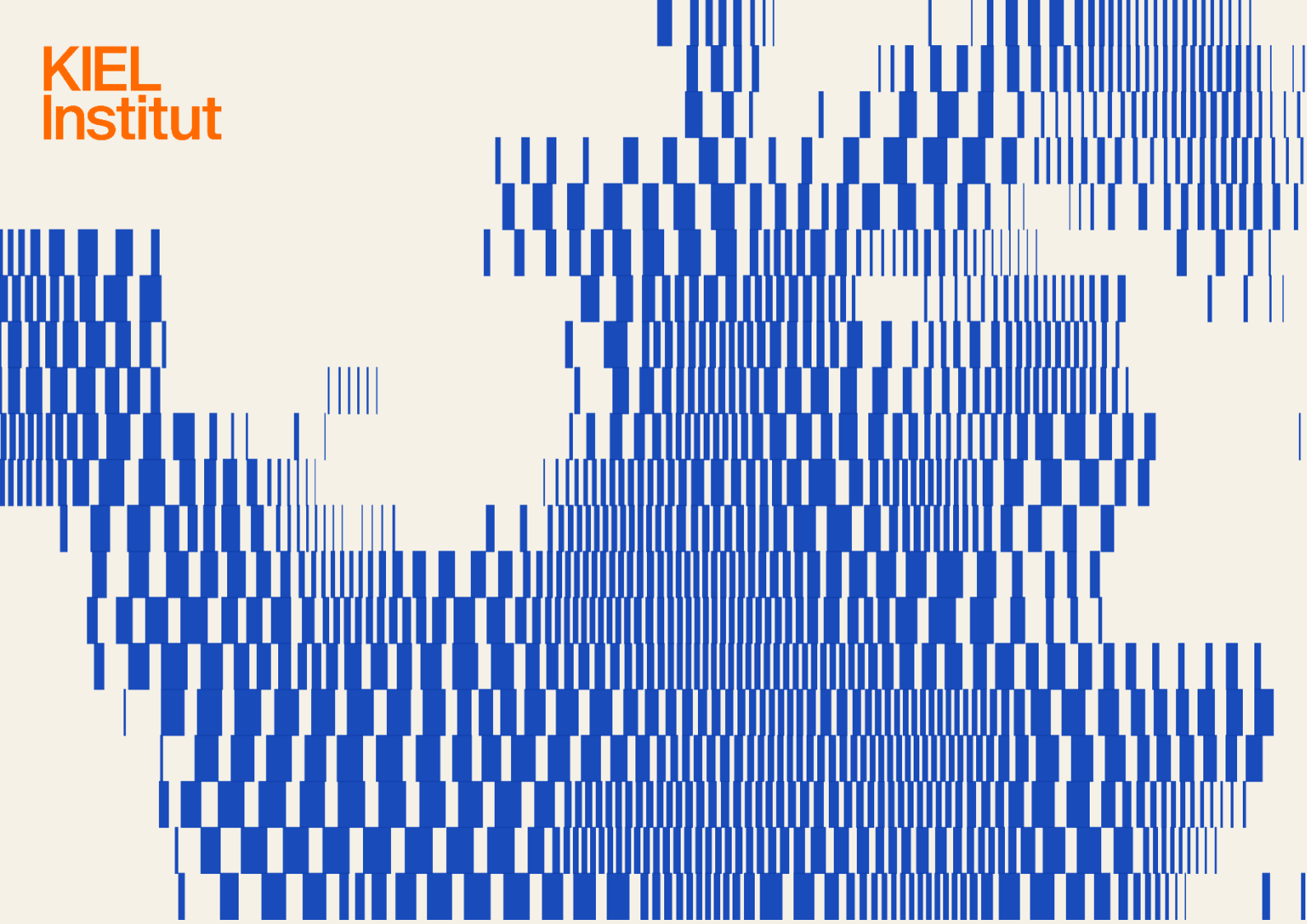
KIEL Institut



Holger Görg, Michael Irlacher, Michael Koch,
Saskia Meuchelböck

November 2026

Trading Through Times of Disintegration: How Services Help Firms Weather Shocks

Kiel Working Paper

No. 2329, ISSN 1862-1155
Kiel Institute for the World Economy

Abstract*

Holger Görg, Michael Irlacher, Michael Koch, and Saskia Meuchelböck

Does exporting both goods and services help firms weather disintegration shocks? Using novel linked German microdata on firms' goods and services exports, we examine how exporters adjusted to the Brexit referendum. Firms exporting only goods or only services reduced their UK sales. Dual exporters, which sell both, proved more resilient: their goods exports fell more, reflecting deeper price cuts, but their exports of complementary services rose. On net, their total UK exports show no statistically detectable decline, and – unlike single-mode exporters – they are no less likely to serve the UK market after the referendum. To rationalize these findings, we develop a model of one-way complementarity, in which services raise demand for the firm's goods. Because complementary services are priced where demand is inelastic, their sales can rise as goods sales fall, giving dual exporters an additional margin of adjustment.

Keywords: Services trade; Goods trade; Brexit; Firm exports; Demand complementarities.
JELs: F10, F14, L80

Authors

Holger Görg
Kiel Institute, Kiel University, GEP Nottingham, IZA
holger.goerg@kielinstitut.de
www.kielinstitut.de

Michael Irlacher
Johannes Kepler University Linz, CESifo
michael.irlacher@jku.at
www.jku.at

Michel Koch
Aarhus University, Kiel Institute
mkoch@econ.au.dk
www.econ.au.dk

Saskia Meuchelböck
Aarhus University, Kiel Institute
sameu@econ.au.dk
www.econ.au.dk

*The authors gratefully acknowledge funding from the EU's Horizon Europe programme (grant agreement no. 101061123, RETHINK-GSC). In addition, S. Meuchelböck gratefully acknowledges funding from the European Union through the Marie Skłodowska-Curie Individual Fellowship SAIL-GSC (grant agreement no. 101203969), and M. Irlacher and M. Koch from the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) for the Research Unit "International Division of Labour (IDoL): New Challenges forWorkers, Firms, and Policy Makers" (project no. 550491480). We are grateful to Alejandro Graziano, Martina Magli, and Farid Toubal for their thoughtful discussions of early drafts, and to participants at the ETSG 2025 in Milan, the Göttingen Workshop on International Economics, the NOITS 2025 in Copenhagen, the World Trade Dialogue 2026 in Hamburg, the DIEW 2026 in Aarhus and the CESifo Junior Workshop on International Economics 2026, as well as seminar participants at the Kiel Institute, the University of Nottingham, and the Norwegian University of Science and Technology in Trondheim. The project (#5091 2024 0080) originated within "Improving Methods for Policy Analysis of Foreign Trade and Investment," financed by the German Federal Ministry for Economic Affairs and Climate Action, in cooperation with the Kiel Institute for the World Economy, the Institute for Applied Economic Research in Tübingen, Destatis, and the Deutsche Bundesbank. We thank the Research Data Centres of Destatis (RDC) and the Bundesbank (RDSC) for their continuous support. Data analyzes were performed on-site at the RDC of Destatis in Wiesbaden and Berlin.

The responsibility for the contents of this publication rests with the authors, not the Institute. Since working papers are of a preliminary nature, it may be useful to contact the author of a particular issue about results or caveats before referring to, or quoting, a paper. Any comments should be sent directly to the authors.

1 Introduction

Geopolitical tensions and rising pressures towards trade disintegration are increasingly shaping global trade dynamics and compelling firms to revise their internationalization strategies. Exporters, in particular, need to adjust to new protectionist barriers and subsequent reductions in access to export markets. Recent research has identified various ways in which exporting firms can respond to such negative shocks – such as trade diversion to new markets, modifying their product portfolios, or adjusting mark-ups in foreign markets (see, for example, Fernandes and Winters (2021), Graziano et al. (2021), Grossman et al. (2024), Jiao et al. (2024)). However, these studies typically focus on goods trade. In this paper we highlight another adjustment mechanism -– firms can supplement their goods exports with services.

While it is widely recognized that services trade is becoming more important (e.g., Antràs (2025), Baldwin et al. (2024)), our understanding of the interaction between goods and services trade is still limited. As Ariu et al. (2020) show, goods and services are in many cases traded in bundles, in particular by large firms. For example, car manufacturers bundle car sales together with insurance or finance contracts, or machinery producers export equipment alongside engineering services to support installation and integration into customers' production processes. What are the benefits of such bundling of goods and services? In particular, might exporting both goods and services to the same destination market allow such firms – which we refer to as dual exporters – to adapt more smoothly to negative shocks?

This is the question we address in this paper. To do so, we combine, for the first time, novel monthly microdata on international trade in goods and services for firms in Germany at the firm–country–product and service-type level. Using these data, we analyze how firms adjusted their goods and services exports in response to a major disintegration announcement, namely the Brexit referendum, which serves as a natural experiment. With Germany as Europe's largest manufacturer and goods exporter, and the UK's second-largest trading partner, this provides an ideal setting to study a hitherto neglected margin of firm resilience, namely services as an internal hedge against shocks.

We first document several new facts about dual exporters from our data. First, although firms exporting both goods and services are relatively rare, they play a dispro-

portionately important role in aggregate trade. Only 2% of all firms in our dataset export both goods and services, compared with 86.5% that export only goods and 11.4% that export only services. Nevertheless, they account for 42% of total goods exports and 37% of total services exports. Second, dual markets are strongly dominated by goods trade. For the average dual exporter, roughly 80% of total export sales originate from goods, while the remaining 20% stem from services. Third, while dual exporters export goods and services similar to those exported by pure goods or services exporters, they typically sell their goods alongside product-related and enterprise-related services. These include technical and engineering services, research and development, maintenance and repair work, as well as financial, legal, or consulting services. In contrast, services that are not closely tied to manufactured products – such as communication, health, or education services – are much less likely to be bundled with goods. Thus, dual exporters primarily combine goods with services that are complementary to manufactured products.

Our paper then goes beyond merely establishing these facts, asking whether services exports can help dual exporters to adjust to negative shocks. We exploit the detailed microdata on goods and services exports for the near-universe of exporters in Germany in a difference-in-differences framework using the Brexit referendum as an arguably exogenous shock. Using monthly observations for the same firm selling the same good or service to buyers in the UK and to other countries, we can cleanly identify the differential response to the shock in the UK market relative to other markets, and examine how this response differs between dual exporters and firms exporting only goods or only services.

Our findings reveal that firms exporting only goods or only services experience a slow down in their value of exports to the UK compared to other destinations following the Brexit referendum. Dual exporters are affected differently. While their goods exports to the UK decline more sharply than for pure goods traders, this is not the case for their services exports. Indeed, dual exporters can increase their exports of goods-related services to the UK after the referendum, and this at least partly compensates for the fall in goods exports. These results are robust to alternative fixed effects specifications, including controls for product-specific demand shocks, to alternative definitions of dual trading at the firm rather than the firm-country level, and to alternative control groups.

Further analysis shows that the more severe reduction in the export value of good exports for dual exporters is due to a more aggressive reduction in prices, while quanti-

ties remain largely unaffected. Looking into goods and services–type heterogeneity, we find that the more resilient services export performance is concentrated among dual exporters selling intermediate and investment goods, and for exports of product-related, enterprise-related and IP-related services types. Overall, these findings suggest that services can cushion the decline in goods exports to the UK for dual traders. Indeed, when we aggregate the exports of goods and services to the firm–country level, dual exporters recorded no statistically detectable decline in total exports to the UK, whereas both groups of single-mode exporters to the UK saw significant declines. Looking at the extensive margin, results show that UK export participation declines significantly relative to other destinations for goods-only and services-only exporters, while this UK-specific decline is negligible for dual exporters. This is in line with the idea that there are complementarities between goods and services exports at the firm level that shape exporters' responses to negative shocks.

Motivated by these empirical findings, we develop a simple theoretical model that rationalizes the differential responses of dual exporters by introducing one-way complementarity between goods and services. Specifically, we assume linear demand with the property that service sales enhance demand for a firm's own goods, following Ariu et al. (2020). Notably, this demand linkage differs from standard multiproduct-firm models, in which a firm's products are typically substitutes, so that expanding one product line cannibalizes sales of the others (e.g., Eckel and Neary 2010; Hottman et al. 2016). Even when products are complements, e.g., a printer and its ink cartridges, demand for the add-on is derived from sales of the core product, and selling more cartridges does not make the printer more attractive. In our setting, by contrast, services such as installation or maintenance raise buyers' valuation of the good itself. This mechanism implies that dual exporters strategically set lower prices for their services – especially for product-related services – to stimulate goods demand.

Modeling the Brexit referendum as an appreciation of the euro relative to the British pound (or as an increase in trade uncertainty), the model predicts that dual exporters reduce goods prices more strongly than single-mode exporters, while service prices may rise when complementarities are sufficiently strong. Under high complementarity, services operate in less elastic regions of demand, allowing dual exporters to increase service sales even as goods sales decline. We further assess several alternative theoretical mecha-

nisms and show that none are capable of reproducing the observed pattern in which dual exporters reduce goods sales but increase (or maintain) complementary service sales after a shock. This highlights the central role of one-way complementarity in explaining the heterogeneous, dual-specific adjustment to the Brexit referendum.

Related Literature: Recent literature has increasingly emphasized the interconnected nature of goods and services trade at the firm level. Earlier work on this relationship focused on the impact of the availability of imported services inputs on firms' ability to export goods (Debaere et al. 2013; Berlingieri et al. 2025; Fauth et al. 2025) and import physical intermediates (Ariu et al. 2019) – in other words, it looks at complementarities between services imports and goods trade. We expand on this literature by investigating complementarities between the simultaneous exporting of goods and services at the level of the firm, which we refer to as dual exporting.

This phenomenon has only recently attracted attention in the international trade literature. In the paper that is most closely related to ours, Ariu et al. (2020) theoretically and empirically document that dual exporters can, by providing services with their goods, increase the demand for their goods and, in turn, increase their markup, which leads to improving the perceived quality of their products. In their theoretical model, they define one-way complementarity in the sense that services exports complement goods exports; a concept that we adopt and expand on in our theory. In their empirical analysis, they show, using micro data for Belgium, that this one-way complementarity appears to be borne out by the data – services exports can boost goods exports at the firm level. We go beyond establishing that such complementarities exist by asking how the complementarities may help dual exporters to adapt to an exogenous negative shock. We show that firms can use services exports to cushion drops in goods exports. Our paper thus offers new insights into the interrelated relationship between goods and services trade.

More broadly, by looking at firms that simultaneously export goods and services our work also links to the theoretical and empirical literature on multi-product firms (e.g., Eckel and Neary (2010), Hottman et al. (2016), Eckel and Riezman (2020), and Irlacher (2024) for a recent review). This literature has emphasized supply-side linkages and substitutability across goods and we return to this literature in Section 5.5 below. Our work contributes by introducing a demand-side linkage between goods and services.

Finally, the consequences of economic disintegration – such as Brexit or the fragmentation of global value chains – have spurred a growing body of research examining its effects on international trade. Several studies analyze how disintegration alters trade flows and firm behavior, however usually with a focus on goods (see, among others, Freeman et al. 2025; Graziano et al. 2021; Fajgelbaum et al. 2024; Huang et al. 2023; Gopinath et al. 2025; Jiao et al. 2024). Only a few papers, such as Ahmad et al. (2023) and Breinlich and Magli (2024), and Bhalotia et al. (2025) consider the impact on services trade. Evidence on the impact of shocks on goods and services trade simultaneously in a common empirical framework is scarce. An exception is Breinlich et al. (2026) who study the adjustment to Brexit of UK firms exposed to the EU through intermediate goods and services imports. They find that firms relying on both experience a smaller decline in EU intermediate goods imports following the implementation of the UK–EU Trade and Cooperation Agreement, but larger declines in employment, sales and wages. We complement this work by examining adjustments on the export side, showing how dual exporters use services exports to partly offset declines in goods export sales. In doing so, this paper is among the first to jointly analyze the impact of a disintegration shock on both goods and services trade at the firm level and contributes to a more comprehensive understanding of how firms navigate structural disruptions in the global trading environment.

2 Background: The Brexit referendum

On 23 June 2016 voters in the United Kingdom were asked in a national referendum whether the country should remain a member of the European Union. With a turnout of over 70 percent, 52 percent voted to leave. The prospect of the UK leaving the EU – widely referred to as *Brexit* – had been debated for years, but the outcome came as a surprise to most forecasters, financial markets, and the public, as opinion polls and betting markets had largely expected a "Remain" victory.

This unexpected result triggered an immediate and sharp depreciation of the British pound of about 10 percent against the euro and the US dollar, alongside a surge in policy uncertainty as to the future of the economic relationship between the UK and EU countries. As shown in Figure 1 the depreciation against the euro was significant and persistent over time, lasting well into 2017. Similarly, trade-policy uncertainty also increased

tremendously in the immediate aftermath of the reference. While it declined again somewhat in the months after June 2016, uncertainty remained much higher than its 2015–2016 levels. Importantly, while inflation did rise moderately due to higher import prices, there was no abrupt collapse in economic activity in the UK: output growth remained positive and macroeconomic conditions outside the exchange rate and uncertainty channels were broadly stable.[1]

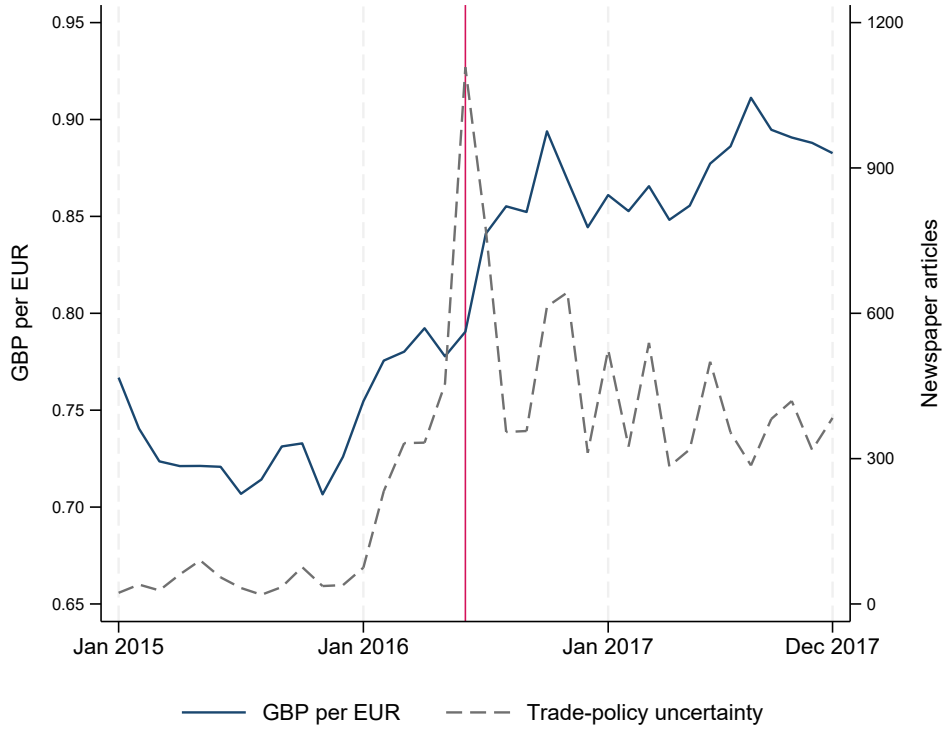
Hence, the outcome of the Brexit referendum generated an unforeseen disintegration shock with strong exchange rate and uncertainty effects, but without a recession. Additionally, it is important to point out that the referendum was separated by more than three and a half years from the UK's actual withdrawal from the EU, which only happened on 31 January 2020. Before that, trade between the UK and EU member countries was still carried out under the old rules, and actual trade policy changes (i.e., trade barriers) only occurred from 2020 onwards. As our analysis relates to the immediate period around the referendum (2015 – 2017) we can therefore be reasonably confident that actual trade barriers do not play a role for our analysis. Hence, our theoretical framework emphasizes exchange rate changes and uncertainty.

Recent studies have exploited the Brexit referendum as an example of a move towards economic disintegration as a quasi-natural experiment to study, among others, the nature of price rigidities (Hobijn et al. 2021), firms' export adjustments to exchange rate or uncertainty shocks (Fernandes and Winters 2021; Crowley et al. 2020), output costs for the UK economy (Born et al. 2019; Bloom et al. 2019), and the impact of trade policy uncertainty on local labor markets (Javorcik et al. 2026).

In this paper, we build on this literature but shift the focus to identifying a new mechanism firms may use to adjust to disintegration shocks: the interaction between goods and services trade. The referendum provides a unique setting to see whether firms can use services exports to cushion potential negative impacts on good exports. While the shock simultaneously affected all exporters to the UK, only some firms could rely on both goods and services as margins of adjustment. This heterogeneity allows us to identify whether access to both margins of trade – goods and services – shaped firms' ability to absorb and adapt to the shock.

[1] For a more detailed discussion of the institutional context, we refer the reader to Sampson (2017) or Dhingra et al. (2017).

Figure 1: Sterling and Brexit-related trade-policy uncertainty



Notes: The exchange rate is a monthly average, expressed as pounds sterling per euro (left axis); an increase indicates an appreciation of the euro. Trade policy uncertainty is measured by the monthly number of articles in ten major UK newspapers jointly mentioning terms relating to Brexit or the EU, uncertainty, and trade policy (right axis). The search terms include services-related terms such as "services agreement". The measure is constructed from Factiva data by Javorcik et al. (2026). The vertical line marks June 2016, the month of the Brexit referendum. Sources: ECB data portal, Javorcik et al. (2026), own illustration.

3 Data and stylized facts

3.1 Data

Our empirical analysis uses a novel monthly firm level dataset that links Germany's official statistics on international trade in goods and services.

Data on goods exports come from the *AFiD Module Statistics on Foreign Trade in Goods* (*Außenhandelsstatistik*, AHS) provided by the Federal Statistical Office (RDC 2024).[2] For each reported transaction, the dataset contains information on the direction of trade, the product category at the 8-digit Combined Nomenclature (CN8) level, the partner country,

[2] doi: 10.21242/51911.2018.00.05.1.1.0

and the value and quantity at the monthly level. The AHS combines two sources. Extra-EU transactions are recorded exhaustively via the "Extrastat" customs system. Intra-EU trade is collected through the "Intrastat" system, which requires only firms whose annual intra-EU exports exceed EUR 500,000 to report their trade activities. Firms below this threshold are not obliged to report; their trade is reconstructed from VAT records but lacks product level detail.[3] As in Ariu et al. (2020), we retain only transactions that involve a transfer of ownership for payment and exclude other exports such as returns or warranty replacements, contract processing, and transfers provided free of charge. We further drop all monthly transactions with a reported value below EUR 1,000.

Data on services exports come from the *Statistics on International Trade in Services* (SITS) compiled by the Deutsche Bundesbank (Biewen and Meinusch 2023).[4] The SITS data cover cross-border service transactions between residents and non-residents that exceed an aggregate reporting threshold of EUR 12,500 per month, partner country, and service type. Transactions below this threshold may still appear in the micro data if reported voluntarily. For each transaction, the data provide the direction of trade, the service type according to the sixth edition of the Balance of Payments and International Investment Position Manual (BPM6), its value, the destination country, as well as the year and month in which it occurred. Table A1 gives an overview of the service types distinguished in the data.

Linking these two data sets has only recently become possible. It is based on harmonized firm identifiers from the *AFiD Module Combined International Trade and Investment Data* (CITID), developed by the German Federal Statistical Office and the Deutsche Bundesbank (Boddin et al. 2025).[5] This, uniquely, allows us to observe firms' goods and services exports jointly, at the firm–country–product/service-type–month level. We can therefore observe if a firm only exports goods, only services, or both to a given destination. In our empirical analysis, we refer to a firm as a dual trader if it exports both goods and services to the same country.[6] To our knowledge, this is the first use of such a com-

[3] A further limitation of the Intrastat system is that the statistical reporting unit may represent a corporate group rather than a single firm. In this case, the Federal Statistical Office assigns the foreign trade flows reported at the group level to individual firms based on information from VAT records. See Kruse et al. (2021) for a detailed description of the methodology, and Görg et al. (2024) for an application using this data.

[4] doi: 10.12757/Bbk.SITS.01010723.07.01

[5] doi: 10.21242/00002.2024.00.03.1.1.0

[6] Note that our data do not identify importing firms, which is why we define dual trading at the firm

bined dataset to study the joint adjustment of goods and services exports to a major trade shock.

Our focus is on analyzing the short-run adjustments of firms in response to the referendum. To do so, we analyze monthly exports at two levels of aggregation: firm–country–month (for total goods, total services, or combined exports) and firm–country–product/service-type–month (for disaggregated flows). Our sample period is from July 2014 through July 2017. For goods, our main dependent variables are the export value, quantity, and price of a firm–country–product combination. Export values are reported in euros. For physical quantities, the data provide two alternatives: the first reports the weight in kilograms; the second reports a supplementary physical unit such as number of items, liters, or meters, for selected products. We use the latter, where available, and the weight in kilograms for all other products. We proxy export prices by unit values, i.e. by the ratio between export value and quantity, as is standard in the literature (Amiti et al. 2014; Berman et al. 2012). For services, our main dependent variable is export value, as measures of quantity and prices are not available in services data.

Following Fernandes and Winters (2021), we use year-over-year log changes of these variables to account for potential seasonality in our data and to absorb unobserved characteristics specific to a firm–product–country combination. Given our sample period, this yields growth rates covering one year before and one year after the referendum. As our empirical analysis relies on comparing monthly exports of firms selling the same product to the UK and to other destinations before and after the referendum, we restrict our sample to firms with an active trade relationship at the time of the referendum, i.e. in 2015. Section 4 provides a detailed description of our empirical strategy.

3.2 Motivating empirical evidence

We begin by documenting three novel facts on German exporters. We distinguish between firms exporting goods only ("goods exporters"), services only ("services exporters"), or both ("dual exporters").

or firm–country level, respectively, as is common in the research examining the interconnections between goods and services at the firm level (Ariu 2016; Ariu et al. 2020).

#1 Dual exporters are few but they matter for aggregate trade. Table 1 displays descriptive statistics by type of exporter. In 2015, only 2 percent of firms in our data – corresponding to 3,045 firms – exported both goods and services, compared with 86.5 percent that exported only goods and 11.4 percent that exported only services. Despite their small number, dual exporters accounted for 42 percent of aggregate goods exports and 37 percent of aggregate services exports.[7] They are systematically larger than single-mode exporters, shipping a wider range of products and services to more destinations. Importantly, as shown in Appendix Tables A2, A3, A4, and A5, dual exporters are present across the same broad goods and service types as goods or service exporters, i.e. dual exporting is not confined to a niche.

Table 1: Summary statistics at the firm level by exporter status, 2015

	#	Mean	SD	P10	P50	P90
Goods exporters						
value^g	130,000	4,163.7	58,000.6	4.12	96.0	5,101.7
#countries^g	130,000	7.26	11.9	1.00	2.00	21.0
#products^g	130,000	8.17	23.4	1.00	2.00	17.0
Services exporters						
value^s	17,167	13,547.7	247,580.3	26.0	451.0	10,771.0
#countries^s	17,167	5.13	9.02	1.00	2.00	13.0
#products^s	17,167	1.79	1.92	1.00	1.00	3.00
Dual exporters						
value^g	3,045	129,683.3	1,533,647.6	19.8	6,230.3	134,941.6
#countries^g	3,045	25.01	27.4	1.00	15.0	65.0
#products^g	3,045	42.22	78.5	1.00	14.0	109.0
value^s	3,045	44,404.2	818,405.7	43.0	1,111.0	28,729.0
#countries^s	3,045	9.16	13.7	1.00	4.00	23.0
#products^s	3,045	3.14	3.71	1.00	2.00	7.00

Notes: Observations are at the firm level, and dual exporting is defined at the firm level, i.e. a firm is classified as a dual trader if it exports both goods and services. The superscripts g and s stand for goods and services exports, respectively. Values are in EUR 1,000. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2015, own calculations.

[7] This aligns with Ariu (2016), who shows, using Belgian transaction data, that only a small minority of firms export both goods and services, yet these firms represent a substantial share of total trade.

#2 Dual markets are dominated by goods trade. For markets to which a firm exports both goods and services (i.e. "dual markets"), goods sales constitute the bulk of trade.[8] In 2015, the average firm–country pair in a dual market recorded goods exports of about EUR 20.6 million versus services exports of about EUR 4.0 million (Table 2). On average, firms sold roughly 24 distinct goods products and 2 distinct service types in such markets. These patterns underscore the asymmetric importance of goods relative to services in dual trading relationships.

Table 2: Summary statistics at the firm–country level for dual markets, 2015

	#	Mean	SD	Sum
Dual markets				
value^g	15,540	20,639.1	194,528.9	320,731,140.1
value^s	15,540	4,041.3	50,023.2	62,801,263.0
#products^g	15,540	23.66	48.04	
#products^s	15,540	2.09	2.33	
# firms	2,589			

Notes: Observations are at the firm-country level. A dual market is a country to which a firm exports both goods and services in 2015. The superscripts g and s stand for goods and services exports, respectively. The number of firms differs from Table 1 because dual exporting is defined at the firm-country level, rather than the firm level. Values are in EUR 1,000. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2015, own calculations.

#3 Dual exporters bundle their goods with product- and enterprise related services. Which services do dual exporters typically export alongside their goods? Table 3 reports the number and share of dual exporters supplying each service category to at least one destination where they also export goods. Product-related and enterprise-related services are the most prevalent, supplied by approximately 52 and 50 percent of dual exporters, respectively. Such services include maintenance and repair work, research and development, technical and engineering services, as well as business and consulting services (see Appendix Table A7 for a detailed list of service types bundled with goods). Most commonly, these services are exported alongside machinery, equipment, and industrial inputs, implying that dual exporting is particularly relevant for investment and interme-

[8] Note that the number of firms that are dual traders differs between Tables 1 and 2 as dual trading is defined at the firm level in Table 1 but at the firm–country level in Table 2.

diate goods.[9] In contrast, services that are not closely tied to manufactured products – such as personal services or government transactions – are bundled by far fewer dual exporters. Thus, dual exporters primarily sell goods with services that plausibly complement manufactured products.

Table 3: Top BPM6 service categories exported in dual markets

Service category i	# firms exporting i	% dual exporters
Product-related services	1,335	51.6
Enterprise-related services	1,289	49.8
Transport	550	21.2
IP-related services	522	20.2
ICT services	404	15.6
Personal services	366	14.1
Other	308	11.9
Construction services	159	6.1
Travel	157	6.1
Insurance	127	4.9
Transfers	90	3.5
Government transactions	67	2.6
Total # firms	2,589	

Notes: The sample consists of firms that export both goods and services to at least one country in 2015. For each service category, the table reports the number and share of these firms exporting that service to a country where they also export goods. Firms may appear in multiple service categories. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2015, own calculations.

4 Empirical analysis

4.1 Empirical strategy

In order to investigate whether firms can use their dual-trading status to adapt to an exogenous shock differently than single traders, we exploit the Brexit referendum as a natural experiment. Utilizing this shock, we estimate the following difference-in-differences

[9] Appendix Table A6 reports the most common combinations of services and HS2 goods categories exported dual traders. The leading combinations involve product- and enterprise related services as well as machinery and mechanical appliances, electrical machinery and equipment, and optical and other instruments.

model at the firm–country–product/service-type level with monthly data: [10]

$$\begin{aligned}\Delta \ln X^m_{fpct} = {} & \beta^m_1 (Post_t \times UK_c) + \beta^m_2 (Post_t \times Dual_{fc}) \\ & + \beta^m_3 (Post_t \times UK_c \times Dual_{fc}) \\ & + \rho^m \pi_{ct} + \delta^m_{fpc} + \delta^m_t + \varepsilon^m_{fpct}. \end{aligned} \tag{1}$$

The superscript m indicates that the dependent variable, coefficients, fixed effects, and error term are specific to goods or services trade. The dependent variable is the year-over-year log change in exports, $\Delta \ln X^m_{fpct} = \ln X^m_{fpct} - \ln X^m_{fpc,t-12}$, which removes the seasonality of monthly trade flows and measures monthly export growth relative to the same month in the previous year. More specifically, X^m_{fpct} denotes the value of product or service type p exported by firm f to country c in month t. $Post_t$ is a dummy variable equal to one for months after the Brexit referendum in June 2016, and UK_c identifies the UK as the destination market. $Dual_{fc}$ is a binary indicator identifying dual trading at the firm–country level. It equals one if firm f exported both goods and services to country c in 2015 (pre-referendum) and zero otherwise. This pre-determined classification ensures that treatment status is not affected by the shock. We refer to firms exporting both goods and services to a given destination as dual exporters, unless otherwise specified. Firms that export only goods or only services to a given destination are single-mode exporters. That is, we define dual exporting at the firm–country level and a firm may be a dual exporter in one market and a single-mode exporter in another.[11]

We estimate separate models for goods and services, indicated by ($m \in g, s$), where g denotes goods and s denotes services. In each regression model, p denotes a goods product or a service type, respectively. This allows us to compare the development of exports in dual firm–country pairs with that in goods-only or services-only firm–country pairs, controlling for persistent heterogeneity at the firm–product/service-type–country level. The difference-in-differences framework compares changes in export growth to the UK with those to other destinations, before and after the referendum. The underlying export data span July 2014 to June 2017. As the dependent variables are year-over-year

[10] This is similar to Fernandes and Winters (2021) but extends their approach to the joint analysis of goods and services trade and to the role of dual traders.

[11] We relax this assumption in a robustness check below.

log changes, our regression sample thus covers July 2015 to June 2017, corresponding to one year before and one year after the Brexit referendum. We restrict our sample to firms that exported goods or services to the UK at least once in 2015, the year before the Brexit referendum.

The coefficients have the following interpretation. β_1^m measures the post-referendum within-firm change in monthly export growth of product p to the UK relative to other destinations for goods-only and services-only exporters. β_2 captures whether, after the referendum, dual and non-dual exporters evolved differently. β_3 is the key coefficient of interest: it captures the differential change in export growth to the UK for dual relative to single-mode exporters after the referendum. The total UK-specific effect for dual exporters is given by $\beta_1 + \beta_3$.

The specification includes rich fixed effects. Because the dependent variable is expressed in year-over-year log differences, time-invariant characteristics in levels for a firm–product–country cell are removed by construction. Firm–product–country fixed effects (δ_{fpc}^m) therefore capture differences in average growth rates specific to each unit, while month fixed effects (δ_t^m) capture shocks common to all goods and services exporters, respectively, in a given month. We also additionally control for monthly inflation in the destination market, π_{ct}, and cluster standard errors by destination country.[12] We estimate the model separately for goods and services. For goods, we examine values (value^g), quantities (quant^g), and unit values (uv^g) to disentangle volume from price adjustments. For services, data on quantities and prices are unavailable; hence the analysis focuses on export values (value^s).

Overall, our empirical strategy uses within-firm differences in export growth for a given product (good or service) across destinations to identify how the Brexit referendum affected exports to the UK relative to other markets. By contrasting dual and non-dual firm–country pairs for goods and services, we test whether access to both goods and services trade margins alters firms' adjustment to the referendum.

[12] As a robustness exercise, we replace the baseline fixed effects with firm–country and product–time fixed effects (δ_{fc}^m, δ_{pt}^m). This alternative specification allows for firm–country-specific average growth patterns and for product-specific shocks that vary over time but are common across firms and destination, providing a check on whether our results are sensitive to product- or service-type specific shocks such as demand fluctuations.

4.2 Baseline results

Table 4 summarizes the baseline estimates for goods exports. The results indicate that, following the referendum, year-over-year goods export growth to the UK fell by approximately 2 percentage points relative to other destinations for goods-only exporters.[13] The coefficient is statistically significant at the 1 percent level. For dual exporters, the decline was even larger: the interaction term $Post_t \times UK_c \times Dual_{fc}$, β_3^g, is negative and statistically significant at the 5 percent level, implying an additional average decline of 1.8 percentage points. The implied UK-specific effect for dual exporters, $\beta_1^g + \beta_3^g$, is therefore approximately -3.8 percentage points.

Table 4: Goods exports – Baseline regressions

	(1) $\Delta \ln(\text{value}^g)$	(2) $\Delta \ln(\text{quant}^g)$	(3) $\Delta \ln(\text{uv}^g)$
Post × UK	-0.020***	0.003	-0.023***
	(0.004)	(0.005)	(0.001)
Post × Dual_{fc}	-0.007	-0.018	0.010
	(0.007)	(0.011)	(0.006)
Post × UK × Dual_{fc}	-0.018**	0.010	-0.027***
	(0.007)	(0.011)	(0.006)
FE	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t
# obs.	13,933,546	13,933,546	13,933,546
# firms	22,773	22,773	22,773
R^2	0.154	0.155	0.154

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

The quantity and unit value results show that the contraction in export values is driven by price rather than quantity adjustments for both dual exporters and goods-only exporters. For goods-only exporters, the estimated UK-specific change in unit value growth is approximately -2.3 percentage points relative to other destinations (column 3), while the estimated change in quantity growth is close to zero and statistically insignificant (column 2). For dual exporters, the additional price effect is approximately -2.7

[13] This compares to an estimated 5.5 percentage point reduction in goods export growth for Portuguese goods exporters in Fernandes and Winters (2021).

percentage points and statistically significant at the 1 percent level, yielding an implied total effect of approximately -5.0 percentage points (column 3). By contrast, the additional quantity effect is statistically indistinguishable from zero (column 2).

The unit value results are consistent with dual exporters making larger downward adjustments in their euro-denominated export prices in the UK market. The pound's average euro value was approximately 13 percent lower in the twelve months following the referendum than in the preceding year. Lowering euro-denominated export prices limits the resulting increase in pound-denominated prices faced by UK buyers – in line with the literature documenting incomplete exchange-rate pass-through (Berman et al. 2012; Amiti et al. 2014) – with a stronger cushioning effect for goods supplied by dual exporters.

A possible interpretation of the stronger decline in euro-denominated unit values among dual exporters is that they reduced their markups more strongly in the UK market. A UK-specific price reduction implies lower markups if marginal costs remain unchanged or increase relative to other destinations. In fact, greater uncertainty regarding the future trade relationship between the EU and the UK could raise the effective cost of supplying the UK market. If prices fall while costs rise, price-cost margins would decline even more than the price reduction alone suggest. To the extent that marginal-cost changes are comparable across exporter types, the larger price reduction among dual exporters implies that they absorbed more of the adverse shock through lower markups, while exhibiting no statistically detectable additional decline in quantity growth.

Table 5 presents the corresponding estimates for services exports. For services-only exporters, the growth rate of exports to the UK dropped by approximately 6.2 percentage points relative to other destinations. The effect is statistically significant at the 1 percent level. By contrast, the triple interaction term for dual exporters is positive and equally significant, indicating that dual exporters were much less affected by the referendum. Its magnitude of approximately 6.0 percentage points almost entirely offsets the negative baseline estimate, yielding an implied UK-specific effect for dual exporters, $\beta_1^s + \beta_3^s$, very close to zero. This implies that the services export growth to the UK of dual exporters remained broadly stable after the referendum. This pattern contrasts with the pronounced contraction observed for pure services exporters.

The difference is economically substantial and contrasts with the goods results: dual

Table 5: Services exports – Baseline regressions

	(1) $\Delta \ln(\text{value}^s)$
Post × UK	-0.062***
	(0.009)
Post × Dual_{fc}	-0.012
	(0.013)
Post × UK × Dual_{fc}	0.060***
	(0.014)
FE	δ_{fpc}, δ_t
# obs.	595,050
# firms	4,976
R^2	0.159

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

exporters in the UK market experienced a sharper decline in goods export growth but no discernible reduction in services export growth compared to their single-mode counterparts. This pattern suggests that the joint provision of goods and services is associated with distinct adjustments across the two export margins. Since services quantities and prices are not separately observed, however, we cannot determine whether the higher resilience of services exports reflects differences in price adjustment, quantities supplied, or both.

Appendix Figure A1 displays event study graphs for the monthly UK-specific responses around the referendum. The graphs mirror the results presented in Tables 4 and 5. Goods export growth falls for goods-only exporters, while the additional effect for dual exporters is negative in all but one month the first half year after the referendum. For services, the decline among services-only exporters is accompanied by a positive additional effect for dual exporters in later months, consistent with the baseline results. As monthly trade flows are volatile, the estimates, unsurprisingly, fluctuate before as well as after the referendum. Importantly, there is no clear trend visible for any outcome variable in the months preceding the reference window, although some pre-referendum estimates differ from zero.

Taken together, our findings reveal asymmetric responses of dual exporters' goods and services exports to the Brexit referendum. In addition, we establish that their exports react differently compared to goods-only or services-only exporters. While dual exporters cut prices more aggressively and experience a sharper contraction in goods exports, they are able to stabilize services exports, cushioning the overall impact. These opposing responses suggest that services may provide an additional margin of adjustment for exporters to shocks, potentially cushioning the impact on combined exports. This is an issue we return to below.

Before doing so, we look at robustness checks in the next section, and also explore heterogeneity across goods categories and service types to shed light on the mechanism behind this stabilizing role.

4.3 Robustness

In this section, we probe the robustness of our findings to alternative fixed effects, control groups, and definitions of dual exporting.

Alternative fixed effects. A first set of robustness checks concerns the choice of fixed effects. Because the dependent variable is specified in first differences, time-invariant characteristics of a firm–product–country are already eliminated by construction. In our baseline, we nevertheless include firm–product–country and month fixed effects. These absorb systematic differences in average growth rates across firm–product–country cells and common shocks affecting all firms in a given month. As a robustness exercise, we re-estimate the regressions replacing these with firm–country and product–time fixed effects. The former allow for firm–country-specific trends across all products, while the latter control for product-specific shocks that vary over time but are common across firms. The results, reported in Appendix Tables A8 and A9, are qualitatively unchanged. Goods exports to the UK still decline more strongly for dual exporters relative to pure goods exporters, with the additional contraction driven by unit values. Likewise, for services, pure service exporters show strong declines while dual exporters maintain stable exports. These findings indicate that our results are not driven by product-specific demand fluctuations or by the particular choice of fixed effects specification.

Alternative control groups. A second robustness check uses different control groups. In our baseline specification, dual traders are compared with all goods-only and all services-only exporters, respectively. While all average exporters are multi-product exporters, dual traders export higher values and more products to more destinations than the average goods-only exporter (see Table 1). To rule out that our results are merely driven by firm size (and thus the fact dual traders merely export more products), we re-run our regressions on three different sub-samples: in addition to all dual exporters, we include the (i) largest 25% of goods-only exporters in terms of their total value exported in the base year (2015), (ii) the largest 10% of goods-only exporters, and (iii) the largest 5% of goods-only exporters. Results in Appendix Tables A11, A12, and A13 indeed confirm that our findings for dual traders are robust when they are compared to (more similar) large (multi-product) exporters.

Alternative measure of dual exporting. A third robustness check redefines dual exporters at the firm level rather than the firm–country level. In this alternative measure, a firm is classified as dual if it exported both goods and services to the UK in 2015. The corresponding estimates, shown in Tables A14 and A15, closely mirror our baseline results. The similarity of results across the two definitions shows that our findings are not sensitive to how dual exporting is measured and that the stabilizing role of services persists under a broader firm level classification.

4.4 Heterogeneity across goods and service types

Our baseline results thus far suggest that dual exporters adjust differently to the Brexit referendum shock than single-mode exporters, with sharper contractions in goods export growth but a more resilient services export performance. To investigate the mechanisms behind this distinct response, we explore heterogeneity across goods and services categories, focusing on the role of complementarities.

Fact 3 above establishes that dual exporters typically export product- and enterprise-related services together with their goods, suggesting such complementarities. If the contrasting responses from dual and single export firms indeed reflect such linkages between goods and services, we would expect them to be particularly pronounced for categories in which joint provision of goods and services is prevalent and economically relevant.

We look at aspects of goods exports first. Table 6 examines the heterogeneity across broad goods categories by distinguishing between intermediates, investment goods, and consumer goods. The results indicate that the additional negative effect for dual exporters is concentrated in intermediates and investment goods. For intermediates, the triple interaction implies an additional decline in export growth of approximately 2.5 percentage points on top of the 1.5 percentage point decrease estimated for goods-only exporters. For investment goods, the negative impact of the Brexit referendum is primarily visible for dual exporters. Their additional decline in growth of exports to the UK relative to other markets is 3.8 percentage points. In contrast, the baseline effect for goods-only exporters is small and statistically insignificant. The implied overall effects for both intermediate and investment goods exports of dual traders are around -4 percentage points, on average.

Table 6: Goods exports – Regressions by product categories

	(1) Intermediates	(2) Investment goods	(3) Consumer goods
Post × UK	-0.015***	-0.007	-0.045***
	(0.004)	(0.006)	(0.004)
Post × Dual_{fc}	-0.012	-0.003	-0.009
	(0.007)	(0.009)	(0.009)
Post × UK × Dual_{fc}	-0.025***	-0.038***	0.022**
	(0.007)	(0.009)	(0.009)
FE	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t
# obs.	6,656,435	4,450,142	2,761,241
# firms	15,758	12,364	8,603
R^2	0.155	0.149	0.158

Notes: The dependent variable is $\Delta \ln(\text{value}^g)$ in all columns. Observations are at the firm–country–product–month level. Products are grouped according to Eurostat's Main Industrial Groupings (MIG) classification into intermediate goods, investment goods, and consumer goods, with the latter combining durable and non-durable consumer goods. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

Consumer goods display the opposite pattern. Goods-only exporters experienced a decline in UK export growth of approximately 4.5 percentage points. For dual exporters, the triple interaction is positive and statistically significant at the 5 percent level, indicat-

ing that this decline was smaller. The implied total effect is around half the size compared to goods-only exporters. Thus, the stronger contraction for goods exports documented in Table 4 is not common to all dual exporters. Instead, it is concentrated in intermediates and investment goods, whereas dual exporters of consumer goods experienced a more favorable response than goods-only exporters. The additional negative effects for dual exporters are therefore concentrated in product categories frequently exported alongside services such as maintenance, software, or technical support (see Fact 3).

Table 7 turns to services and disaggregates exports across different categories according to the Bundesbank's classification of service types (see Table A1). The near-zero UK-specific response of services export growth for dual exporters in the baseline masks substantial variation across service categories. Exports of services-only traders saw a statistically significant decline in every category, with coefficients ranging from -0.05 and -0.06 for intellectual property- and product-related services, respectively, to -0.07 for enterprise and ICT services. The additional response associated with dual exporting, however, differs sharply across categories. For product-related, enterprise-related, and intellectual property-related services, the triple interactions are positive, large, and statistically significant. Quantitatively, the additional effects more than offset the negative baseline point estimates, suggesting increased export growth for dual exporters in the UK market relative to other destinations in categories closely linked to the provision and use of goods (Fact 3).

The pattern is different for the remaining service categories. For ICT services, the triple interaction is negative, large, and statistically significant, implying a decline of dual exporters' services exports related to information and communication technology. The additional effect is also negative for transport and other services, but only statistically significant for the latter. Overall, the results suggest that the resilience of services associated with dual exporting is concentrated in particular service categories rather than reflecting a general advantage across all services. Its concentration in product-related, enterprise-related, and IP-related services is consistent with complementarities playing a role in the adjustment of dual exporters.

Finally, Table 8 examines whether the services export response varies with firms' goods specialization. We classify firms according to the goods category accounting for the largest share of their total goods export value across all destinations in 2015, distinguish-

Table 7: Services exports – Regressions by service types

	(1) Product-related	(2) Enterprise-related	(3) IP-related	(4) ICT	(5) Transport	(6) Other
Post × UK	-0.064***	-0.074***	-0.049***	-0.071***	-0.056***	-0.049***
	(0.019)	(0.011)	(0.017)	(0.017)	(0.013)	(0.016)
Post × Dual_{fc}	-0.031	0.023	-0.076*	-0.061**	0.008	0.040
	(0.031)	(0.023)	(0.045)	(0.024)	(0.026)	(0.029)
Post × UK × Dual_{fc}	0.211***	0.091***	0.290***	-0.192***	-0.033	-0.063**
	(0.031)	(0.023)	(0.045)	(0.024)	(0.026)	(0.030)
FE	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t
# obs.	74,554	155,083	42,095	72,261	146,929	104,128
# firms	1,321	2,330	634	824	914	1,109
R^2	0.149	0.149	0.233	0.164	0.176	0.141

Notes: The dependent variable is $\Delta \ln(\text{value}^s)$ in all columns. Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

ing intermediate, investment, and consumer goods. This predetermined classification is held fixed across destinations and over time. Firms predominantly exporting other goods are excluded, and services-only exporters form the reference group.

The results indicate that the more resilient services export performance following the referendum is concentrated among exporters specialized in intermediate and, to a lesser extent, investment goods. For intermediate-goods specialists, the positive triple interaction more than offsets the negative baseline estimate for services-only exporters, yielding a sizeable positive overall point estimate. For investment-goods specialists, the additional effect is positive and statistically significant but smaller in absolute magnitude than the negative baseline estimate, leaving the overall estimate negative. Exporters specializing in consumer goods instead exhibit a pronounced additional decline, significant at the 10 percent level.

These findings complement the goods-category results in Table 6. The additional contraction in goods export growth is concentrated in intermediates and investment goods, while services exports are more resilient among dual exporters specializing in these categories. This alignment supports the interpretation that goods–services complementarities

shape exporters' responses to the shock.

Table 8: Services exports – Heterogeneity by firm-level goods specialization

	(1) $\Delta \ln(\text{value}^s)$
Post × UK	-0.063***
	(0.009)
Post × Intermediate	0.049***
	(0.018)
Post × Investment	-0.054***
	(0.019)
Post × Consumer	0.021
	(0.047)
Post × UK × Intermediate	0.159***
	(0.018)
Post × UK × Investment	0.038**
	(0.019)
Post × UK × Consumer	-0.089*
	(0.047)
FE	δ_{fpc}, δ_t
# obs.	590,634
# firms	4,939
R^2	0.159

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

4.5 Regressions on combined firm–country exports

The results thus far are in line with the idea that service exports act as an additional channel of adjustment for dual exporters, cushioning the impact of overall export performance. In order to investigate this further, we now look at whether the services expansion we observe may be large enough to matter for total trade. To so so, we aggregate the exports of goods and services to the firm–country level and estimate difference-in-differences regressions akin to Eq. (1), however, now at the firm–country level. Specifically, we estimate:

$$\Delta \ln X_{fct} = \beta_1 (Post_t \times UK_c) + \rho \pi_{ct} + \delta_{ft} + \delta_c + \epsilon_{fct}, \tag{2}$$

where X_{fct} denotes the value of *total* exports of firm f to country c in month t, $Post_t$ is an indicator for the months after the referendum in June 2016, and UK_c identifies the UK as the destination market. As for our product-/service-type level regressions, we define the dependent variable as the year-over-year log change, $\Delta \ln X_{fct} = \ln X_{fct} - \ln X_{fc,t-12}$. This removes time-invariant firm–country characteristics and controls for seasonal export patterns. The specification includes firm–time fixed effects (δ_{ft}), which capture all contemporaneous shocks at the firm level, and country fixed effects (δ_c), which absorb persistent differences across destinations. Identification therefore relies on within-firm comparisons of export growth to the UK and other destinations over time. We also include monthly destination-specific inflation, π_{ct}, and cluster standard errors by country. We estimate Eq. (2) separately for firms that exported only goods, only services, or both goods and services to the UK in 2015.

Table 9 reports the results. The estimates indicate that the growth rate of exports to the UK fell by approximately 2.3 percentage points for pure goods exporters (column 1) and by 4.6 percentage points for pure services exporters (column 2), relative to their export growth to other markets. By contrast, the growth rate of combined goods-and-services exports of dual exporters remained unchanged, i.e., is not statistically different from zero (column 3).[14] Taken together, the disaggregated and aggregate results indicate that dual exporters contracted goods exports more sharply than pure goods traders, expanded complementary services, and recorded no statistically detectable decline in total exports to the UK, whereas both groups of single-mode exporters to the UK saw significant declines. These findings are consistent with services cushioning the decline in goods exports for dual traders.

[14] The number of observations and firms differs between estimates of Eq. (1) and Eq. (2) due to differences in the aggregation level, i.e., product level vs. firm–country level estimates, and different sets of fixed effects, e.g., firm-product-country vs. firm-time fixed effects. Consequently, the point estimates arising from Eq. (1) and Eq. (2) are not directly comparable. The latter regression takes the log of the value-weighted sum at the firm–country level, while the product level results average log changes with equal weight across firm–product–country cells. In addition, dual status is destination-specific in Eq. (1), while the subsamples in 9 are defined exclusively by firms' export status in the UK.

Table 9: Firm–country level regressions: Response of total trade

	(1) Goods-only UK exporters $\Delta \ln(\text{value})$	(2) Services-only UK exporters $\Delta \ln(\text{value})$	(3) Dual UK exporters $\Delta \ln(\text{value})$
Post × UK	-0.023***	-0.046***	-0.009
	(0.005)	(0.012)	(0.010)
FE	δ_{ft}, δ_c	δ_{ft}, δ_c	δ_{ft}, δ_c
# obs.	4,758,985	394,957	369,906
# firms	21,941	3,733	696
R^2	0.141	0.201	0.104

Notes: Observations are at the firm–country–month level. The subsamples are based on firms' trade status with the UK in 2015. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

4.6 Probability of exporting

Finally, we examine whether the Brexit referendum changed the probability that a firm exports goods and/or services to the UK. To do so, we collapse our data to the firm–country–half-year level. Aggregating monthly exports to half-years reduces the influence of the infrequency of shipments on whether a firm is classified as serving a destination (Bekes and Murakozy 2012). We define Y^m_{fct} to equal one if firm f records positive exports of type $m \in g, s$ to country c in half-year t, and zero otherwise. As above, g denotes goods and s denotes services. As in the intensive margin analysis, we restrict the sample to firms that exported goods or services to the UK at least once in 2015. For each selected firm, we retain destinations to which it exported goods or services at least once during the sample period. We construct a balanced half-yearly panel for these firm–country pairs, assigning 1 to half-years with recorded transactions and 0 otherwise. The estimates therefore describe changes in export participation among firms with a pre-referendum UK trading relationship, rather than entry into the UK market by firms outside this group. The estimation sample spans the second half of 2014 through the first half of 2017, matching the underlying data window used for the intensive-margin analysis.[15]

[15] The intensive margin regressions use year-over-year growth rates from the second half of 2015 through the first half of 2017, which require export data beginning in the second half of 2014.

The linear probability model we estimate separately for goods and services trade, respectively, is given by:

$$\begin{aligned} Y_{fct}^{m} = \beta_1^m (Post_t \times UK_c) + \beta_2^m (Post_t \times Dual_{fc}) \\ + \beta_3^m (Post_t \times UK_c \times Dual_{fc}) + \delta_{fc}^m + \delta_{ft}^m + \varepsilon_{fct}^m. \end{aligned} \tag{3}$$

Again, $Post_t$ equals one from the Brexit referendum onwards, and $Dual_{fc}$ is the destinations-specific classification of dual exporting based on exports in 2015. Firm–country fixed effects δ_{fc}^m absorb persistent differences in export propensity across firm–country pairs. Firm–half-year fixed effects δ_{ft}^m absorb changes common to all destinations served by a firm in a given half-year. Identification therefore relies on within-firm comparisons across destinations over time. The coefficient β_1^m captures the post-referendum change in the probability of exporting to the UK, relative to other destinations, for non-dual firm–country pairs. The triple interaction β_3^m measures how this UK-specific change differs for dual firm–country pairs; their total UK-specific effect is given by $\beta_1^m + \beta_3^m$. Standard errors are clustered by destination country.

Table 10 reports the results for goods and services exports. Columns (1) and (3) use the full sample of firms that exported goods or services to the UK in 2015. For goods-only and services-only exporters, the post-referendum probability of exporting to the UK falls relative to other destinations by 4.8 percentage points for goods and 1.2 percentage points for services. The positive triple interactions of 5.5 and 1.4 percentage points basically offset these declines for dual exporters, implying that extensive margin adjustments to the Brexit referendum for dual exporters are negligible.

Columns (2) and (4) control for the lagged logarithm of the firm's total exports of the corresponding type, summed across destinations, to account for prior export scale. This requires replacing firm–half-year fixed effects with half-year fixed effects. It also restricts each sample to firms that exported goods or services, respectively, in the preceding half-year, which reduces the sample substantially in the case of services trade. In these specifications, the positive triple interactions again offset the negative UK-specific coefficient for dual exporters.

All in all, the extensive-margin results show that UK export participation declines significantly relative to other destinations for goods-only and services-only exporters. This UK-specific decline is negligible for dual exporters, as shown by the positive triple

interaction. This is consistent with adjustment to the referendum occurring mainly through trade values rather than withdrawal from the UK market.

Table 10: Brexit and the probability of goods and services trade

	Goods trade		Services trade	
	(1)	(2)	(3)	(4)
Post × UK	-0.048^{***}	-0.076^{***}	-0.012^{***}	-0.086^{***}
	(0.002)	(0.002)	(0.001)	(0.002)
Post × Dual_{fc}	-0.055^{***}	-0.048^{***}	-0.116^{***}	-0.111^{***}
	(0.003)	(0.004)	(0.004)	(0.005)
Post × UK × Dual_{fc}	0.055^{***}	0.082^{***}	0.014^{***}	0.095^{***}
	(0.003)	(0.004)	(0.005)	(0.005)
Lagged log firm exports		0.036^{***}		0.008^{***}
		(0.001)		(0.001)
FE	δ_{fc}, δ_{ft}	δ_{fc}, δ_t	δ_{fc}, δ_{ft}	δ_{fc}, δ_t
# obs.	5,637,000	4,225,291	5,637,000	871,841
# firms	28,973	24,308	28,973	7,020
R^2	0.664	0.604	0.778	0.670

Notes: Observations are at the firm–country–half-year level. The dependent variable equals one if the firm exports goods (columns 1–2) or services (columns 3–4) to a country in a given half-year, and zero otherwise. Columns 2 and 4 additionally control for the lagged log value of goods and services trade, respectively. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

5 A theoretical perspective on dual exporters

Our empirical analysis documents substantial differences in how dual exporters respond to the Brexit shock compared with firms that export only goods or only services. When we zoom in on dual exporters, we find important asymmetries in how their goods and services trade margins adjust, as well as pronounced heterogeneity across different types of goods and services. In particular, sales of product-related and enterprise-related services, which are categories typically bundled with or complementary to goods exports (see Fact 3), increased following the Brexit referendum. In this section, we develop a model that captures this differential behavior among dual exporters. To do so, we focus specifically on the pricing and sales decisions of a representative dual exporter, rather than modeling

the selection into dual exporting or general equilibrium effects.

5.1 Basic setup

Consider a German firm that produces a good G and/or a service S, sold at prices p_G and p_S, respectively. If the firm wishes to sell either product in the UK, it faces an exchange rate e, defined as the amount of foreign currency per unit of home currency. Accordingly, the UK-market prices of the good and the service are $p_G^{UK} = ep_G$ and $p_S^{UK} = ep_S$. An appreciation (depreciation) of the home currency – that is, an increase (decrease) in e – reduces (increases) the competitiveness of exports by making them more (less) expensive for foreign buyers.

To introduce a systematic link between services and goods, we follow Ariu et al. (2020), who impose *one-way complementarity* in utility. In their framework, consuming optional services does not increase utility unless these services are bundled with an essential good. When bundled, services raise the perceived quality of the good, thereby shifting demand. This setup rationalizes firms' incentives to bundle goods and services, as well as the higher market shares of dual exporters (see Fact 1). Inspired by this one-way complementarity, we specify UK demand for services and goods as

$$Q_S^{UK} = A_S - \alpha e p_S, \tag{4}$$

$$Q_G^{UK} = A_G + \lambda Q_S^{UK} - \gamma e p_G, \tag{5}$$

respectively.[16] The parameters α and γ determine the price sensitivity, while A_S and A_G capture market potential for services and goods in the UK. Throughout the analysis, we assume $A_S < A_G$, implying that, for dual exporters, the goods market is relatively more important – a pattern consistent with Fact 2. When $\lambda = 0$, goods demand is independent of service sales. When $\lambda > 0$, however, goods demand is amplified by the quantity of services sold.

[16] We do not interpret Equations 4 and 5 as the unique demand system implied by a particular utility function. Rather, following the platform-markets literature, we use a reduced-form specification in which activity on one side of the market shifts demand on the other side. For example, Rochet and Tirole (2003) emphasize that participation or demand on one side of a platform may depend directly on the size or activity of the other side through cross-group externalities, thereby explaining different pricing strategies of firms.

We model complementarity as strictly one-way, with service sales boosting goods demand but not vice versa. This assumption reflects the nature of many business-to-business service offerings, which are purchased in order to support the use and operation of a good. As documented in Section 3, dual exporters predominantly bundle their goods with goods-related and enterprise-related services (see Fact 3). In such cases, additional goods sold do not necessarily increase the demand for complementary services, making one-way complementarity a realistic and empirically grounded simplification. Moreover, as we show below, the parameter λ plays a central role in capturing the heterogeneous responses to the Brexit shock across service types, related to the results presented in Table 7. High values of λ correspond to strongly complementary service types – such as product-related, enterprise-related, or intellectual property-related services – which are closely tied to goods exports. In contrast, low values of λ represent weakly complementary services, such as personal services or transfers. Finally, this assumption keeps the model tractable while allowing it to explain the empirical findings presented in Section 4.[17]

5.2 Firm side

We focus on a single exporting firm, which we model as an entity producing one good G and one service S. In Appendix B.2, we extend this simple model to a Cournot oligopoly with N^{GER} German exporters and N^{UK} UK firms.[18] The baseline model presented here is nested in the Cournot extension by setting $N^{GER} = 1$ and $N^{UK} = 0$. The firm's profits from exporting to the UK are given by

$$\Pi = [p_S - \nu c_S]\,(A_S - \alpha e p_S) + [p_G - \nu c_G]\,(A_G + \lambda Q_S - \gamma e p_G)\,, \tag{6}$$

where c_S and c_G denote the marginal costs of producing services and goods, respectively. The parameter ν captures any type of trade friction between the UK and Germany, such

[17] In Section 5.5 we discuss alternative mechanisms, such as a "lock-in" effect of services – that is, one-way complementarity in which service demand depends on goods sales, as well as two-way complementarity.

[18] As our primary objective is to analyze the interaction between goods and services *within* the firm, we focus on a single firm and abstract from (oligopolistic) competition across firms in the main text. As we show in Appendix B.2, despite the introduction of strategic interaction, the central mechanism remains unchanged. We also abstract from multiproduct production, in contrast to the literature on multiproduct firms, which emphasizes supply-side and demand-side linkages across product lines (see Irlacher 2024, for a recent review). In our context, the relevant margin is not the interaction between multiple goods, but rather the interplay between goods and services supplied by the same firm.

as regulatory barriers, uncertainty, or additional variable costs.

Throughout the theoretical analysis, we interpret the Brexit referendum as inducing either (i) an exogenous exchange-rate shock – specifically, an appreciation of the euro relative to the British pound – or (ii) an increase in trade frictions ν. Both mechanisms raise the effective cost of exporting and thus constitute adverse shocks for the firm.[19]

5.3 Optimal prices and quantities

Maximising profits as defined in Equation (6) with respect to the prices of goods and services, p_G and p_S, yields the firm's optimal pricing rules. Substituting these prices into the respective demand functions then gives the equilibrium quantities Q_G^{UK} and Q_S^{UK}. The resulting expressions are:

$$p_S = \frac{\left(1 - \frac{\lambda^2\alpha}{2\gamma}\right) A_S - \frac{\lambda\alpha}{2\gamma} A_G + e\nu\alpha \left[\frac{\lambda}{2} c_G + c_S\right]}{\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right) e\alpha}, \qquad Q_S^{UK} = \frac{A_S + \frac{\lambda\alpha}{2\gamma} A_G - e\nu\alpha \left[\frac{\lambda}{2} c_G + c_S\right]}{\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)}, \tag{7}$$

$$p_G = \frac{2A_G + \lambda A_S - \lambda e\alpha\nu c_S + 2\gamma \left[1 - \frac{\lambda^2\alpha}{2\gamma}\right] e\nu c_G}{2\gamma e \left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)}, \quad Q_G^{UK} = \frac{A_G + \frac{\lambda}{2} A_S - e\nu \left[\gamma c_G + \frac{\lambda\alpha}{2} c_S\right]}{\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)}. \tag{8}$$

Strict concavity of the firm's profit function requires:

$$2 - \frac{\lambda^2\alpha}{2\gamma} > 0 \quad \Longleftrightarrow \quad \lambda < 2\sqrt{\frac{\gamma}{\alpha}}. \tag{9}$$

Throughout the analysis, we impose the stronger regularity condition

$$1 - \frac{\lambda^2\alpha}{2\gamma} > 0 \quad \Longleftrightarrow \quad \lambda < \sqrt{\frac{2\gamma}{\alpha}}. \tag{10}$$

[19] The Brexit referendum did not change regulatory barriers or formal trade arrangements, but it increased uncertainty about the UK's future trade relationship with the EU regarding both goods and services. *nu* therefore captures uncertainty about future trading conditions rather than de jure changes to market access.

In addition to guaranteeing strict concavity, this restriction ensures that the coefficient on the stand-alone service-market potential A_S in the optimal service-price expression is positive.[20] Moreover, note that the optimal service price p_S is decreasing in λ:

$$\frac{d \ln p_S}{d \ln \lambda} = -\frac{\lambda}{\left(2 - \frac{\lambda^2 \alpha}{2\gamma}\right) \gamma e p_S} \left[Q_G^{UK} + \frac{\lambda}{2} Q_S^{UK} \right] < 0, \tag{11}$$

while the opposite is true for the price of goods p_G:

$$\frac{d \ln p_G}{d \ln \lambda} = \frac{\lambda}{2\gamma^2 e \left(2 - \frac{\lambda^2 \alpha}{2\gamma}\right) p_G} \left[2\gamma Q_S^{UK} + \lambda \alpha Q_G^{UK} \right] > 0. \tag{12}$$

A higher λ increases the marginal benefit of service provision for goods profits. Hence, the firm strategically reduces p_S to stimulate Q_S^{UK}, which raises Q_G^{UK} through complementarity. The lower service price and higher service quantity reduce the absolute own-price elasticity of service demand evaluated at the optimum. Although the optimal goods price increases, this does not imply that goods demand becomes more elastic: stronger complementarity also shifts goods demand outward. As shown below, goods demand remains in its elastic region, while service demand may become locally inelastic. Define the absolute own-price elasticities of demand as

$$\varepsilon_i \equiv -\frac{\partial Q_i^{UK}}{\partial p_i} \frac{p_i}{Q_i^{UK}}, \qquad i \in \{G, S\}. \tag{13}$$

Because

$$-\frac{\partial Q_G^{UK}}{\partial p_G} = \gamma e, \qquad -\frac{\partial Q_S^{UK}}{\partial p_S} = \alpha e,$$

the elasticities are

$$\varepsilon_G = \frac{\gamma e p_G}{Q_G^{UK}} = 1 + \frac{\gamma e v c_G}{Q_G^{UK}} > 1, \tag{14}$$

[20] Furthermore, this condition ensures that the own-price sensitivities – the slopes of the service and goods demands with respect to their own prices (α and γ) – are sufficiently strong relative to the one-way complementarity parameter. If λ becomes too large, then even small reductions in the service price would generate disproportionately strong increases in the demand for goods. This, in turn, feeds back into the firm's pricing incentives: lowering p_S boosts Q_G, strengthening the incentive to reduce p_S further. If λ is too large, this mechanism produces an unstable loop rather than a well-behaved tradeoff.

and

$$\varepsilon_S = \frac{\alpha e p_S}{Q_S^{UK}} = 1 + \frac{\alpha e \nu c_S}{Q_S^{UK}} - \frac{\alpha \lambda Q_G^{UK}}{\gamma Q_S^{UK}}. \tag{15}$$

Equation (14) shows that the firm always sets the goods price in the elastic portion of goods demand at an interior optimum with positive marginal costs. This is the standard monopoly-pricing result. For services, however, the complementarity term in Equation (15) reduces the elasticity evaluated at the firm's optimal service price. Service demand is locally inelastic if and only if

$$\frac{\lambda Q_G^{UK}}{\gamma} > e \nu c_S. \tag{16}$$

Substituting the equilibrium expression for Q_G^{UK}, this condition can equivalently be written as

$$\frac{\lambda^2 \alpha}{2\gamma} A_S + \frac{\lambda \alpha}{\gamma} A_G > 2 e \alpha \nu \left(\frac{\lambda}{2} c_G + c_S \right). \tag{17}$$

When $\lambda = 0$, Equation (15) reduces to

$$\varepsilon_S = 1 + \frac{\alpha e \nu c_S}{Q_S^{UK}} > 1.$$

Thus, a stand-alone service is priced in the elastic portion of demand, whereas sufficiently strong complementarity may induce a dual exporter to price services in the inelastic portion of demand. Using the fact that the absolute value of the price elasticity increases with the price level implies that stronger complementarities (i.e., larger λ) amplify the difference in price elasticities between goods and services.

Result 1. *In the presence of one-way complementarity between goods and services, a dual exporter has an incentive to set lower prices for services than a stand-alone services exporter. In a setting with linear demand, this pricing strategy reduces the price elasticity of services, ceteris paribus.*

5.4 Model predictions regarding the Brexit referendum

In this section, we derive predictions on how the Brexit referendum affects the firm's prices and sales of goods and services.

5.4.1 Effects on prices

We analyze the firm's pricing decisions for goods and services with respect to the two key parameters in our model – namely the exchange rate e and the trade friction ν – which capture the economic effects of the Brexit referendum.

Exchange rate shock: We begin with the service price p_S and note that its derivative with respect to e is ambiguous. Hence, an appreciation of the euro (i.e., an increase in e) may, under certain parameter constellations, lead to higher service prices:

$$\frac{dp_S}{de} = \frac{\left(\frac{\lambda^2\alpha}{2\gamma} - 1\right)\frac{A_S}{\alpha} + \frac{\lambda}{2\gamma}A_G}{\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)e^2} \lessgtr 0. \tag{18}$$

Under the stability condition in Eq. (10), the denominator is always positive. The sign therefore depends on the numerator, which may be positive or negative depending on the relative magnitudes of A_G, A_S, and the parameters λ, α, and γ. The derivative is positive only if goods market potential A_G is sufficiently large relative to A_S, and complementarity sufficiently strong, specifically if $\frac{A_G}{A_S} > \frac{2\gamma}{\lambda\alpha}\left(1 - \frac{\lambda^2\alpha}{2\gamma}\right)$. If we switch off the complementarity channel by setting $\lambda = 0$, this heterogeneous price response disappears. In that case, the firm clearly lowers the price of services – as it does for goods – in response to an appreciation:

$$\frac{dp_G}{de} = -\frac{2A_G + \lambda A_S}{2\gamma e^2\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)} < 0. \tag{19}$$

Note that dual exporters respond more strongly to the exchange rate shock than goods-only exporters: $|\frac{dp_G}{de}| - |\frac{dp_G^{only}}{de}| = \lambda\left[A_S + A_G\frac{\lambda\alpha}{2\gamma}\right] / \left[2\gamma e^2\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)\right] > 0$.

Taking stock, the model reveals a nuanced pricing response to an exchange-rate appreciation. Firms selling only goods or only services reduce their euro prices in an attempt to offset the increase in the prices faced by UK customers. For a dual exporter, however, the service price also reflects the indirect value of service sales for goods profits. In particular, the optimal service-pricing rule is

$$p_S = \nu c_S + \frac{Q_S^{UK}}{\alpha e} - \frac{\lambda Q_G^{UK}}{\gamma e}.$$

The last term can be interpreted as an implicit subsidy to services. The firm wants to price

services more aggressively because additional service sales stimulate goods demand. An appreciation reduces equilibrium goods sales and therefore lowers the indirect return from subsidizing services. The firm consequently reduces the implicit service subsidy. If this effect is sufficiently strong, the euro price of services may increase even though the euro price of goods decreases. Hence, the model illustrates how product interdependencies can generate asymmetric price responses between goods and services.

Result 2. *Following an appreciation of the home currency, the exporter reduces prices for goods. In the presence of one-way complementarity between goods and services, a dual exporter may increase service prices if the complementarity is sufficiently strong. Firms that export only goods or only services clearly reduce their prices in response to an appreciation of the home currency.*

Increase in trade frictions: The optimal price responses to trade friction ν are:

$$\frac{dp_S}{d\nu} = \frac{\left[\frac{\lambda}{2}c_G + c_S\right]}{\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)} > 0 \tag{20}$$

$$\frac{dp_G}{d\nu} = \frac{-\lambda\alpha c_S + 2\gamma\left[1 - \frac{\lambda^2\alpha}{2\gamma}\right]c_G}{2\gamma\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)} \lessgtr 0. \tag{21}$$

Under our assumptions, the denominator of $\frac{dp_G}{d\nu}$ is always positive, while the numerator consists of the opposing terms: a positive component, $2\gamma\left(1 - \frac{\lambda^2\alpha}{2\gamma}\right)c_G$, and a negative component, $-\lambda\alpha c_S$. The first reflects the direct increase in the marginal cost of exporting goods, which pushes the optimal goods price upward. The second captures the indirect effect operating through complementarity with services. Higher trade frictions raise the marginal cost of supplying services, leading the firm to increase service prices and thereby reduce service sales. With fewer complementary services sold, goods become less "valuable" to buyers, weakening the firm's incentive to set a high goods price. Because these two forces work in opposite directions, the sign of $\frac{dp_G}{d\nu}$ is not determined a priori. The optimal goods price increases with ν if $c_G > \frac{\lambda\alpha}{2\gamma - \lambda^2\alpha}c_S$, and decreases otherwise. Economically, this means that goods prices rise when goods are relatively costly to produce; conversely, goods prices fall when services are relatively costly and complementarity is strong.

Result 3. *Following an increase in trade frictions, the exporter increases prices for services. The*

effect of the trade friction ν on the optimal goods price p_G is ambiguous and depends on the relative magnitudes of the cost parameters c_G and c_S.

5.4.2 Effect on sales

As we only observe sales – but not prices – for services in our data, we focus on the effect of the Brexit referendum on the sales of goods and services, as given by:

$$S^S = \frac{\left[\left(1 - \frac{\lambda^2\alpha}{2\gamma}\right) A_S - \frac{\lambda\alpha}{2\gamma} A_G + e\nu\alpha \left[\frac{\lambda}{2} c_G + c_S\right]\right] \left(A_S + \frac{\lambda\alpha}{2\gamma} A_G - e\nu\alpha \left[\frac{\lambda}{2} c_G + c_S\right]\right)}{\left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)^2 e\alpha}, \quad (22)$$

$$S^G = \frac{\left(2A_G + \lambda A_S - \lambda e\alpha\nu c_S + 2\gamma \left[1 - \frac{\lambda^2\alpha}{2\gamma}\right] e\nu c_G\right) \left(A_G + \frac{\lambda}{2} A_S - e\nu \left[\gamma c_G + \frac{\lambda\alpha}{2} c_S\right]\right)}{2\gamma e \left(2 - \frac{\lambda^2\alpha}{2\gamma}\right)^2}. \quad (23)$$

The presence of λ in both the quantity and sales equations illustrates how service demand amplifies goods demand. In what follows, we show that firms capable of effectively bundling or integrating services with goods are better able to mitigate adverse shocks (such as exchange rate movements) than firms selling only a single product type. More specifically, we demonstrate that firms with strong complementarities between goods and services are better positioned to sustain sales in foreign markets, even under unfavourable exchange rate conditions.

The mechanism operates as follows. When services are priced in a segment of the demand curve characterised by relatively low price elasticity, consumers respond only weakly to price changes. Consequently, following an exchange rate appreciation or an increase in trade frictions, the equilibrium price of services rises, but the resulting decline in quantities sold remains modest. In this situation, the increase in price outweighs the reduction in quantity, leading to an overall increase in the value of service sales. Thus, the inelastic nature of service demand amplifies the impact of such shocks on nominal sales relative to goods.

By contrast, when prices lie in the elastic region of the demand curve, quantity responses dominate: an increase in price induces a more than proportional reduction in quantity demanded, thereby reducing total sales, while a decrease in price leads to a

more than proportional expansion in quantity, raising total sales.[21] Formally, when the absolute value of the price elasticity of demand exceeds one, $|\varepsilon| > 1$, total revenue and price move in opposite directions. Intuitively, consumers are sufficiently price-sensitive in the elastic portion of the demand curve that firms cannot raise prices without incurring substantial sales losses, whereas lower prices stimulate demand enough to increase total revenue.[22]

Result 4. *When goods and services are jointly exported, an adverse shock (e.g., an exchange rate appreciation) may reduce goods sales while increasing service sales, provided services operate in a relatively inelastic segment of demand. In contrast, goods priced in the elastic portion of the demand curve experience a more than proportional decline in quantity demanded, leading to a reduction in total sales.*

Proof. In Appendix B.1, we provide a detailed analytical derivation for this result. □

5.5 Alternative mechanisms

Our framework rationalises why dual exporters respond differently to a disintegration shock than firms that export only goods or only services. Whether it is the *right* framework depends on whether competing mechanisms could deliver the same predictions. In this section we therefore confront alternatives with the set of facts documented in Section 4 above, namely that (i) goods exports to the UK fall more for dual exporters than for goods-only exporters; (ii) this additional contraction operates through unit values rather than quantities; (iii) services-only exporters reduce their UK sales; (iv) dual exporters nonetheless expand their sales of complementary services; and (v) both adjustments line up with the bundling ranking documented in Fact 3, i.e., the extra goods contraction is concentrated in intermediates and investment goods, and the services expansion in product-, enterprise-, and IP-related categories.[23]

[21] Our model predicts an additional quantity response for dual exporters that the empirical analysis does not detect. However, the quantity coefficients shown in Table 4 are estimated with standard errors of 0.011, i.e. the data cannot clearly reject a decline.

[22] In the Appendix (see Section B.3), we provide a model simulation illustrating that the mechanisms described in the paper can indeed be realized under plausible parameter values.

[23] Notably, we do not argue that these alternative mechanisms are absent or implausible. Indeed, they might certainly operate alongside ours, but, none of them can account for the full set of empirical facts, while our model, which relies on the assumption of one-way complementarity between goods and services, can account for facts (i), (iii), (iv) and (v), and is consistent with (ii) given the precision of the quantity estimates.

5.5.1 Different direction of complementarity: lock-in effect

The closest alternative to our framework also builds on one-way complementarity but reverses its direction. Suppose that purchasing a good creates a form of customer lock-in for the associated services, so that

$$Q_G = A_G - \alpha e p_G; \qquad Q_S = A_S + \lambda Q_G - \gamma e p_S. \tag{24}$$

A familiar example, though with a dynamic perspective, is the market for elevators: after acquiring the physical product, buyers are effectively locked into long-term maintenance contracts. Similar patterns arise for durable goods requiring periodic servicing, software updates, or mandatory inspections. However, by reversing the direction of the complementarity, it also reverses the pricing arithmetic.[24] Even more crucially, with such a lock-in mechanism, service sales will fall following the Brexit shock.[25] Put differently, falling goods sales together with rising sales of complementary services cannot occur under a lock-in mechanism. Arguably, lock-in might be rather a dynamic phenomenon, and our claim is only that the static counterpart of the lock-in mechanism in Eq. (24) predicts the reverse of what we estimate, not that lock-in is absent from these markets. Moreover, demand linkages might operate simultaneously, i.e., from goods to services and vice versa, and we return to that case below.

5.5.2 Multiproduct firms and within-firm reallocation

Our model abstracts from multiproduct production, focusing on the strategic interaction between a single good and a single service within the firm rather than on linkages across a broader portfolio. A substantial literature documents that reallocation across products within firms is an important margin of adjustment to globalization and other shocks (see, among others, Arkolakis et al. 2021; Bernard et al. 2011; Chan et al. 2025). In these models firms typically possess a core competence in producing one variety, while production of additional varieties is less efficient, which is called flexible manufacturing (Eckel and

[24] In our baseline model, the euro goods price falls unambiguously after an appreciation while the service-price response is ambiguous. Under (24) the roles are exactly interchanged: the euro service price now falls for certain, at the rate $dp_S/de = -(\lambda A_G + 2A_S)/[e^2(4\gamma - \alpha\lambda^2)] < 0$, while the goods-price response becomes ambiguous and turns on whether $A_G(2\gamma - \alpha\lambda^2) \gtrless \alpha\lambda A_S$.

[25] To see this, one can apply to (24) the same argument that delivers the unconditional decline of goods sales in our baseline model (see Appendix B.1).

Neary 2010). Such models rely on differences in production efficiency across product lines and on substitutability among goods, so that expanding the product range cannibalizes sales of other products. Importantly, multiproduct models of this kind do generate opposing adjustments across product lines: an adverse shock leads firms to skew activity toward their core competence, expanding the best-performing variety while contracting peripheral ones. That is, they emphasize the ordering along which reallocation occurs, namely product level efficiency or core competence, which would yield a sharp prediction for dual exporters. Because goods account for the overwhelming share of a dual exporter's sales in dual markets (Fact 2), reallocation should favor goods and come at the expense of services. Our empirical results, however, reveal the opposite.[26]

5.5.3 Pass-through: markup asymmetry and invoicing currency

Yet a different mechanism rests on the asymmetry in price setting rather than demand linkages, that can arise from differences between goods and services in the markup or the invoicing currency choice. Suppose firms face CES demand, so that markups are

$$\mu_G = \frac{\eta_G}{\eta_G - 1}, \qquad \mu_S = \frac{\eta_S}{\eta_S - 1}, \tag{25}$$

with $\eta_S < \eta_G$, i.e., goods markets are more competitive and services more differentiated. However, under constant markups the optimal euro price is independent of the exchange rate and pass-through into the UK price is therefore complete for both products and identical across them, whatever the gap between η_S and η_G. Thus, a markup asymmetry predicts no exchange-rate response of euro unit values at all, which is inconsistent with the unit-value declines we estimate in Table 4. Furthermore, as pricing problems are separable and independent, there is no reallocation margin, and thus no incentive of firms to shift revenues toward services.[27]

A related possibility is that goods and services differ in the currency in which export prices are invoiced, that is, in producer-currency pricing (PCP) versus local-currency

[26] We read this as complementary to, rather than in competition with, the multiproduct literature, that has emphasized supply-side linkages across product lines and substitutability in demand. Indeed, a multiproduct model of goods and services would rationalize our findings if supplying a service to a market generated a positive demand shifter for the firm's own goods beyond standard cross-price effects. See also the discussion in Ariu et al. (2020) at the end of their Section 5.4.

[27] Even with variable markups, the two pricing problems might remain separable in the absence of further links across activities, such as a shared capacity or fixed cost, or a demand linkage of the kind we impose.

pricing (LCP). Under PCP the euro price is fixed in the short run, the UK price rises mechanically with e, and quantities and euro-denominated sales both decline. Under LCP the UK price is insulated, quantities need not respond, but the euro price received falls, so euro-denominated sales again decline unless quantities rise sufficiently.[28] In either regime, and in any mixture of the two, euro sales of both products decline.[29]

5.5.4 Two-way complementarity

A final alternative is that goods and services are mutually complementary. In contrast to our baseline, where service sales raise goods demand but not conversely, a two-way structure allows both margins to reinforce each other:

$$Q_G = A_G + \lambda_S Q_S - \gamma e p_G, \qquad Q_S = A_S + \lambda_G Q_G - \alpha e p_S, \tag{26}$$

where $\lambda_S > 0$ captures the effect of services on goods demand, $\lambda_G > 0$ the effect of goods on service demand, and $\lambda_S \lambda_G < 1$ is required for the demand system to be well defined. This structure looks appealing because many goods and services bundles plausibly involve reciprocal linkages: installation, maintenance, training, or consulting may raise the value of a manufactured good, while the sale of the good may also generate subsequent demand for related services. Two-way complementarity, however, generates positive co-movement between the two activities.[30]

[28] The same logic applies when goods and services are invoiced in different currencies. If goods are priced under PCP and services under LCP, goods sales fall through lower quantities while service sales fall mechanically in euros (and vice versa if the assignment is reversed.) Mixed invoicing therefore affects the magnitude and composition of adjustment, but not its sign.

[29] Thus, invoicing cannot by itself generate a differential response across exporter types, unless invoicing shares differ systematically between dual and single-mode exporters, an auxiliary assumption we cannot evaluate with our data. Indeed, using Belgian customs data, Amiti et al. (2022) show that the invoicing currency is an active firm level choice that depends, among other things, on firm size, and that this choice has a direct causal effect on exchange-rate pass-through into prices and quantities. However, the additional decline in unit values for dual exporters persists when we compare them with goods-only exporters of similar size (Appendix Tables A11, A12, and A13), which suggests that size-related differences in invoicing are unlikely to account fully for our results. Invoicing currency may well shape the magnitude of exporters' responses to Brexit, but it can hardly explain why the same firm, in the same destination, contracts one activity while expanding another. Finally, it is worth noting that the invoicing currency has allocative content only when nominal prices are rigid or set in advance; under flexible repricing it is a unit of account without real consequences.

[30] Solving the demand system gives $Q_G(1 - \lambda_S \lambda_G) = A_G + \lambda_S A_S - \lambda_S \alpha e p_S - \gamma e p_G$, so that any force depressing one activity is transmitted to the other and then partly back again, with the multiplier $1/(1 - \lambda_S \lambda_G) > 1$ amplifying the joint contraction. Thus, if an adverse shock reduces goods demand, this feeds into lower service demand through $\lambda_G Q_G$; the fall in Q_S in turn depresses goods demand further through

6 Conclusion

This paper provides the first joint analysis of how firms adjust their goods and services exports in response to a major geopolitical shock, exploiting the Brexit referendum as a quasi-natural experiment. Using novel monthly micro data that link Germany's official statistics on international trade in goods and services at the firm-country-product level, we document new empirical facts about dual exporters – firms that simultaneously export goods and services – and show that they respond in systematically different ways to negative shocks than firms specializing in only one mode of trade. While dual exporters are relatively few in number, they account for a disproportionately large share of total exports and tend to be substantially larger and more diversified than single-mode exporters.

We then go beyond merely establishing these facts, investigating whether services exports can help dual exporters to adjust to the negative shock from the Brexit referendum. Our econometric results show that pure goods exporters and pure services exporters both significantly reduced their exports to the UK following the referendum. By contrast, dual exporters display a markedly different adjustment pattern: their goods exports decline even more strongly than those of pure goods traders, but their exports of complementary services – particularly product-related, enterprise-related, and intellectual property-related services – increase or at least remain stable. These results are robust across alternative specifications, fixed effects structures, and definitions of dual exporting. They suggest that services exports can play a cushioning role, compensating for the drop in goods exports for dual exporters.

To rationalize these findings, we develop a simple model of a representative dual exporter facing one-way complementarity between goods and services. In this framework, services enhance the perceived quality of goods, making demand for the latter partly dependent on the provision of the former. The model predicts that, following an adverse shock such as an exchange-rate appreciation or rising trade frictions, dual exporters adjust prices and quantities in ways that differ from single-mode exporters: goods prices fall while service prices may rise or remain stable, particularly when complementarities are strong. Moreover, services tend to be priced in a relatively inelastic region of demand,

$\lambda_S Q_S$.

meaning that increases in prices lead to relatively small quantity responses. This mechanism generates the observed pattern in which dual exporters experience falling goods sales but rising or stable service sales.

Our paper highlights the strategic importance of services as a margin of adjustment in international trade. They show that access to both goods and services markets allows firms to reallocate activity internally in response to external shocks, thereby reducing volatility in total export performance. This insight contributes to the growing literature on the interconnectedness of goods and services trade and offers a more complete understanding of how firms navigate periods of heightened uncertainty or geopolitical disintegration.

From a policy perspective, the results underscore the need to consider the services dimension when evaluating the resilience of exporters, the effects of trade policy changes, or the broader consequences of economic fragmentation. More broadly, our work suggests that future research on firms' responses to global shocks should take seriously the multidimensional nature of modern exporting, in which goods and services are increasingly produced, marketed, and consumed as intertwined components of global value creation.

References

Ahmad, S., Limão, N., Oliver, S., Shikher, S., 2023. Brexit uncertainty and its (dis)service effects. American Economic Journal: Economic Policy 15, 459–485.

Amiti, M., Itskhoki, O., Konings, J., 2014. Importers, exporters, and exchange rate disconnect. American Economic Review 104, 1942–78.

Amiti, M., Itskhoki, O., Konings, J., 2022. Dominant currencies: How firms choose currency invoicing and why it matters. The Quarterly Journal of Economics 137, 1435–1493.

Antràs, P., 2025. The uncharted waters of international trade. Journal of the European Economic Association 23, 1–51.

Ariu, A., 2016. Services versus goods trade: A firm-level comparison. Review of World Economics 152, 19–41.

Ariu, A., Breinlich, H., Corcos, G., Mion, G., 2019. The interconnections between services and goods trade at the firm-level. Journal of International Economics 116, 173–188.

Ariu, A., Mayneris, F., Parenti, M., 2020. One way to the top: How services boost the demand for goods. Journal of International Economics 123, 103278.

Arkolakis, C., Ganapati, S., Muendler, M.A., 2021. The extensive margin of exporting products: A firm-level analysis. American Economic Journal: Macroeconomics 13, 182–245.

Baldwin, R., Freeman, R., Theodorakopoulos, A., 2024. Deconstructing deglobalization: The future of trade is in intermediate services. Asian Economic Policy Review 19, 18–37.

Bekes, G., Murakozy, B., 2012. Temporary trade and heterogeneous firms. Journal of International Economics 87, 232–246.

Berlingieri, G., Marcolin, L., Ornelas, E., 2025. Service offshoring and export experience. The Economic Journal 135, 1980–2016.

Berman, N., Martin, P., Mayer, T., 2012. How do different exporters react to exchange rate changes? The Quarterly Journal of Economics 127, 437–492.

Bernard, A.B., Jensen, J.B., Schott, P.K., 2011. Multiple-product firms and trade liberalization. Quarterly Journal of Economics 126, 1271–1318.

Bhalotia, S., Dhingra, S., Arnold, D., 2025. Deglobalisation in Disguise?: Brexit Barriers and Trade in Services. Centre for Economic Performance, London School of Economics and Political ....

Biewen, E., Meinusch, A., 2023. Statistics on international trade in services (SITS) 01/2001–07/2023 (SITS), Data Report 2023-24 – Metadata ID SITS Version 7. Deutsche Bundesbank, Research Data and Service Centre. doi:10.12757/Bbk.SITS.01010723.07.01.

Bloom, N., Bunn, P., Chen, S., Mizen, P., Smietanka, P., Thwaites, G., 2019. The looming tariff threat: Entry into exporting under trade agreement renegotiation. NBER Working Paper 26218.

Boddin, D., Kruse, H.W., Merkle, H., Walter, S., Zapf, B., 2025. Combined international trade and investment data "CITID"–A new innovative and comprehensive data landscape for Germany. Jahrbücher für Nationalökonomie und Statistik 245, 339–350.

Born, B., Müller, G.J., Schularick, M., Sedláček, P., 2019. The costs of economic nationalism: Evidence from the Brexit experiment. The Economic Journal 129, 2722–2744.

Breinlich, H., Leromain, E., Magli, M., 2026. Mind the break-up: When policy disrupts firms' supply chains. CESifo Working Paper 12672.

Breinlich, H., Magli, M., 2024. Should we stay or should we go? Firms' decision on services mode of supply. CESifo Working Paper 11331.

Chan, J.M.L., Irlacher, M., Koch, M., 2025. Multiproduct firms, horizontal mergers, and international trade. Review of Economics and Statistics , 1–45.

Crowley, M., Exton, O., Han, L., 2020. The looming tariff threat: Entry into exporting under trade agreement renegotiation. AEA Papers and Proceedings 110, 547–551.

Debaere, P., Görg, H., Raff, H., 2013. Greasing the wheels of international commerce: Service market thickness and firms' international sourcing. Canadian Journal of Economics 46, 78–102.

Dhingra, S., Huang, H., Ottaviano, G., Pessoa, T., Sampson, T., Van Reenen, J., 2017. The costs and benefits of Brexit. Economic Policy 32, 651–705.

Eckel, C., Neary, J.P., 2010. Multi-product firms and flexible manufacturing in the global economy. Review of Economic Studies 77, 188–217.

Eckel, C., Riezman, R., 2020. CATs and DOGs. Journal of International Economics 126, 103338.

Fajgelbaum, P., Goldberg, P., Kennedy, P., Khandelwal, A., Taglioni, D., 2024. The US-China trade war and global reallocations. American Economic Review: Insights 6, 295–312.

Fauth, M., Jung, B., Kohler, W., 2025. Complementarities between import and export activities: Firm-level evidence for goods and services. CESifo Working Paper 11673.

Fernandes, A.P., Winters, L.A., 2021. Exporters and shocks: The impact of the Brexit vote shock on bilateral exports to the UK. Journal of International Economics 131, 103489.

Freeman, R., Garofalo, M., Longoni, E., Manova, K., Mari, R., Prayer, T., Sampson, T., 2025. Deep integration and trade: UK firms in the wake of Brexit. CESifo Working Paper 11614.

Gopinath, G., Gourinchas, P.O., Presbitero, A.F., Topalova, P., 2025. Changing global linkages: A new Cold War? Journal of International Economics 153, 104042.

Görg, H., Jacobs, A., Meuchelböck, S., 2024. Who is to suffer? Quantifying the impact of sanctions on German firms. Journal of Economic Behavior & Organization 228, 106767.

Graziano, A.G., Handley, K., Limão, N., 2021. Brexit uncertainty and trade disintegration. The Economic Journal 131, 1150–1185.

Grossman, G., Helpman, E., Redding, S., 2024. When tariffs disrupt global supply chains. American Economic Review 114, 988–1029.

Hobijn, B., Nechio, F., Shapiro, A.H., 2021. Using Brexit to identify the nature of price rigidities. Journal of International Economics 130, 103448.

Hottman, C.J., Redding, S.J., Weinstein, D.E., 2016. Quantifying the sources of firm heterogeneity. Quarterly Journal of Economics 131, 1291–1364.

Huang, Y., Lin, C., Liu, S., Tang, H., 2023. Trade networks and firm value: Evidence from the U.S.-China trade war. Journal of International Economics 145, 103811.

Irlacher, M., 2024. Multiproduct firms in international trade. Oxford Research Encyclopedia of Economics and Finance. Oxford University Press.

Javorcik, B., Kett, B., Stapleton, K., O'Kane, L., 2026. Unravelling deep integration: Local labour market effects of the Brexit vote. Journal of the European Economic Association 24, 429–475. doi:10.1093/jeea/jvaf040.

Jiao, Y., Liu, Z., Tian, Z., Wang, X., 2024. The impacts of the U.S. trade war on Chinese exporters. The Review of Economics and Statistics 106, 1576–1587.

Kruse, H., Meyerhoff, A., Erbe, A., 2021. Neue Methoden zur Mikrodatenverknüpfung von Außenhandels- und Unternehmensstatistiken. WISTA-Wirtschaft und Statistik 73, 53–63.

RDC, 2024. AFiD Panel Foreign Trade Statistics. Research Data Centre of the German Federal Statistical Office and Statistical Offices of the Federal States. doi:10.21242/51911.2018.00.05.1.1.0.

Rochet, J.C., Tirole, J., 2003. Platform competition in two-sided markets. Journal of the European Economic Association 1, 990–1029.

Sampson, T., 2017. Brexit: The economics of international disintegration. Journal of Economic Perspectives 31, 163–184.

A Empirical Appendix

A.1 Data

Table A1: Service categories and their components

Service category	Service types (Bundesbank SITS codes)
Product-related	Research and development (549); product tests (551); audiovisual and other artistic production (564); maintenance and repair (566); contract production (567); technical (553), architectural (554), and engineering services (555); disposal (534); agricultural and mining services (558).
Enterprise-related	Commissions (523); financial (533) and legal services (536); auditing, bookkeeping, and tax consultancy (546); management consultancy activities (556); advertising, market research, and trade fairs (540); operational leasing (594); official fees (619); rents (694); other product-related or enterprise-related services (571).
Intellectual property (IP)	*Use:* software (613); audiovisual and other artistic copyrights (614); research findings, inventions, and processes (615); brands, trademarks, and franchises (616); other rights (617). *Reproduction and distribution:* software (623); audiovisual and other artistic works (624); other distribution rights (627). *Acquisition and sale:* software (633); audiovisual and other artistic copyrights (634); research results (635); trademarks and brands (636); other rights (637).
ICT	Communication services (576); IT services (573); news and information services (572); information storage and related infrastructure (574).
Transport	Shipping; air, road, rail, and inland waterway transport; pipelines and electricity transmission; postal and courier services; other transport services.
Other	Personal services (e.g., health, education, recreation, and staff leasing); construction services; insurance transactions (including reinsurance); travel; transfers (e.g., private transfers and remittances); government transactions (e.g., taxes and public payments).

Notes: The service categories group service types according to the Bundesbank's classification based on BPM6. Numbers in parentheses are Bundesbank service-type codes. All service types are listed for product-related, enterprise-related, IP-related, and ICT services; Transport and Other are summarized at a broader level. Source: Biewen and Meinusch (2023), Appendix A.2.

A.2 Additional summary statistics

Table A2: Service categories exported by services-only exporters

Service type *i*	# firms	# countries	value	% *i*	% services only
Insurance	xxx	xxx	xxx	xxx	xxx
Government transactions	358	185	36,111,830	15.5	96.2
Transport	2,824	203	35,465,546	15.3	53.9
Enterprise-related	7,930	212	35,182,981	15.1	70.3
IP-related	1,873	205	25,487,860	11.0	76.3
Product-related	4,338	194	23,875,480	10.3	50.9
ICT	2,222	189	12,689,435	5.5	73.6
Construction	730	147	4,023,483	1.7	67.1
Other	608	101	3,686,389	1.6	41.4
Transfers	862	118	2,129,098	0.9	86.1
Personal	1,201	144	2,030,645	0.9	56.1
Travel	xxx	xxx	xxx	xxx	xxx

Notes: A services-only exporter exports services but no goods to any destination. % *i* is the share of services category *i* in services-only firms' total service exports. % services-only is the share of total exports of service type *i* accounted for by services-only firms. Values are in EUR 1,000. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2015, own calculations.

Table A3: Types of services exported by dual exporters

Service type *i*	# firms	# countries	value	% *i*	% duals
Insurance	xxx	xxx	xxx	xxx	xxx
Transport	726	199	30,384,491	22.5	46.1
Product-related	1,537	194	22,995,591	17.0	49.1
Enterprise-related	1,526	186	14,886,621	11.0	29.7
IP-related	610	136	7,938,608	5.9	23.7
Other	367	93	5,212,039	3.9	58.6
ICT	492	146	4,546,281	3.4	26.4
Construction	190	122	1,969,045	1.5	32.9
Personal	447	125	1,586,655	1.2	43.9
Government transactions	90	106	1,433,488	1.1	3.8
Transfers	128	58	343,609	0.3	13.9
Travel	xxx	xxx	xxx	xxx	xxx

Notes: Dual exporting is defined at the firm level, i. e. a firm is classified as a dual trader if it exports both goods and services. % *i* is the share of services type *i* in dual exporters' total service exports. % dual is the share of total exports of service type *i* accounted for by dual exporters. Values are in EUR 1,000. Source: Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2015, own calculations.

Table A4: Product categories exported by goods-only exporters

Product category *i* (HS2)	# firms	# countries	value	% *i*	% goods-only
Machinery and mechanical appliances (84)	42,118	226	114,636,171	21.2	65.7
Electrical machinery and equipment (85)	28,867	220	65,861,600	12.2	69.9
Vehicles excl. rail- or tramway rolling stock (87)	23,886	202	44,133,081	8.2	21.2
Plastics and articles thereof (39)	24,019	208	30,277,658	5.6	69.7
Optical, photographic etc. instruments (90)	19,951	219	28,820,186	5.3	63.1
Articles of iron or steel (73)	19,823	209	17,598,012	3.3	82.7
Iron and steel (72)	4,901	154	14,876,748	2.8	77.3
Pharmaceutical products (30)	2,024	188	11,770,595	2.2	36.7
Paper, paperboard, articles of paper (48)	7,032	187	10,701,221	2.0	84.5
Furniture, lamps etc. (94)	12,660	207	10,371,719	1.9	82.7

Notes: A goods-only exporter exports goods but no services to any destination. % *i* is the share of product category *i* in goods-only firms' total goods exports. % goods-only is the share of total exports of product category *i* accounted for by goods-only firms. Values are in EUR 1,000. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2015, own calculations.

Table A5: Product categories exported by dual exporters

Product category *i* (HS2)	# firms	# countries	value	% *i*	% duals
Vehicles excl. rail- or tramway rolling stock (87)	588	188	164,213,696	41.6	78.8
Machinery and mechanical appliances (84)	1,958	207	59,973,169	15.2	34.4
Electrical machinery and equipment (85)	1,715	203	28,333,024	7.2	30.1
Pharmaceutical products (30)	181	184	20,344,913	5.2	63.4
Optical, photographic etc. instruments (90)	1,391	207	16,823,518	4.3	36.9
Plastics and articles thereof (39)	1,454	191	13,173,528	3.3	30.3
Mineral fuels, mineral oils etc. (27)	311	141	12,871,618	3.3	57.5
Organic chemicals (29)	317	151	10,784,527	2.7	55.4
Miscellaneous chemical products (38)	608	194	6,031,025	1.5	37.8
Iron and steel (72)	459	109	4,375,065	1.1	22.7

Notes: Dual exporting is defined at the firm level, i. e. a firm is classified as a dual trader if it exports both goods and services. % *i* is the share of product category *i* in dual firms' total goods exports. % duals is the share of exports of product category *i* accounted for by dual firms. Values are in EUR 1,000. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2015, own calculations.

Table A6: Most common service–product combinations in dual markets

Rank	Service type	Product category (HS2)
1	Product-related services	Machinery and mechanical appliances (84)
2	Product-related services	Electrical machinery and equipment (85)
3	Product-related services	Optical, photographic etc. instruments (90)
4	Enterprise-related services	Machinery and mechanical appliances (84)
5	Enterprise-related services	Electrical machinery and equipment (85)
6	Product-related services	Plastics and articles thereof (39)
7	Product-related services	Articles of iron or steel (73)
8	Enterprise-related services	Plastics and articles thereof (39)
9	Enterprise-related services	Optical, photographic etc. instruments (90)
10	Enterprise-related services	Articles of iron or steel (73)

Notes: The table reports the ten most common combinations of service categories and HS2 product categories exported by the same firm to the same country in 2015. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2015, own calculations.

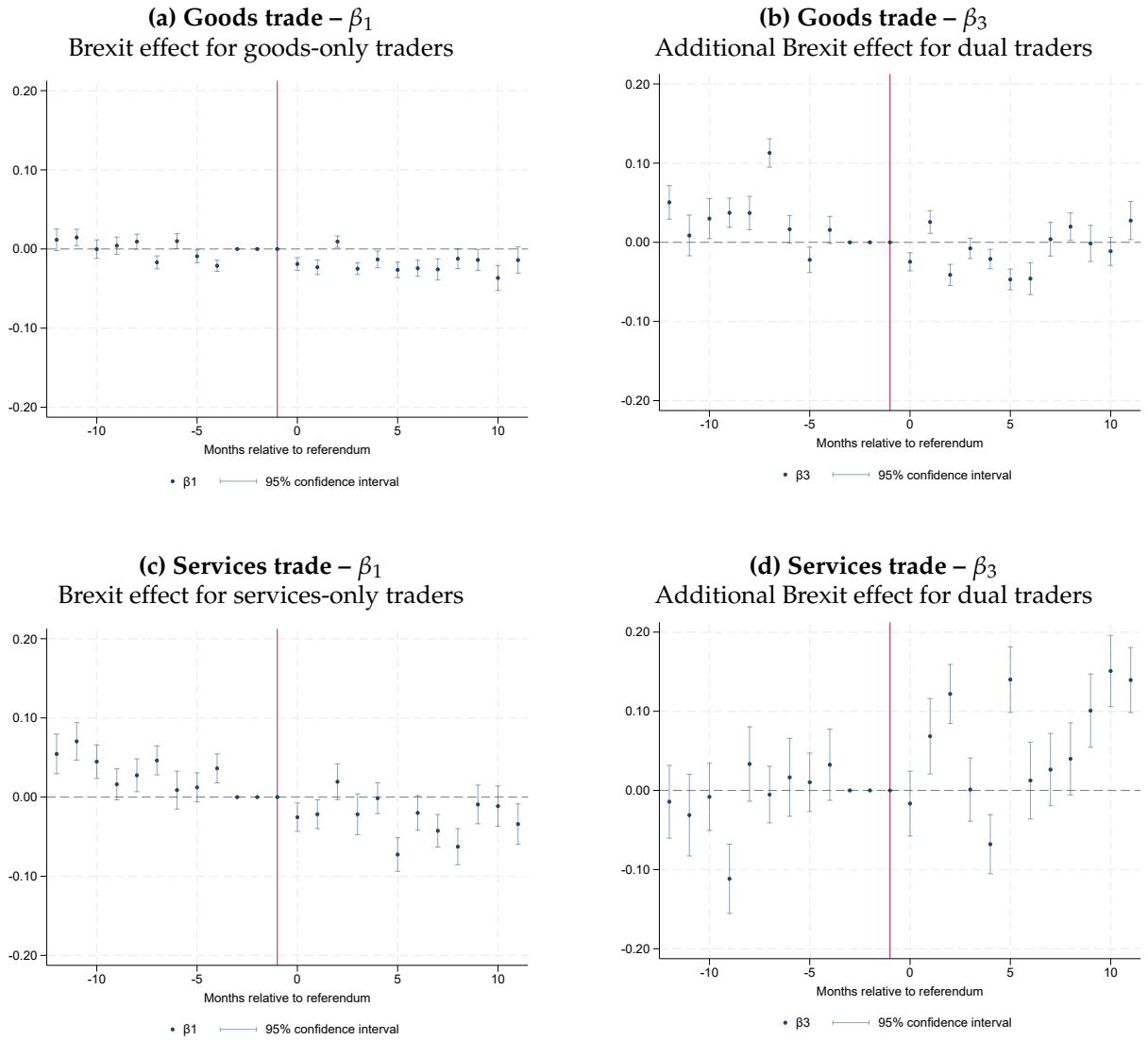
Table A7: Top (detailed) BPM6 service types by number of dual exporters

Item i	Description of service type i	# firms exporting i	% duals exporters
556	Management consultancy activities	696	26.9
555	Engineering services	603	23.3
566	Maintenance and repair work	496	19.2
571	Other product-related or enterprise-related services	443	17.1
553	Technical services	415	16.0
573	IT services	380	14.7
549	Research and development	357	13.8
523	Commissions	357	13.8
540	Advertising, market research, trade fair costs	339	13.1
240	Road transport related to German imports and exports	247	9.5
615	Use of research findings, inventions and processes	245	9.5
517	Staff leasing	232	9.0
594	Operational leasing	205	7.9
600	Incidental payments for merchandise and service transactions	181	7.0
613	Use of software	162	6.3
17	Travel	157	6.1
616	Use of brands, trademarks and franchises	147	5.7
669	Sea transport related to German imports and exports	142	5.5
570	Construction receipts (sites abroad or Germany, $<$ 1 year)	129	5.0
601	Incidental payments for merchandise and service transactions	125	4.8

Notes: The sample consists of firms that export both goods and services to at least one country in 2015. For each service type, the table reports the number and share of these firms exporting that service to a country where they also export goods. Firms may appear in multiple service types. Item denotes the service type according to the Deutsche Bundesbank's coding list for the balance of payments (BPM6); see Biewen and Meinusch (2023). Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

A.3 Event study regressions

Figure A1: Event-study estimates for goods and services exports



Notes: The figure reports event-study estimates of the response of exports to the Brexit referendum. The estimating equation is the dynamic analogue of equation (1), replacing the post-referendum indicator and its interactions with a full set of event-time indicators relative to the referendum. The specification includes firm-product-country and time fixed effects as well as destination-specific inflation π_{ct}. The coefficients β_1 capture the differential change in exports to the UK relative to other destinations, while β_3 captures the additional differential change for dual exporters. The three months preceding the referendum ($t = -3, -2, -1$) constitute the reference window. Coefficients are normalized relative to the average estimate over these months, and the three reference-period estimates are displayed at zero. Vertical bars indicate 95% confidence intervals. The vertical line marks the referendum month, i.e. June 2016. All panels exclude observations below the 1st percentile and above the 99th percentile of the dependent variable. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

A.4 Robustness

Table A8: Goods trade – Alternative fixed effects

	(1) $\Delta \ln(\text{value}^g)$	(2) $\Delta \ln(\text{quant}^g)$	(3) $\Delta \ln(\text{uv}^g)$
Post × UK	-0.014***	0.007	-0.021***
	(0.004)	(0.004)	(0.001)
Post × Dual_{fc}	0.001	-0.008	0.009
	(0.007)	(0.011)	(0.006)
Post × UK × Dual_{fc}	-0.026***	0.001	-0.028***
	(0.008)	(0.012)	(0.006)
FE	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}
# obs.	14,257,891	14,257,891	14,257,891
# firms	22,890	22,890	22,890
R^2	0.0744	0.0693	0.0595

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

Table A9: Services trade – Alternative fixed effects

	(1) $\Delta \ln(\text{value}^s)$
Post × UK	-0.062***
	(0.009)
Post × Dual_{fc}	-0.004
	(0.014)
Post × UK × Dual_{fc}	0.052***
	(0.012)
FE	δ_{fc}, δ_{pt}
# obs.	602,915
# firms	5,013
R^2	0.109

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

Table A10: Summary statistics for alternative control groups

Group	Cutoff	# firms	Mean	SD
Dual exporters	—	1,561	238,820	2,132,344
Goods-only exporters	—	21,739	19,907	138,505
Goods-only exporters above p75	p75	5,218	71,497	276,403
Goods-only exporters above p90	p90	2,090	146,145	425,948
Goods-only exporters above p95	p95	1,047	242,104	586,334

Notes: Statistics are calculated at the firm level for firms included in the goods-trade estimation sample used in the firm–product–country regressions. Mean and SD refer to firm level goods export value, measured in EUR 1,000. The p75, p90, and p95 rows restrict goods-only exporters to those above the respective percentile cutoff. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

Table A11: Goods exports – Control group: Top 25% of goods-only exporters

	(1) $\Delta \ln(\text{value}^g)$	(2) $\Delta \ln(\text{quant}^g)$	(3) $\Delta \ln(\text{uv}^g)$	(4) $\Delta \ln(\text{value}^g)$	(5) $\Delta \ln(\text{quant}^g)$	(6) $\Delta \ln(\text{uv}^g)$
Post × UK	-0.025***	0.006	-0.030***	-0.017***	0.011**	-0.027***
	(0.005)	(0.005)	(0.001)	(0.005)	(0.005)	(0.001)
Post × Dual_{fc}	-0.008	-0.018	0.009	-0.000	-0.011	0.011*
	(0.007)	(0.011)	(0.006)	(0.007)	(0.011)	(0.006)
Post × UK × Dual_{fc}	-0.013*	0.007	-0.020***	-0.024***	-0.003	-0.021***
	(0.007)	(0.011)	(0.006)	(0.008)	(0.011)	(0.006)
FE	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}
# obs.	10,837,352	10,681,861	10,681,861	11,065,034	10,904,265	10,904,265
# firms	6,749	6,745	6,745	6,757	6,753	6,753
R^2	0.156	0.157	0.152	0.0688	0.0627	0.0494

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

Table A12: Goods exports – Control group: Top 10% of goods-only exporters

	(1) $\Delta \ln(\text{value}^g)$	(2) $\Delta \ln(\text{quant}^g)$	(3) $\Delta \ln(\text{uv}^g)$	(4) $\Delta \ln(\text{value}^g)$	(5) $\Delta \ln(\text{quant}^g)$	(6) $\Delta \ln(\text{uv}^g)$
Post × UK	-0.018***	0.015***	-0.032***	-0.008	0.021***	-0.028***
	(0.005)	(0.006)	(0.002)	(0.005)	(0.005)	(0.002)
Post × Dual_{fc}	-0.009	-0.018	0.009	-0.000	-0.010	0.010*
	(0.007)	(0.011)	(0.006)	(0.008)	(0.011)	(0.006)
Post × UK × Dual_{fc}	-0.020***	-0.001	-0.018***	-0.033***	-0.013	-0.020***
	(0.007)	(0.011)	(0.006)	(0.008)	(0.012)	(0.006)
FE	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}
# obs.	8,505,481	8,384,098	8,384,098	8,675,077	8,549,565	8,549,565
# firms	3,632	3,631	3,631	3,633	3,632	3,632
R^2	0.157	0.158	0.152	0.0672	0.0604	0.0474

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

Table A13: Goods exports – Control group: Top 5% of goods-only exporters

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta \ln(\text{value}^g)$	$\Delta \ln(\text{quant}^g)$	$\Delta \ln(\text{uv}^g)$	$\Delta \ln(\text{value}^g)$	$\Delta \ln(\text{quant}^g)$	$\Delta \ln(\text{uv}^g)$
Post × UK	-0.023***	0.014**	-0.036***	-0.012**	0.021***	-0.033***
	(0.005)	(0.006)	(0.002)	(0.005)	(0.005)	(0.002)
Post × Dual_{fc}	-0.010	-0.018	0.008	-0.001	-0.011	0.009
	(0.008)	(0.012)	(0.006)	(0.008)	(0.012)	(0.006)
Post × UK × Dual_{fc}	-0.014*	-0.000	-0.014**	-0.028***	-0.013	-0.015**
	(0.008)	(0.012)	(0.006)	(0.008)	(0.012)	(0.006)
FE	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}
# obs.	7,127,458	7,020,570	7,020,570	7,264,752	7,154,322	7,154,322
# firms	2,590	2,589	2,589	2,589	2,588	2,588
R^2	0.159	0.159	0.152	0.0677	0.0608	0.0476

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

Table A14: Goods trade – Alternative measure of dual exporting

	(1) $\Delta \ln(\text{value}^g)$	(2) $\Delta \ln(\text{quant}^g)$	(3) $\Delta \ln(\text{uv}^g)$	(4) $\Delta \ln(\text{value}^g)$	(5) $\Delta \ln(\text{quant}^g)$	(6) $\Delta \ln(\text{uv}^g)$
Post × UK	-0.020***	0.003	-0.023***	-0.014***	0.007	-0.020***
	(0.005)	(0.005)	(0.001)	(0.004)	(0.004)	(0.001)
Post × UK × Dual_f^{UK}	-0.004	-0.016*	0.011**	0.003	-0.007	0.010**
	(0.006)	(0.009)	(0.005)	(0.006)	(0.009)	(0.005)
Post × UK × Dual_f^{UK}	-0.021***	0.008	-0.028***	-0.028***	0.000	-0.028***
	(0.006)	(0.009)	(0.005)	(0.006)	(0.010)	(0.005)
FE	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fpc}, δ_t	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}	δ_{fc}, δ_{pt}
# obs.	13,933,546	13,933,546	13,933,546	14,257,891	14,257,891	14,257,891
# firms	22,773	22,773	22,773	22,890	22,890	22,890
R^2	0.154	0.155	0.154	0.0744	0.0693	0.0595

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

Table A15: Services trade – Alternative measure of dual exporting

	(1) $\Delta \ln(\text{value}^s)$	(2) $\Delta \ln(\text{value}^s)$
Post × UK	-0.064***	-0.065***
	(0.009)	(0.009)
Post × Dual_f^{UK}	-0.027*	-0.019
	(0.015)	(0.016)
Post × UK × Dual_f^{UK}	0.075***	0.066***
	(0.015)	(0.015)
FE	δ_{fpc}, δ_t	δ_{fc}, δ_{pt}
# obs.	595,050	602,915
# firms	4,976	5,013
R^2	0.159	0.109

Notes: Observations are at the firm–country–product–month level. All regressions include monthly inflation as a control variable. Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank and RDC of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, AHS, SITS, CITID, 2014-2017, own calculations.

B Theoretical Appendix

B.1 Sales responses to adverse shocks

In this section, we present the analytics for our Result 4 in the main text. To derive the sales responses, it is important to distinguish between prices received by the German exporter and prices paid by UK customers. Let

$$p_i^{UK} = e p_i, \qquad i \in \{G, S\},$$

denote the UK price in pounds. Sales measured in euros are therefore

$$S^i = p_i Q_i^{UK} = \frac{p_i^{UK} Q_i^{UK}}{e}, \qquad i \in \{G, S\}. \tag{27}$$

We define the absolute own-price elasticities with respect to UK prices as

$$\varepsilon_S = -\frac{\partial Q_S^{UK}}{\partial p_S^{UK}} \frac{p_S^{UK}}{Q_S^{UK}} = \frac{\alpha p_S^{UK}}{Q_S^{UK}}, \tag{28}$$

and

$$\varepsilon_G = -\frac{\partial Q_G^{UK}}{\partial p_G^{UK}} \frac{p_G^{UK}}{Q_G^{UK}} = \frac{\gamma p_G^{UK}}{Q_G^{UK}}. \tag{29}$$

As shown in Result 1, the optimal pricing conditions imply $\varepsilon_G > 1$, whereas sufficiently strong complementarity may produce $\varepsilon_S < 1$.

Increase in trade frictions. We first consider an increase in the trade friction ν, holding the exchange rate fixed. Since service demand is:

$$Q_S^{UK} = A_S - \alpha p_S^{UK},$$

its response satisfies:

$$\frac{dQ_S^{UK}}{d\nu} = -\alpha \frac{dp_S^{UK}}{d\nu}. \tag{30}$$

Differentiating euro service sales gives:

$$\begin{aligned}\frac{dS^S}{d\nu} &= \frac{1}{e}\left[Q_S^{UK}\frac{dp_S^{UK}}{d\nu} + p_S^{UK}\frac{dQ_S^{UK}}{d\nu}\right] \\ &= \frac{Q_S^{UK}}{e}\frac{dp_S^{UK}}{d\nu}\left(1-\varepsilon_S\right). \end{aligned} \tag{31}$$

The optimal service price satisfies:

$$\frac{dp_S^{UK}}{d\nu} = e\frac{dp_S}{d\nu} = \frac{e\left(c_S + \frac{\lambda}{2}c_G\right)}{2-\frac{\lambda^2\alpha}{2\gamma}} > 0.$$

It follows that euro service sales increase following an increase in trade frictions if and only if service demand is locally inelastic:

$$\frac{dS^S}{d\nu} > 0 \quad \Longleftrightarrow \quad \varepsilon_S < 1. \tag{32}$$

For goods, the corresponding calculation must account for the fact that a change in service demand shifts goods demand:

$$Q_G^{UK} = A_G + \lambda Q_S^{UK} - \gamma p_G^{UK}.$$

Hence,

$$\frac{dQ_G^{UK}}{d\nu} = \lambda\frac{dQ_S^{UK}}{d\nu} - \gamma\frac{dp_G^{UK}}{d\nu}. \tag{33}$$

Differentiating euro goods sales therefore gives

$$\begin{aligned}\frac{dS^G}{d\nu} &= \frac{1}{e}\left[Q_G^{UK}\frac{dp_G^{UK}}{d\nu} + p_G^{UK}\frac{dQ_G^{UK}}{d\nu}\right] \\ &= \frac{Q_G^{UK}}{e}\frac{dp_G^{UK}}{d\nu}\left(1-\varepsilon_G\right) + \frac{\lambda p_G^{UK}}{e}\frac{dQ_S^{UK}}{d\nu}. \end{aligned} \tag{34}$$

The first term is the conventional own-price effect. The second term captures the inward shift in goods demand caused by the decline in complementary service provision. Because

$$\varepsilon_G > 1 \qquad \text{and} \qquad \frac{dQ_S^{UK}}{d\nu} < 0,$$

both terms in Equation (34) are negative whenever

$$\frac{dp_G^{UK}}{dv} \geq 0.$$

Consequently, a non-negative goods-price response is a sufficient condition for goods sales to decline.

Exchange-rate appreciation We next consider an appreciation of the euro, represented by an increase in e. In this case, the sales response includes not only the price and quantity responses in the UK market but also the conversion of pound revenues into euros. First, we derive logarithmic derivatives of euro service sales.

$$\ln S^S = \ln p_S^{UK} + \ln Q_S^{UK} - \ln e.$$

Hence,

$$\frac{d \ln S^S}{d \ln e} = \frac{d \ln p_S^{UK}}{d \ln e} + \frac{d \ln Q_S^{UK}}{d \ln e} - 1. \tag{35}$$

As $\frac{dQ_S^{UK}}{de} = -\alpha \frac{dp_S^{UK}}{de}$ it follows that:

$$\begin{aligned} \frac{d \ln Q_S^{UK}}{d \ln e} &= \frac{e}{Q_S^{UK}} \frac{dQ_S^{UK}}{de} \\ &= -\frac{\alpha p_S^{UK}}{Q_S^{UK}} \left(\frac{e}{p_S^{UK}} \frac{dp_S^{UK}}{de} \right) \\ &= -\varepsilon_S \frac{d \ln p_S^{UK}}{d \ln e}. \end{aligned} \tag{36}$$

Substituting Equation (36) into Equation (35) yields:

$$\frac{d \ln S^S}{d \ln e} = (1 - \varepsilon_S) \frac{d \ln p_S^{UK}}{d \ln e} - 1. \tag{37}$$

The first term captures the change in pound-denominated service revenue. The second term, -1, captures the conversion of pound revenues into euros following an appreciation. Because $dp_S^{UK}/de > 0$, inelastic service demand causes pound service revenue to increase. For service sales measured in euros, however, inelasticity alone is not sufficient.

The increase in pound revenue must also be large enough to compensate for the less favorable conversion of pound revenues into euros. Specifically,

$$\frac{dS^S}{de} > 0 \quad \Longleftrightarrow \quad (1-\varepsilon_S)\,\frac{d\ln p_S^{UK}}{d\ln e} > 1. \tag{38}$$

For goods, the exchange-rate response of demand is

$$\frac{dQ_G^{UK}}{de} = \lambda \frac{dQ_S^{UK}}{de} - \gamma \frac{dp_G^{UK}}{de}. \tag{39}$$

Taking logarithmic derivatives of euro goods sales yields

$$\frac{d\ln S^G}{d\ln e} = (1-\varepsilon_G)\,\frac{d\ln p_G^{UK}}{d\ln e} - 1 + \frac{\lambda e}{Q_G^{UK}}\frac{dQ_S^{UK}}{de}. \tag{40}$$

The first term is the conventional own-price revenue effect. The second term is the currency-conversion effect. The final term captures the decline in goods demand caused by lower service provision.

B.2 An extended framework with Cournot competition

This section extends the baseline model to an oligopolistic environment with Cournot competition between German exporters and UK firms. The objective is to examine whether the mechanism identified in the single-firm framework can continue to operate when firms compete strategically in quantities. We consider N^{GER} German exporters and N^{UK} UK firms competing in the UK market. Each firm supplies one good and one service.

The quantity of services supplied by German firm i is denoted by q_{Si}^{GER}, and its goods quantity by q_{Gi}^{GER}. Analogously, q_{Sj}^{UK} and q_{Gj}^{UK} denote the quantities supplied by UK firm j.

B.2.1 Inverse demand

We distinguish between the price paid by UK customers in pounds and the price received by German exporters in euros. Let P_{ri}^{GER}, $r \in \{G, S\}$, denote the pound-denominated UK-market price charged by German firm i. The superscript GER identifies the origin of the firm rather than the currency of the price.

Inverse demand for the service supplied by German firm i is

$$P_{Si}^{GER} = \frac{1}{\alpha}\left[A_S - q_{Si}^{GER} - \eta \sum_{\substack{k=1 \\ k\neq i}}^{N^{GER}} q_{Sk}^{GER} - \eta \sum_{j=1}^{N^{UK}} q_{Sj}^{UK}\right], \tag{41}$$

where $\eta \in [0,1)$ measures the substitutability between services supplied by different firms. Inverse demand for its good is

$$P_{Gi}^{GER} = \frac{1}{\gamma}\left[A_G - q_{Gi}^{GER} - \theta \sum_{\substack{k=1 \\ k\neq i}}^{N^{GER}} q_{Gk}^{GER} - \theta \sum_{j=1}^{N^{UK}} q_{Gj}^{UK} + \lambda q_{Si}^{GER}\right], \tag{42}$$

where $\theta \in [0,1)$ measures substitutability between goods and $\lambda > 0$ captures firm-specific one-way complementarity.

The corresponding inverse demands for UK firm j are

$$P_{Sj}^{UK} = \frac{1}{\alpha}\left[A_S - q_{Sj}^{UK} - \eta \sum_{\substack{\ell=1 \\ \ell\neq j}}^{N^{UK}} q_{S\ell}^{UK} - \eta \sum_{i=1}^{N^{GER}} q_{Si}^{GER}\right], \tag{43}$$

and

$$P_{Gj}^{UK} = \frac{1}{\gamma}\left[A_G - q_{Gj}^{UK} - \theta \sum_{\substack{\ell=1 \\ \ell\neq j}}^{N^{UK}} q_{G\ell}^{UK} - \theta \sum_{i=1}^{N^{GER}} q_{Gi}^{GER} + \lambda q_{Sj}^{UK}\right]. \tag{44}$$

Complementarity is firm-specific: the services supplied by a firm raise demand for that firm's own good but do not directly shift demand for the goods supplied by its competitors. The demand linkage is one-way because goods quantities do not enter service demand.

B.2.2 Profit maximization

Let e denote pounds per euro, such that an increase in e corresponds to an appreciation of the euro. A pound-denominated price P_{ri}^{GER} corresponds to the euro price

$$p_{ri}^{GER} = \frac{P_{ri}^{GER}}{e} \tag{45}$$

received by the German exporter.

German firm i's profits, measured in euros, are

$$\Pi_i^{GER} = \left(\frac{P_{Gi}^{GER}}{e} - \nu c_G \right) q_{Gi}^{GER} + \left(\frac{P_{Si}^{GER}}{e} - \nu c_S \right) q_{Si}^{GER}, \tag{46}$$

where ν represents the variable trade friction faced by German exporters. The exchange rate enters through the conversion of UK revenues from pounds into euros. After multiplying the first-order conditions by e, this revenue-conversion effect is isomorphic to an increase in marginal costs measured in pounds.

UK firm j produces and sells locally and therefore faces neither the exchange-rate conversion nor the export friction. Its profits are

$$\Pi_j^{UK} = \left(P_{Gj}^{UK} - c_G \right) q_{Gj}^{UK} + \left(P_{Sj}^{UK} - c_S \right) q_{Sj}^{UK}. \tag{47}$$

For German firm i, the first-order condition for services is

$$\begin{aligned} \frac{\partial \Pi_i^{GER}}{\partial q_{Si}^{GER}} &= \frac{1}{e} \left[P_{Si}^{GER} + q_{Si}^{GER} \frac{\partial P_{Si}^{GER}}{\partial q_{Si}^{GER}} + q_{Gi}^{GER} \frac{\partial P_{Gi}^{GER}}{\partial q_{Si}^{GER}} \right] - \nu c_S \\ &= \frac{1}{e} \left[P_{Si}^{GER} - \frac{q_{Si}^{GER}}{\alpha} + \frac{\lambda q_{Gi}^{GER}}{\gamma} \right] - \nu c_S = 0. \end{aligned} \tag{48}$$

The final term arises because the firm internalizes that an additional unit of services raises willingness to pay for its own good.

The first-order condition for goods is

$$\begin{aligned} \frac{\partial \Pi_i^{GER}}{\partial q_{Gi}^{GER}} &= \frac{1}{e} \left[P_{Gi}^{GER} + q_{Gi}^{GER} \frac{\partial P_{Gi}^{GER}}{\partial q_{Gi}^{GER}} \right] - \nu c_G \\ &= \frac{1}{e} \left[P_{Gi}^{GER} - \frac{q_{Gi}^{GER}}{\gamma} \right] - \nu c_G = 0. \end{aligned} \tag{49}$$

We consider an equilibrium that is symmetric within origin groups:

$$q_{Si}^{GER} = q_S^{GER}, \qquad q_{Gi}^{GER} = q_G^{GER} \qquad \forall i, \tag{50}$$

and

$$q_{Sj}^{UK} = q_S^{UK}, \qquad q_{Gj}^{UK} = q_G^{UK} \qquad \forall j. \tag{51}$$

Substituting inverse demand into the first-order conditions and imposing within-group symmetry gives

$$q_S^{GER} = \frac{A_S - \eta N^{UK} q_S^{UK} - \alpha e \nu c_S + \frac{\alpha\lambda}{\gamma} q_G^{GER}}{2 + \eta(N^{GER} - 1)}, \tag{52}$$

$$q_G^{GER} = \frac{A_G + \lambda q_S^{GER} - \theta N^{UK} q_G^{UK} - \gamma e \nu c_G}{2 + \theta(N^{GER} - 1)}, \tag{53}$$

$$q_S^{UK} = \frac{A_S - \eta N^{GER} q_S^{GER} - \alpha c_S + \frac{\alpha\lambda}{\gamma} q_G^{UK}}{2 + \eta(N^{UK} - 1)}, \tag{54}$$

and

$$q_G^{UK} = \frac{A_G + \lambda q_S^{UK} - \theta N^{GER} q_G^{GER} - \gamma c_G}{2 + \theta(N^{UK} - 1)}. \tag{55}$$

Although complementarity is one-way in demand, the service and goods first-order conditions are jointly determined. This does not imply two-way complementarity in demand. It reflects the fact that a multiproduct firm internalizes the effect of service provision on goods profits.

B.2.3 Concavity and equilibrium conditions

The Hessian of the German firm's profit function with respect to $(q_{Si}^{GER}, q_{Gi}^{GER})$ is

$$\nabla^2 \Pi_i^{GER} = \frac{1}{e} \begin{pmatrix} -\frac{2}{\alpha} & \frac{\lambda}{\gamma} \\ \frac{\lambda}{\gamma} & -\frac{2}{\gamma} \end{pmatrix}. \tag{56}$$

Strict concavity requires

$$\lambda^2 \alpha < 4\gamma. \tag{57}$$

This condition is implied by the stronger regularity condition $\lambda^2 \alpha < 2\gamma$ imposed in the baseline model.

To characterize the symmetric equilibrium, define

$$D_S^{GER} = 2 + \eta(N^{GER} - 1), \qquad D_G^{GER} = 2 + \theta(N^{GER} - 1), \tag{58}$$

$$D_S^{UK} = 2 + \eta(N^{UK} - 1), \qquad D_G^{UK} = 2 + \theta(N^{UK} - 1). \tag{59}$$

Let

$$\mathbf{q}(e) = \begin{pmatrix} q_S^{GER} \\ q_G^{GER} \\ q_S^{UK} \\ q_G^{UK} \end{pmatrix} \tag{60}$$

and

$$\mathbf{b}(e) = \begin{pmatrix} A_S - \alpha e \nu c_S \\ A_G - \gamma e \nu c_G \\ A_S - \alpha c_S \\ A_G - \gamma c_G \end{pmatrix}. \tag{61}$$

The four equilibrium conditions can be written as

$$M\mathbf{q}(e) = \mathbf{b}(e), \tag{62}$$

where

$$M = \begin{pmatrix} D_S^{GER} & -\frac{\alpha\lambda}{\gamma} & \eta N^{UK} & 0 \\ -\lambda & D_G^{GER} & 0 & \theta N^{UK} \\ \eta N^{GER} & 0 & D_S^{UK} & -\frac{\alpha\lambda}{\gamma} \\ 0 & \theta N^{GER} & -\lambda & D_G^{UK} \end{pmatrix}. \tag{63}$$

Provided that M is nonsingular, the symmetric equilibrium is

$$\mathbf{q}(e) = M^{-1}\mathbf{b}(e). \tag{64}$$

We restrict attention to parameter values for which M is nonsingular and all equilibrium prices and quantities are strictly positive. These restrictions ensure that the numerical exercise describes a unique interior symmetric equilibrium.

Because M does not depend on e, the equilibrium quantity responses can be written

compactly as

$$\frac{\partial \mathbf{q}(e)}{\partial e} = M^{-1} \begin{pmatrix} -\alpha \nu c_S \\ -\gamma \nu c_G \\ 0 \\ 0 \end{pmatrix}. \tag{65}$$

The signs of the individual elements generally depend on strategic interaction and are therefore evaluated numerically below.

B.2.4 Relationship to the baseline model

The single-firm model is nested as a special case of the Cournot framework. Setting

$$N^{GER} = 1, \qquad N^{UK} = 0,$$

eliminates strategic interaction and reduces Equations (52) and (53) to

$$q_S = \frac{A_S - \alpha e \nu c_S + \frac{\alpha \lambda}{\gamma} q_G}{2}, \tag{66}$$

and

$$q_G = \frac{A_G + \lambda q_S - \gamma e \nu c_G}{2}. \tag{67}$$

These are exactly the quantity first-order conditions implied by the single-firm model in the main text. The Cournot extension therefore preserves the baseline demand and pricing mechanism while adding strategic interaction between German exporters and UK competitors.

B.2.5 Prices and elasticities

After solving for equilibrium quantities, the pound-denominated prices charged by a representative German exporter are recovered from inverse demand:

$$P_S^{GER} = \frac{A_S - \left[1 + \eta(N^{GER} - 1)\right] q_S^{GER} - \eta N^{UK} q_S^{UK}}{\alpha}, \tag{68}$$

and

$$P_G^{GER} = \frac{A_G - \left[1 + \theta(N^{GER} - 1)\right] q_G^{GER} - \theta N^{UK} q_G^{UK} + \lambda q_S^{GER}}{\gamma}. \tag{69}$$

The corresponding euro prices received by German exporters are

$$p_S^{GER} = \frac{P_S^{GER}}{e}, \qquad p_G^{GER} = \frac{P_G^{GER}}{e}. \tag{70}$$

The first-order conditions provide the equivalent pricing rules

$$P_G^{GER} = e\nu c_G + \frac{q_G^{GER}}{\gamma}, \tag{71}$$

and

$$P_S^{GER} = e\nu c_S + \frac{q_S^{GER}}{\alpha} - \frac{\lambda q_G^{GER}}{\gamma}. \tag{72}$$

Equation (72) displays the same loss-leader mechanism as the baseline model. The German exporter prices services below their stand-alone Cournot level because service provision raises demand for its own good.

Define the absolute own-price elasticities of the residual demands faced by a representative German exporter as

$$\varepsilon_S^{GER} = \frac{\alpha P_S^{GER}}{q_S^{GER}}, \qquad \varepsilon_G^{GER} = \frac{\gamma P_G^{GER}}{q_G^{GER}}. \tag{73}$$

Using Equations (71) and (72) gives

$$\varepsilon_G^{GER} = 1 + \frac{\gamma e\nu c_G}{q_G^{GER}} > 1, \tag{74}$$

and

$$\varepsilon_S^{GER} = 1 + \frac{\alpha e\nu c_S}{q_S^{GER}} - \frac{\alpha\lambda q_G^{GER}}{\gamma q_S^{GER}}. \tag{75}$$

Thus, goods demand is evaluated in its elastic region, whereas service demand may be locally inelastic because the firm internalizes the positive effect of services on goods profits.

B.3 Model simulation

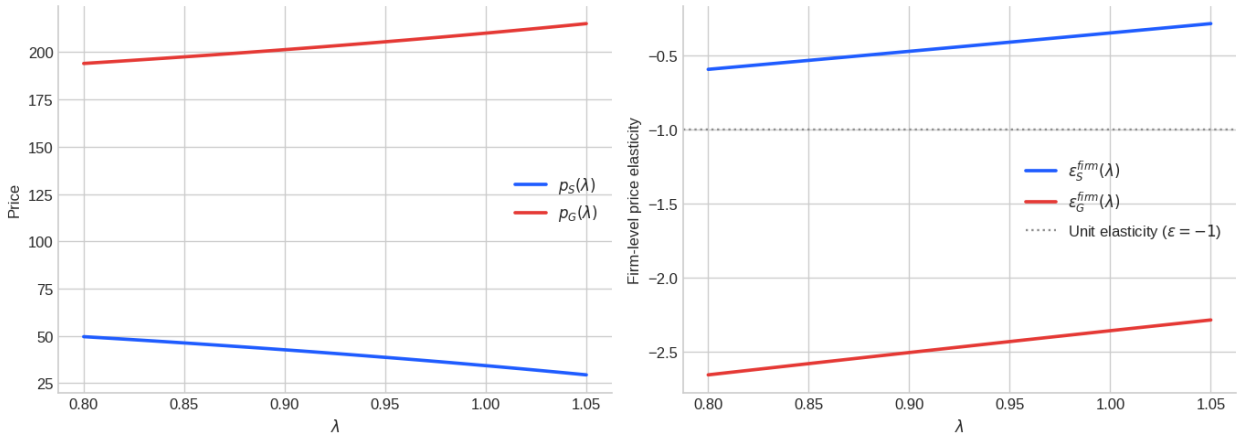
In this appendix, we provide a numerical simulation of the baseline model presented in Section 5 as well as the extended Cournot model to illustrate that the mechanisms described in the paper can indeed be realized under plausible parameter values. The simulations highlight how dual exporters may respond asymmetrically to shocks in the exchange rate and trade frictions, showing, for example, cases where service sales rise while goods sales decline. To aid intuition, we also present graphical representations of the key mechanisms, including the effects of complementarities on pricing and quantities, which provide a visual confirmation of the theoretical predictions.

B.3.1 Simulation of the baseline model

Complementarity, pricing, and elasticities We first explore how the strength of complementarity, captured by parameter λ, affects optimal prices and demand elasticities for goods and services. Panel (a) of Figure B1 illustrates that as λ increases, the price of services (p_S) declines while the price of goods (p_G) increases, reflecting stronger complementarity in the pricing decision. At the same time, the value of the price elasticity of services decreases (see Panel (b)), indicating a shift toward less elastic demand as complementarities deepen. The grey dotted line marks the unit-elasticity threshold, $|\varepsilon| = 1$, showing that service demand is inelastic ($|\varepsilon_S| < 1$), whereas goods demand is elastic ($|\varepsilon_G| > 1$).

Sales effects in the baseline model We graphically show how an increase in the exchange rate (e) or in trade frictions (ν) asymmetrically affects sales of goods and services. Figure B2 illustrates that, as e or ν rises, goods sales (S^G) decline while service sales (S^S) increase. This divergence stems from differences in demand elasticities and the complementarity structure: services operate in a relatively inelastic market segment, allowing firms to pass higher trade costs into prices with limited quantity responses, whereas goods face more elastic demand and thus experience a pronounced contraction in sales. As a result, stronger complementarity between goods and services can partially stabilize total export revenues when trade frictions rise, even if the goods component declines substantially.

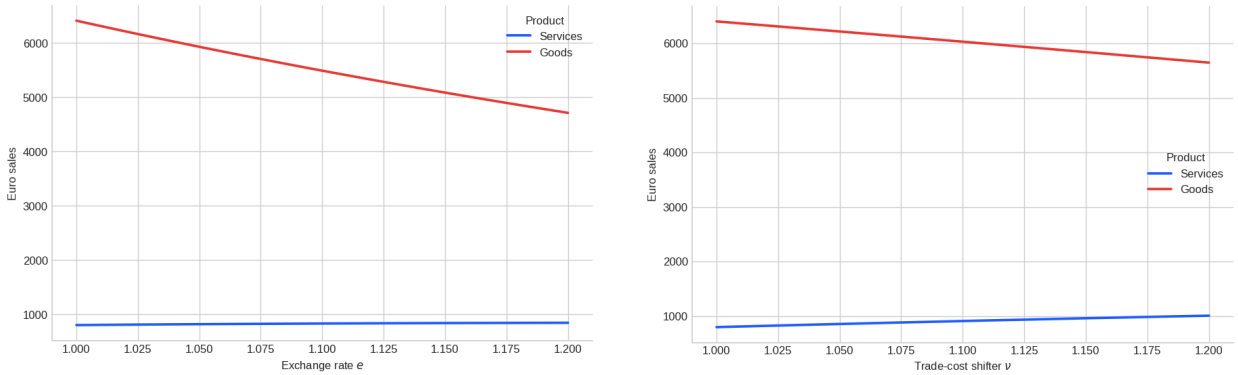
Figure B1: Evolution of prices and price elasticities with complementarity strength λ



(a) Goods and service prices as a function of λ (b) Price elasticities as a function of λ

Notes: Numerical results and parameter values are reported in Table B1.

Figure B2: Effects of exchange rate (e) and trade cost (ν) shocks on sales of goods and services in the baseline model



(a) Sales as a function of e (b) Sales as a function of ν

Notes: Numerical results and parameter values are reported in Table B1.

The numerical results and the parameter values used in these simulations are reported in Table B1.[31]

Table B1: Baseline model: prices, quantities, sales, euro sales, and firm level elasticities.

Panel A: Variation in e ($v = 1.0$)

e	Product	Price	Quantity	Sales (local)	Sales (EUR)	ε^{firm}
1.0	Services	24.444	32.667	798.519	798.519	-0.224
1.0	Goods	204.444	31.333	6405.926	6405.926	-1.957
1.1	Services	29.111	31.267	910.207	827.461	-0.279
1.1	Goods	207.111	29.133	6033.837	5485.306	-2.133
1.2	Services	33.778	29.867	1008.830	840.691	-0.339
1.2	Goods	209.778	26.933	5650.015	4708.346	-2.337

Panel B: Variation in v ($e = 1.0$)

v	Product	Price	Quantity	Sales (local)	Sales (EUR)	ε^{firm}
1.0	Services	24.444	32.667	798.519	798.519	-0.224
1.0	Goods	204.444	31.333	6405.926	6405.926	-1.957
1.1	Services	29.111	31.267	910.207	910.207	-0.279
1.1	Goods	207.111	29.133	6033.837	6033.837	-2.133
1.2	Services	33.778	29.867	1008.830	1008.830	-0.339
1.2	Goods	209.778	26.933	5650.015	5650.015	-2.337

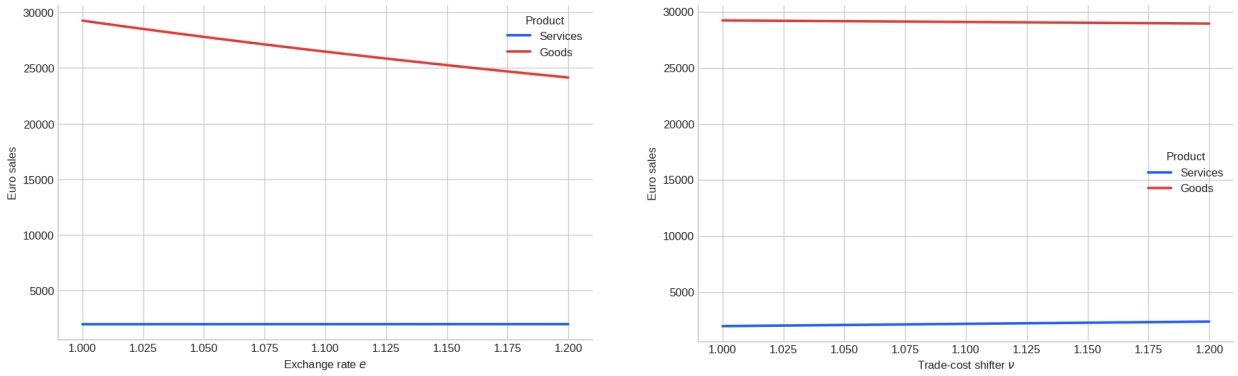
Notes: Simulation parameters are $A_S = 40.00$, $A_G = 60.00$, $\alpha = 0.30$, $\gamma = 0.30$, $\lambda = 1.00$, $c_S = 20.00$, $c_G = 100.00$, $N_{GER} = 1$, and $N_{UK} = 0$. The varied parameter takes values 1.0, 1.1, and 1.2; the other parameter is fixed at 1.0. Euro sales equal local sales divided by e.

B.3.2 Numerical simulation of the extended Cournot model

The Cournot extension, with firms active in both Germany and the United Kingdom, confirms the qualitative mechanisms identified in the baseline model. Figure B3 shows the result of our numerical simulation. The purpose of the simulation is to demonstrate that the qualitative mechanism derived in the single-firm model survives in an oligopolistic environment. In particular, for parameter values under which service demand is relatively inelastic and goods demand is relatively elastic, an adverse shock to German exporters can increase S_S^{GER} while reducing S_G^{GER}.

[31] Thereby, note that as e and v affect prices and quantities only through their product, i.e., ev, Panel A and B of Table B1 (and, below in Table B2), report identical prices, quantities, local sales, and demand elasticities.

Figure B3: Effects of exchange rate (e) and trade cost (ν) shocks on sales of goods and services in the extended Cournot model



(a) Sales as a function of e

(b) Sales as a function of ν

Notes: Numerical results and parameter values are reported in Table B2.

Table B2: Two-country Cournot extension: prices, quantities, sales, euro sales, and firm level elasticities.

Panel A: Variation in e ($\nu = 1.0$)

e	Product	Price	Quantity	Sales (local)	Sales (EUR)	ε^{firm}
1.0	Services	22.299	88.554	1974.648	1974.648	-0.076
1.0	Goods	332.880	87.864	29248.248	29248.248	-1.137
1.1	Services	24.784	87.917	2178.938	1980.853	-0.085
1.1	Goods	334.271	87.081	29108.759	26462.508	-1.152
1.2	Services	27.269	87.279	2380.062	1983.385	-0.094
1.2	Goods	335.662	86.298	28967.093	24139.244	-1.167

Panel B: Variation in ν ($e = 1.0$)

ν	Product	Price	Quantity	Sales (local)	Sales (EUR)	ε^{firm}
1.0	Services	22.299	88.554	1974.648	1974.648	-0.076
1.0	Goods	332.880	87.864	29248.248	29248.248	-1.137
1.1	Services	24.784	87.917	2178.938	2178.938	-0.085
1.1	Goods	334.271	87.081	29108.759	29108.759	-1.152
1.2	Services	27.269	87.279	2380.062	2380.062	-0.094
1.2	Goods	335.662	86.298	28967.093	28967.093	-1.167

Notes: Simulation parameters are $A_S = 600.00$, $A_G = 600.00$, $\eta = 0.30$, $\theta = 0.30$, $\alpha = 0.30$, $\gamma = 0.30$, $\lambda = 1.00$, $c_S = 20.00$, $c_G = 40.00$, $N_{GER} = 10$, and $N_{UK} = 10$. The varied parameter takes values 1.0, 1.1, and 1.2; the other parameter is fixed at 1.0. Euro sales equal local sales divided by e.