallel to the red line trend, while the curved arrow shows direction and size of τ for the corresponding method. Finally, the transparent lines represent the trajectories of services exports in the countries with highest weights used to construct SDID estimator.

Figure 6: SDID plot for aggregate Irish services exports



Note: The red curve presents the trajectory of the control group, while the blue curve presents the Irish actual services exports. The red and blue lines present the average trends within the studied period. The dashed line is parallel to the red line trend, while the curved arrow shows direction and size of $\hat{\tau}_{SDID}$. Time weights used in the SDID estimation are shown at the lower left corner of the figure.

Figure 7: Weight plots for DID, SC, and SDID for aggregate Irish services export



Note: The figure shows the largest five w_i used for DID method, central for SC method, and right for SDID method. The size of the dot is proportional to the weight. The solid horizontal line shows the method specific $\hat{\tau}$ for Ireland, while the height of a dot represents the country-by-country adjusted outcome difference between Ireland and the corresponding country, $\hat{\delta}_{tr} - \hat{\delta}_i$.

5.2 Aggregate analysis of UK services trade: EU vs non-EU

A standard trade model, which looks at the long run equilibrium, emphasizes the negative impact of trade costs on exports. As the most immediate effect of Brexit were the expected changes in the trade policy of the EU and the UK in terms of goods and services, it is natural to assume that exports from the UK to the EU countries should be affected more negatively than to the non-EU countries. Despite the actual changes occurred only when the UK left in 2021, in the situation when the required adjustments are costly, incur fixed costs, and take time to adjust, the optimal strategy of the businesses would require changes to occur prior to the policy changes. For example, policy uncertainty around international trade since the 2016 Brexit referendum has reduced firms' export participation (Crowley et al., 2018) and aggregate trade flow (Douch et al., 2018; Graziano et al., 2020). UK firms, especially smaller ones, have already responded to the Brexit uncertainty by redirecting their trade away from the close, rich, and previously frictionless EU neighboring markets to places further afield (Douch et al., 2019). Some of the effects were detectable even before 2016, when the anticipation of future trade shocks led to tangible changes in trade dynamics (Handley and Limão 2017; Douch et al., 2018; Douch et al., 2019).[4] To test the hypothesis if trade within the EU is affected more than outside the EU, we estimate the following model

$$Y_{ij,t} = \gamma_{ij} + \upsilon_t + B_{it} \times \tau_{it}^0 + nonEU_{jt} \times B_{it}\tau_{it}^1 + \epsilon_{ij,t} \text{ if } j \notin EU_t$$

$$Y_{ij',t} = \gamma_{ij'} + \upsilon_t + B_{it} \times \tau_{it}^1 + \epsilon_{ij',t} \text{ if } j' \in EU_t$$

We aggregate all EU and all non-EU trade flows as $Y_{it,EU} = \sum_{j \notin EU_t} Y_{ij,t}$ and $Y_{it,non-EU} = \sum_{j' \in EU_t} Y_{ij',t}$ and construct the difference in export of product s from country i at time t between EU and non-EU countries as given by

$$\Delta Y_{it} = Y_{it,non-EU} - Y_{it,EU} = \overline{\gamma_i} + \overline{\upsilon_t} + nonEU_{it} \times B_{it}\tau_{it}^1 + e_{it} \quad (2)$$

We consider the policy change as before – it is the UK services export trade since 2016, which is exposed to the Brexit impact.

Table 3 reports the results of the model (2) estimated by different methods using the sample of 2012-2019. DID reports a positive and significant coefficient for the UK and negative and significant

[4] This is known as anticipation effect. Brexit was not the first occasion when such an effect was observed. Freund and McLaren (1999) show the rising trade years before the EU trade agreement comes into force. The primary reason for anticipation effect to take effect in policy uncertainty situation is the inherent sunk costs associated with trade. Firms would have to bear certain costs to export, most notably when entering a new market (Melitz, 2003; Eaton et al, 2011). The costs of searching for partners, developing local knowledge and reputation, marketing and following legal procedures, cannot be recouped if the firm subsequently withdraw from exporting, and hence would become sunk costs.

coefficient for Ireland, which goes against the expected outcome if the decline in the UK trade is due to reduced trade with the EU countries, while Ireland would fill that gap. However, it should be pointed out that the parallel trend assumption test fails for both countries. Moving to more robust methods, which include SC and SDID in columns (2) and (3), shows that there is no significantly more positive effect of the Brexit referendum on the UK services exports to non-EU than to the EU destinations, while the effect for Ireland remains positive. This means that at the aggregate level, there is no evidence to support the hypothesis of services trade diversion from EU to elsewhere. Finally, DIFP and modifications SC REG and DIFP REG confirm no significant effect of the UK. For Ireland, SC REG produce non-significant effect due to higher standard error, while DIFP REG estimates a negative and significant effect.

Table 3: Synthetic DID Aggregate flows to non-EU

	(1) DID	(2) SC	(3) Synthetic DID	(4) DIFP	(5) SC REG	(6) DIFP REG
	A: Brexit and UK aggregate services export to non-EU					
Non-EU # Brexit=1 # After=1	-12985**	-4238	436	-3344	-4117	-3206
	(3278)	(11774)	(2591)	(3595)	(11948)	(2575)
Parallel trend test, F(1, 201)	353					
p value	0.000					
N	1616	1616	1616	1616	1616	1616
	B: Brexit and Ireland aggregate services export to non-EU					
Non-EU # Brexit=1 # After=1	9100**	23981*	22083***	24021***	21399	21408***
	(3175)	(11701)	(2062)	(2849)	(11867)	(2111)
Parallel trend test, F(1, 201)	91					
p value	0.000					
N	1616	1616	1616	1616	1616	1616

Note: Outcome variable is the difference in value of aggregate services export to EU and non-EU countries in million USD, $\Delta Y_{it} = Y_{it,non-EU} - Y_{it,EU}$. Placebo standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.3 Sector level analysis

To understand how the aggregate effects estimated the post-Brexit trends in the services sectors trade may differ across different sectors, we perform a more detailed sectoral analysis of the aggregate services exports from the major EU services exporters. The results of the overall and sectoral estimates

are reported and visualized in Figure 8, with the bottom panel reporting the estimated coefficients and the upper panel visualising them where red bars negative effect and blue bars positive effect.

The first thing to note, according to the overall estimate, is that the UK stands out as the country whose trade in services was most negatively impacted by Brexit, whilst Irish services trade benefitted. The rest of the countries in the EU do not see significant impacts. The following analysis suggests that this will depend on the sector of concern.

It is clear that the negative Brexit effect on UK services trade is concentrated in some UK sectors. These include Transport sectors (-US$5.38/£4.2 bln USD; 12% down compared to 2019 level), Travel (-US$4.86/£3.8 bln USD; 8.6% down) and Insurance (-US$4.8/£3.8 bln USD; 20% down), Telecom (-US$3.3/£2.6 bln ; 10% down). In comparison, there is no statistically significant decline according to the SDID estimates in Business Services, Intellectual Property Services and the Construction Services sectors. Interestingly, we find a small but positive and statistically significant effect in Financial sectors (US$0.58/£0.45 bln; 0.85% up compared to 2019 level) and Cultural sectors (US$0.59/£0.6 bln; 6% up).

Ireland does particularly well post Brexit Referendum in Telecom (US$10.4/£8.1 bln; 14% up compared to 2019 level), Business (US$10.9/£8.5 bln; 18% up), Intellectual Property Services (US$4.31/£3.4 bln; 22% up), and Insurance (US$1.19/£0.9 bln; 9.5% up). The most remarkable growth occurs in the Telecom sectors, where Ireland seems to have enhanced its clear market dominance, claiming one-third of all telecom services exported during 2017-2019 by all the countries included in this study.

Although as a whole, other EU countries do not seem to have exported more trade in services due to the Brexit, some sectors in some countries do seem to have gained from the Brexit. In particular, Germany and Spain have exported more services in Transport sectors (US$4.16/£3.3 bln for Germany, 5.6% up compared to its 2019 level; and US$1.35/£1.1 bln for Spain 5.7% up). While the UK has lost grounds in Travel, Spain has been the biggest winner with exporting an extra of US$7.88/£6.2 bln (10.5% up compared to its 2019 level). In the sector of Insurance that UK has experienced a significant decline, a few others might have picked up the UK's lost businesses – Germany has grown by US$1.35/£1.06 bln (10% up its 2019 level), Switzerland (US$0.68/£0.53 bln; 6% up compared to its 2019 level) and Bermuda (US$1.58/£1.24 bln; 5.5% up compared to its 2019 level) in addition to the big winner Ireland (US$1.19/£0.9 bln; 9.5% up).

Further, we find that Ireland and the Netherlands have increased considerably exports in Business services. Ireland grew Business services by US$10.9/£8.5 bln (18% up compared to its 2019 level), while

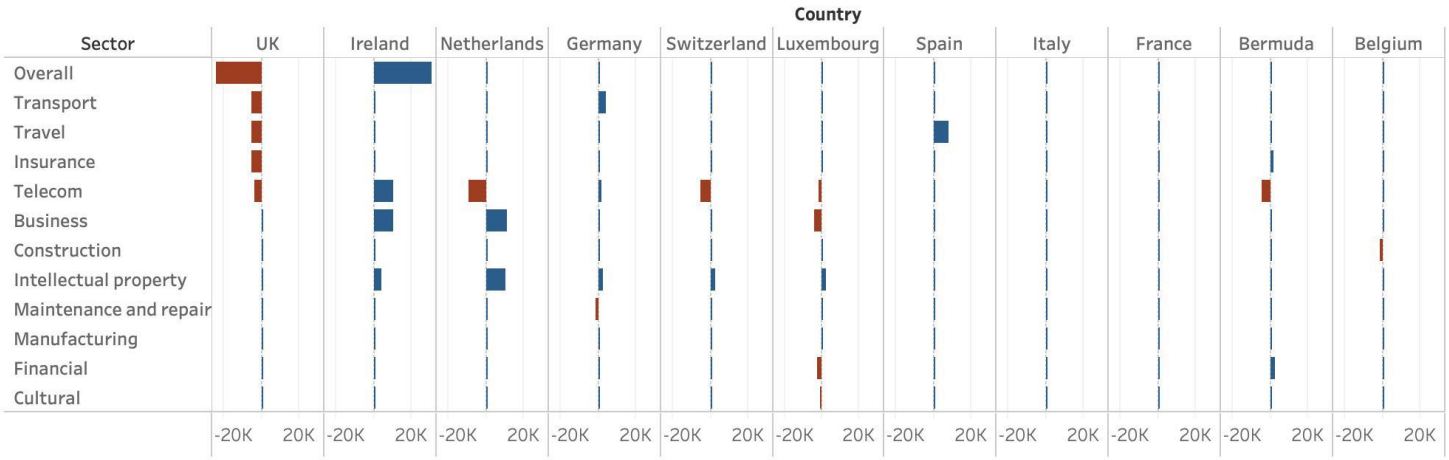
the Netherlands expanded its Business services by US$11.3/£8.9 bln (14% up compared to its 2019 level).

Little evidence suggests that the Brexit Referendum has caused much disruption in the flow of Financial services exports. However, apart from a small gain estimated for the UK (by less than 1%), we find a relatively significant above-trend growth in Bermuda Financial services exports (US$2.79/£2.2 bln; 19% up compared to its 2019 level), while Luxembourg saw a decline (US$2.2/£1.7 bln; 6.4% down compared to its 2019 level).

Interestingly, although there is no statistically significant decline in the UK's Intellectual Property Services, we find that several other countries have expanded their IP services since the Brexit Referendum – Germany (US$2.68/£2.1 bln; 10% up), the Netherland (US$10.8/£8.5 bln; 10% up), Switzerland (US$2.5/£2 bln; 8.9% up) and Luxemburg (US$2.18/£1.7 bln; 28% up) in addition to Ireland (US$4.3/£3.4 bln; 22% up). Similarly, although there is no statistically significant decline in the UK's Manufacturing Services, Germany has expanded its exports (US$1.03/£0.8 bln; 11.5% up).

Figure 8: SDID by EU countries and sectors

Exports in services to the EU: SDID estimate, value (Billion USD), by sector



Sector	UK	Ireland	Netherlands	Germany	Switzerland	Luxembourg	Spain	Italy	France	Bermuda	Belgium
Overall	-23,677	30,762	0	0	0	0	0	0	0	0	0
Transport	-5,380	0	0	4,163	0	0	1,351	0	0	0	0
Travel	-4,862	0	0	0	0	0	7,881	0	0	0	0
Insurance	-4,800	1,185	0	1,349	680	0	0	0	0	1,578	0
Telecom	-3,276	10,360	-9,013	1,865	-4,744	-2,026	0	0	0	-4,457	0
Business	0	10,899	11,340	0	0	-4,017	0	0	0	0	0
Construction	0	0	0	0	0	0	0	0	0	0	-1,330
Intellectual property	0	4,318	10,789	2,681	2,540	2,184	0	0	0	0	0
Maintenance and repair	0	0	0	-987	0	0	0	0	0	0	0
Manufacturing	0	0	0	1,026	0	0	0	1,055	0	0	0
Financial	584	0	0	0	0	-2,192	0	0	0	2,790	0
Cultural	587	480	645	717	299	-670	0	0	246	0	0

Note: This is a simplifed table for the SDID estimates at sectoral level for each country reported. The estimated coefficients reported in the table are statistically signficant at p<0.05. Those not statistically signficant are replaced by zeros for visualisation purposes but do not necessarily mean zero effect.

5.4 Robustness Tests

We produce a number of robustness checks in this section. The focus is on the SDID coefficient for the aggregate trade flows. Results are presented in Table 4.

Policy timing

The timing of the policy has been debated. Some researchers argue that the treatment should start in 2015, when the Conservatives won a majority and announced the Brexit referendum (Douch and Edwards, 2015), while others emphasize 2016 when the outcome has been announced as the beginning of the treatment (Crowley et al 2018, Graziano et al. 2020). In column (1) we change the timing of the policy change from 2016 to 2015, as the referendum announcement has been made in 2015, which already created some uncertainty. It reduces the Brexit effect of services for the UK considerably, while increasing the result for Ireland. Still, the effects remain significant. Based on this analysis, the major changes to services exports in the UK actually occurred in 2016 and onwards. For Ireland, however, they started earlier.

Time frame

As we discussed in the methodology section, there is a trade-off between a better fit and higher probability that the parameters stability condition is satisfied, when the duration of the sample period is extended. The trade-off in this exercise is that by using the extended sample we improve the selection of the synthetic control counterfactual by looking at its behavior under different policy shocks. However, the downside of this is that the world economy has been undergoing significant structural changes and the assumption of the model stability is less reasonable.

A good match of the UK performance to the synthetic control during 2008-2011 crises is on the one hand a desirable property, but it also relies on the assumption that the structural parameters of the global trade system remained the same. It is hard to argue that the system retained its parameters stable, as there are very important structural changes observed in the world trade due to increasing role of China and other emerging economies and declining role of Western Europe. In column (2) we look at the whole duration of the sample in 2005-2019. Column (3) includes data for 2010-2019. The extension of the sample reduces the impact of Brexit on the UK, while the results for Ireland are slightly higher than what we report for the sample of 2012-2019.

Donor pool

We test sensitivity of the results to the size of the donor pool by limiting it to OECD countries only. Results are presented in column (4) with no significant impact on our conclusions.

Placebo test

In column (5) we perform a placebo test by excluding the period of 2016-2019 from the sample, moving the sample window to 2008-2015, and assigning timing of Brexit to 2012. As we expect, the causal effects turn insignificant as there was no policy change in 2012-2015. It gives us more confidence that our approach is able to distinguish the impact of policy change from the secular decline of the UK share of export of services and secular increase in the Irish share of export of services during 2008-2015.

Table 4: Robustness checks

	(1)	(2)	(3)	(4)	(5)
	Brexit=2015	2005-2019 sample	2010-2019 sample	OECD sample	Placebo 2008-2015
	A: UK				
Brexit=1 # After=1	-9913*	-13635*	-21959***	-20196*	3202
	(4587)	(5147)	(2895)	(8197)	(1888)
	B: Ireland				
Ireland=1 #	33334***	38092***	33947***	32278***	3597
	(4748)	(5548)	(3428)	(9673)	(1849)

Note: Outcome variable is value of aggregate services export in mln USD. Brexit is a dummy variable which is equal to 1 for the UK and zero otherwise, After is a dummy variable which is equal to 1 for time periods after 2014 in column (1), time periods after 2015 in columns (2) and (3), time periods after 2011 in column (4) and zero otherwise Brexit=1 # After=1 is an interaction term of Brexit=1 and After=1, capturing the difference in difference impact of Brexit on the aggregate services exports. In panel B, Ireland is a dummy variable which is equal to 1 for Ireland and zero otherwise. Placebo standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6. DISCUSSION

The overall effects

Our SDID estimates suggest that the EU exit has resulted the UK to experience a shortfall of US$23.7/£18.5 bln worth services exports every year between 2016-2019 relative to what it would have been, had the UK remained in the EU. This translates into 5.7% lower at the level of 2019 aggregate UK services exports. While the majority of existing studies focus on trade in goods, this estimate provides a new assessment of the Brexit impact on trade in services using the recently improved methodology.

Echoing the studies focused on trade in goods (Dinghra et al., 2017; Mulabdic et al., 2017; Bloom et al., 2019; Born et al., 2019; Douch et al., 2020 and Fernandes and Winters, 2021), we find that the estimates of the magnitudes of the Brexit impact are sensitive to the methodologies adopted for evaluation. Specifically, Douch and Edwards (2021) use monthly aggregate export data from the WTO Data Portal and SC method and estimate the Brexit effect on UK commercial services exports to be 7-8% during

July 2016 and March 2018. Du and Shepotylo (2021), also using SC method for a pool of OECD countries and constructing the synthetic control based on the pre-trend log of services exports, GDP, and GDP per capita estimate the effect of Brexit to be 9.2%for UK services as a whole. Applying SDID to the level of services export in this paper give an estimated effect of 5.7 percent shortfall, which is a more conservative estimate when not conditioning on the countries of similar size and similar level of development. It nevertheless highlights the importance of the research method in the evaluation and of understanding the assumptions one must make when adopting a specific modelling approach.

The findings of this paper are consistent with the preceding analyses reporting a significant negative effect of the Brexit announcement, which could be attributed to deterrence effect and anticipated trade costs of goods (Crowley et al 2008; Graziano et al 2018; Douch et al 2020; Douch and Edwards 2021), or other channels such as FDI relocation (Breinlich et al 2020), and more generally GDP effects (Born et al 2019), as well as consumer sentiment shifts from EU and non-EU products and services (Douch and Edwards, 2021). Comparable findings are also reported for negative effects of policy uncertainty on services exports (Ahmad et al 2021; Douch and Edwards, 2021). In the long run, the trade loss will translate into productivity loss (Van Reenen, 2016), further eroding UK industries' competitiveness.

Ireland appears to be the big winner from Brexit as its services exports boomed, with its overall services exports expanded by US$30.8/£24 bln annually over 2016-2019 period compared to the counterfactual scenario if Brexit did not occur. This corresponds to an impressive 14.75% annual increase in Ireland's 2019 total services exports. A likely explanation is that Ireland has benefited from firms relocating and business being rerouted in order to retain frictionless access to the EU's Single Market. There are a number of ways in which Ireland is a favorable location than before for businesses aiming to establish an EU presence. Its low corporate tax for R&D/intangibles encourages knowledge-intensive multinationals. Its globally connectivity and open society increasingly magnetise talents. Now Ireland is the only predominantly English-speaking country in the EU, which means it can be attractive to skills and talents to emigrate from the UK. With 40% of the population under 29 years old, Ireland has a young, well-educated English-speaking workforce.

While Ireland's success in expanding services economy over the whole period in this study feeds on its overall liberal economic policy and tax advantages, the facts that the growth trend has changed since 2016 and there is a substantial heterogeneity in performance across different services sectors point that the measured effect cannot be attributed solely to its economic policy.

We do not find evidence to suggest that UK services exporters redirected exports from the EU to outside of EU countries. This is unlike exporters of goods. It may imply that there is a limited scope for UK businesses to find alternative markets to divert their services to beyond the EU markets.

Sectoral effects

The large heterogeneity among sectors is really important for understanding the uneven Brexit effect across sectors and markets. To some extent, the dearth of the research at sector level hampers effective debates and discussions during the Brexit negotiation between the UK and the EU on the specific terms of trade in services.

In this study, the large variations of the impacts we identify among different services show that it is important to look into sectoral differences to obtain a close picture. We estimate that the UK particularly saw declines in Transport, Travel, Insurance and Telecoms in the run up to 2020 as a result of Brexit. This helps to understand the varying degree of the impact on different EU member countries stress the heterogeneity among the related parties within the EU trade partners.

There is little surprise that Transport and Travel have suffered considerable disruptions as a result of Brexit. Transport sectors, in particular Aviation and Shipping, are heavily regulated sectors facing complex regulatory environment. Therefore it is fair to say that these sectors have benefited the most from the trade liberalisation brought by being integrated in the EU single market. Transport and Travel sectors require free movement to offer and deliver services and face webs of regulatory, economic, employment legal and tax issues. As it is expected, UK's EU exit has deep implications on the sectors' access to skills, suppliers, customers, business models and market structure. Given the degree of 'certainty' of extremely high trade barriers post Brexit in the Brexit uncertainty, it is not surprising that the UK trade in services by Transport and Travel has been declined by 12% and 8.6% annual over 2016-2019 relative to 2019 level.

Financial and professional services

Interestingly, we do not find evidence of significant decline in UK's exports of Financial services. This is despite of abundant anecdotes of the relocation of UK businesses to Dublin/Ireland, the Netherlands, and other popular EU destinations.[5] This highlights the differences between anecdotes and raw statistics and the estimates obtained through carefully conducted econometric analysis that aims to disentangle causal relationships.

As the second largest service exporter in the world, after the United States, the UK exports a wide range of services, but in particular leads the global market in financial services and professional business services. Over the Brexit period, speculations abound about the future of the city, the financial centre of London. Amsterdam surpassed London as Europe's largest share trading centre in January 2021.

[5] See among others, Bloomberg report, and many business services mushrooming since 2016 to help UK businesses to relocate, for example Company Bureau, Sherwin O'Riordan.

Frankfurt attracts bankers to relocate with its home to European Central Bank and the European insurance authority. Luxembourg has expertise on banking, asset management and attractive low corporate tax. Paris is an all-rounder with attractive high-quality financial services, professional and business services, home to the second largest stock exchange in Europe, and now an alternative gateway to London for businesses to serve Europe.

On the other hand, a historical account of the international financial centres shows that they have long-term trajectories and tend to be very stable over time (Cassis, 2010). London has strong comparative advantages in financial services, which is hard to replace, even it is no longer Europe's *de facto* financial centre. The UK financial market activities not only outsize other peers in the EU in its domestic financial system (Rajan and Zingales, 2003), but also have almost total dominance in certain wholesale market sectors, hedge fund management, FX trading, Over-the-counter (OTC) derivatives, and private equity management to name a few (Armour, 2017). The agglomeration effects enjoyed by the sectors allow businesses to benefit from a deep and liquid pool of human capital and tacit knowledge in some unparalleled fashion. Thus, despite of the speculations about its position, the evidence seems to suggest that the City dominance is rather secure and the impact is minimal.[6] This can be later seen from its renewed attraction to capital investment. London continued to do well with IPOs in 2021 amidst the pandemic, raising nearly one-third of IPOs and a quarter of further offers of the whole Europe, Middle East and Africa regions, proved to remain attractive to new capital investment.

In addition, financial services differ from Travel and Transport services for their relatively lower fixed costs of relocation. It is arguably cheaper and easier to relocate business functions to Europe at the time of Brexit, while transport and travel services require longer time to set up in a new location and are more likely to be costly. Given the real trade barriers were not erected over the period of 2016-2019, and the sector anticipated the EU's third country 'equivalence' framework to apply for the UK post Brexit, banks and financial services businesses might have held off actions to relocating businesses amid policy uncertainty, compared to transport and travel businesses.

According to our estimate, there is little evidence that the UK financial services sectors have exported less as a result of Brexit. They actually have a small gain around 0.85% of 2019 level. This seems to support the argument for the strong competitive position the City of London holds. Interestingly, we find that Luxemburg has reduced exports in services by US$2.2/£1.7 bln a year (corresponding to 6.4% of its 2019 total financial services exports) in the same period. The UK's EU exit is not a one-way traffic. Just as businesses based in the UK no longer have unfettered access to the EU's markets, so most EU-

[6] There are many discussions in the public domains, for example, https://www.theguardian.com/business/2021/may/18/has-brexit-fatally-dented-the-city-of-londons-future.

located firms expect barriers to access and serve London-based clients. More research is required to ascertain the nature of the above-trend growth in UK's financial services exports and the decline of Luxemburg services trade before drawing any more definitive conclusions.

7. CONCLUSION

Drawing on Synthetic Difference in Differences (SDID) methodology due to Arkhangelsky et al (2019), this paper is an empirical analysis of the Brexit effect on trade in services adds drawing on the state of the art methodology. The new evidence confirms that the Brexit has caused a large negative effect on the UK trade. The EU exit has resulted the UK to experience a shortfall of US23.7/£18.5 bln worth services exports every year between 2016-2019 relative to what it would have been, had the UK remained in the EU, which is 5.7% lower at the level of 2019 aggregate UK services exports.

There are large variations of the impacts across different sectors. Statistically significant decline followed the Brexit Referendum is seen in Transport, Travel, Insurance and Telecom exported services in the run up to 2020. We did not find significant decline in Business Services, Intellectual Property Services, Construction Services sectors, nor in Financial sectors and Cultural sectors.

The only country in Europe that seems to have significantly benefited as a whole from the Brexit Referendum is Ireland, which resulted in growth of total services exports by US$30.8/£24 bln annually over 2016-2019 compared to the counterfactual scenario if Brexit did not occur. This translates to an impressive 14.75% of Ireland's 2019 total services exports.

Besides Ireland, EU countries have also noticeably benefited from the Brexit in some areas. The Netherlands have increased considerably exports in Business services and IP services. Spain has seen growth in Travel and Transport services exports. Germany has gained in Transport and Insurance and IP services exports. While Ireland seems to have done exceptionally well in relation to the export of Telecom services, a sharp contrast emerges to the lost exports not just from the UK, but also from the Netherlands, Switzerland and France.

An economic disintegration like the Brexit creates major changes to the international trade in services. This paper responds to the fact that this hugely important issue has not been openly or deeply debated in either the public sphere or within the research communities; indeed it has received even less critical attention than the international trade in goods. Part of the reason for its absence from the front-line debate is the lack of reliable data and rigorous analysis. The factual knowledge this study offers about the prevalence and severity of the Brexit impact on UK competitiveness of global servicing provides

important evidence and a step further in the discussion about the future services trade relationship between the UK and the EU post the Trade and Cooperation Agreement.

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