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ABSTRACT

SHOCKING A CEO: ECONOMIC DISINTEGRATION AND EXECUTIVE COMPENSATION IN MANUFACTURING AND SERVICES FIRMS

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This paper uses the Brexit referendum in 2016 as a quasi-natural experiment to estimate the effect of an exogenous negative shock to globalization on executive compensation for German companies listed in the DAX and MDAX stock indices. We show that it matters whether they work for firms exporting goods or services. The main results indicate that executive compensation in firms operating in sectors that export services was negatively affected, in particular through lower variable compensation. On the contrary, executives of firms that operate in sectors exporting goods were not negatively affected overall, though they experienced a compositional change (from bonuses to equity payments). Sectoral regressions suggest that manufacturing firms redirected successfully exports from the UK to other relevant trade partners, while this was not the case in the service sector.

Keywords: Brexit, executive compensation, dividend, services.

JEL classification: F14, F16, E24, J33, G35

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1 Introduction

How does the remuneration of top executives in internationally operating firms respond to negative shocks to global economic integration? We know that, in the era of globalization, executives have seen their compensation packages increase as a result of such global integration, both in absolute terms and relative to the average pay of "normal" workers (Ma & Ruzic, 2020; Keller & Olney, 2021). However, the last two decades, starting with the financial crisis in 2008 have seen many negative shocks to integration. And this trend towards disintegration seems, if anything, to be accelerating since the Covid pandemic in 2020 and rising geopolitical tensions. How does this affect executives as the top earners in an economy? This is the question we address in this paper.

For our empirical analysis, we exploit an unexpected and arguably exogenous shock to globalization, namely, the Brexit referendum in 2016. We investigate how this unexpected signal towards economic disintegration between the UK and the EU affected compensation for executives in German DAX and MDAX listed firms, using executive-firm level data for 2006 to 2020. This paper is, to the best of our knowledge, the first that investigates the link between such an exogenous negative shock to globalization and executive compensation.[1]

An important novelty and contribution of our paper is that we distinguish firms and executives in manufacturing and services sectors, and consider trade in goods and services. Hence, uniquely, we can look at the different ways manufacturing and service firms adjust to exogenous trade shocks.[2] This links our work to papers that study both sectors from different perspectives, like comparing the characteristics of firms trading goods or services (e.g., Ariu, 2016; Breinlich & Criscuolo, 2011), looking at service sales by manufacturing firms (e.g., Ariu et al., 2019; Grover & Mattoo, 2021; Gu et al., 2020), or estimating the

[1] Ma and Ruzic (2020) use the accession of China to the WTO as a positive shock to integration, and look at the impact on executive compensation. Keller and Olney (2021) use an instrumental-variables strategy in a period where globalization also increased. Both papers look at the US, and only consider trade in goods. Though the data include both manufacturing and services firms, only trade in goods is considered.

[2] Yahmed and Dougherty (2016) analyzes the import penetration impact on firms' productivity in several industries, including manufacturing and services, without performing a heterogeneity analysis.

impact of services liberalization on manufacturing firm performance (e.g., Arnold et al. 2011; Debaere et al., 2013; Shepotylo & Vakhitov, 2015). We complement these studies by looking at the heterogeneous impact of a negative trade shock on firms trading goods and services.[3]

We would expect differences due to the nature of the products traded. Services trade may be more difficult to adjust than goods trade, and this inhibits reallocations by firms. This matters for executive compensation. We can illustrate this point adopting the conceptual framework by Ma and Ruzic (2020), where the basic idea is that executive compensation is to some extent linked to the sales of the firm, while the wages for production workers are set in a country-wide labour market. Hence, a trade shock can influence executive compensation through changes in firms' output. If the shock is positive, executive compensation should rise faster than pay for average workers, which is what Ma and Ruzic (2020) and Keller and Olney (2021) find. In the case of a negative shock, firms may try to readjust their export activity and redirect exports to other destinations (including the domestic market). If this is done successfully, then executive compensation may not be negatively affected. Our working hypothesis is that such adjustment is easier for goods than for services trade. While a car that was previously sold to the UK may be easily sold to other markets, this may be far more difficult for a business or financial service. Not only are services more likely to be tailored to the customers, but services trade restrictions may prohibit an easy redirection of services exports away from the UK to other markets.

Our results suggest that this is indeed the case. We use a difference-in-differences approach that uses the Brexit referendum in 2016 as an exogenous shock, where we compare executive compensation of firms highly exposed in their export activity to the UK market and those in firms with less exposure, before and after the referendum. We find that German executives in sectors exporting services were not immune to Brexit, as their compensation was negatively affected. Distinguishing variable and fixed components of pay, we find that

[3]Overall, there is an imbalance in the literature with only few papers analyzing the impact of trade shocks in the services sectors (Bombarda et al, 2010; Hijzen et al, 2011; Christen et al, 2019) in comparison to the abundant literature for the manufacturing sector.

in particular the former are hit, as is the probability of the executive to receive a bonus. Interestingly, in an extension to our empirical model, we also find that the CEO-to-worker pay ratio increased as a result of Brexit in the services sector, hence, there is a rise in inequality. This suggests that wages of the average worker fell proportionally more than executive compensation. By contrast, executives in manufacturing firms were not affected in their total, variable or fixed compensation. The only adjustment we find is a shift away from bonuses towards equity. In the same way, the CEO-to-worker pay ratio in the manufacturing sector did not change due to Brexit.

These results appear to be driven by the inability of services firms to adjust their exports.[4] While manufacturing firms are able to increase overall sales in the wake of Brexit, and adjust export destinations (in particular increasing exports to China), this is not the case for services firms. Hence, it seems that manufacturing firms successfully implemented a *"redirecting exports strategy"*, switching exports destined to the UK to other clients, like China. This paid off for executives in terms of avoiding losses to compensation.

This paper proceeds as follows. Section 2 describes the data and some of its limitations, section 3 shows the descriptive statistics, section 4 explains the methodology, section 5 analyses the results, section 6 performs robustness checks and extensions, and section 7 concludes.

2 Data

In order to conduct the empirical analysis, we merged three datasets:

Executive compensation: Information on executive pay is obtained from the "German executive compensation database" constructed by Beck et al. (2020).[5] This database

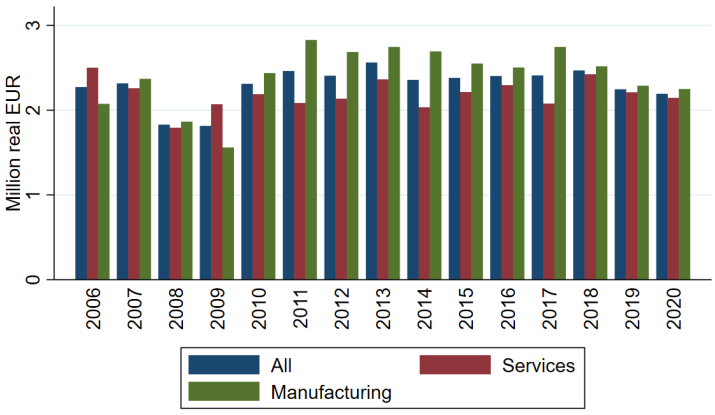
[4]The difference-in-differences econometric approach implemented in this paper focuses on the Brexit effect via exports, not imports, since Brexit affected in higher proportion German exports to UK than German imports from UK (see figures 2 and 14 and Section 3). However, most of the main results are robust when sectoral import shares from the UK are included as covariates in the baseline specification.

[5]We are very grateful to the authors for sharing their data with us. While Beck et al. (2020) show descriptive statistics for 2006 to 2018, the data they shared cover 2006-2020.

contains the fixed compensation (salary, fringe benefits and personal benefits) and variable compensation (equity -stock and option grants-, one-year bonus, and multi-year bonus) for executives of firms listed in the DAX and MDAX stock indices. The database contains on average 76 firms per year and 5 executives per firm per year for the 2006-2020 period. Details about the collection of this database are described in Beck et al. (2020).

The data show that the total average compensation for executives in German DAX and MDAX listed firms fluctuated substantially between 2006 and 2020 (see Figure 1)[6]. There was a decline during the financial crisis 2008 / 2009 followed by a quick recovery, reaching a peak in 2013. There has again been a decline in 2019 / 2020 which was also experienced in countries like the UK and the US, partly explained by Covid.[7] Whether and how such developments and variations of the total compensation and its components (variable and fixed compensation) may be related to globalization is an open question, that we aim to address in this paper.[8]

Figure 1: Total executive compensation (simple average), 2006-2020



Real measures calculated based on the consumer price index from Destatis Statistisches Bundesamt. 2020 is the base year.
Initially, the sample of the graph is the sample of the total compensation regression (table 6), that covers the 2007-2020 period, since the independent variables are lagged one period (Xt-1). The sample of the initial year (2006) was added including the 2006 observations (executive-firm pairs) that are also present in the total compensation regression sample (2020-2007).

[6]Figure 17 in the Appendix shows the median of the total compensation between 2006 and 2020.

[7]See *"What happened to CEO pay in 2020?"* `https://trustforlondon.org.uk/research/what-happened-to-ceo-pay-in-2020/`; *"S&P 500 CEO Compensation Increase Trends"* `https://corpgov.law.harvard.edu/2024/02/17/sp-500-ceo-compensation-increase-trends-6/`

[8]Figures 18, 19, 20, and 21 in the Appendix show the evolution of the simple average and the median of the variable and fixed compensation between 2006 and 2020.

Firm level data: We obtain firm level data from the Worldscope database (Thomson, 2007). This can be linked to the executive compensation data. For most of the DAX and MDAX firms in Beck et al. (2020), we obtain information on the number of employees, average wages, total assets value, CAPEX (capital Expenditures), return and leverage rates relative to assets and dividend declared per share.[9] Also, we obtain one SIC (Standard Industrial Classification) code of the principal product of the firm, which is used to classify the main industry of the firm.[10] The link of the Worldscope data with the executive compensation dataset is done through the *ISIN* (International Securities Identification Number).

Industry output, exports, imports: We obtain values of exports and imports, output, value added, turnover, and gross margin data at the industry level from the Eurostat datasets detailed in Table 1.

In order to homogenize the industrial classification to generate a consistent trade in services panel data between 2006 and 2020, traded values from 2006 to 2009 - which are classified in Extended Balance of Payments Services (EBOPS) 2002 - are converted to EBOPS 2010 based on the concordance shown in table 18 in Appendix C.[11] In the same way, the services

[9] 95.7% of the firm-year observations in Beck et al. (2020) merged satisfactory with Worldscope; 3% were not in Worldscope and 1.3% had incomplete information.

[10] We assign one NACE Rev 2 code for manufacturing firms and one EBOPS 2010 code for services firms based on the SIC (Standard Industrial Classification) code reported by Worldscope and public information of firms. However, this assignment involves subjective criteria. For those firms whose SIC code was considered accurately aligned with the most important product/service sold by the firm (according to the firms' web pages), the assignment is subjective since there is no official concordance between SIC and NACE Rev 2 and SIC and EBOPS 2010. For those firms whose SIC code was not considered accurately aligned with the most important product/service sold by the firm (according to the firms' web pages), the assignation is also subjective since the most important product/service described in the firms' web pages could be accurately linked to different industry codes. Table 20 in the Appendix contains the definitive industry for each firm. The single-industry assumption per firm could be debatable since these large firms could operate in many industries (even spanning both manufacturing and services). However, this assumption tends to prevail in the literature even in topics that could be driven by few and big firms, like innovation (Chakravorty et al., 2024).

[11] Originally, the first trade in services dataset is disaggregated at EBOPS 2002 and covers from 2006 to 2013. The second trade in services dataset is disaggregated at EBOPS 2010 and covers from 2010 to 2020. The traded values for the overlapping years (2010-2013) are obtained from the second dataset with the exception of the construction sector, whose values tend to be more realistic in the first dataset. We linearly interpolate missing values. If the missing values were at the initial years, they are replaced by: $X_{t-1} = X_t - \hat{\beta}_1$, in which $\hat{\beta}_1$ is obtained from a simple regression: X=β_0+β_1Year. If the missing values were at the final years, the missing values were replaced by: $X_{t-1} = X_t + \hat{\beta}_1$, in which $\hat{\beta}_1$ is obtained from a simple regression: X=β_0+β_1Year.

Table 1: Eurostat datasets and correspondences description

Variables	Dataset name	Industry classification	Coverage years
1. Production and value added	*estat_nama_10_a64*	NACE Rev 2	2006-2020
2. Trade value in services	*estat_bop_its_det*	EBOPS 2002	2006-2013
3. Trade value in services	*estat_bop_its6_det*	EBOPS 2010	2010-2020
4. Trade value in goods	*DS-059327*	CPA 2.1	2006-2020
5. Exports and imports - wholesale and retail trade (goods)	*estat_ext_tec01*	NACE Rev 2	2014-2020
6. Turnover and gross margin - wholesale and retail industry	*estat_sbs_na_dt_r2*	NACE Rev 2	2008-2020
7. Correspondence table between EBOPS 2002 - EBOPS 2010. See table 18			
8. Correspondence table between NACE Rev 2 - EBOPS 2010. See table 19			

Note: EBOPS: Extended Balance of Payments Services Classification. NACE: Classification of economic activities in the European Union (EU). CPA: Classification of products parallel to that of the NACE at all levels.

output data, which is classified in NACE Rev 2, is converted to EBOPS 2010 using the concordance shown in Table 19 (Appendix C) in order to calculate the export share relative to output.[12]

Unfortunately, services exports for the wholesale and retail (WR) sector are not included in the EBOPS statistics. Hence, we need to approximate their value. Doing so is based on the idea that the WR sector exports goods but embedded in those goods are services exports which are represented by the traders' margins. Hence, we approximate the value of services exports as the product of the German goods exports for the WR sector multiplied with its industry margin rate (gross margin/turnover):[13]

$$Exp\_serv\_WR_{DE} = Exp\_goods\_WR_{DE} * \frac{Gross\_margin\_WR_{DE}}{Turnover\_WR_{DE}} \tag{1}$$

[12]Eurostat also publishes trade in services in NACE Rev 2, which would avoid the use of the NACE Rev 2- EBOPS 2010 concordance. However, the public information is not disaggregated by destination country, which is required to calculate the export share to UK. Note that the correspondence table does not include "Travel" EBOPS code, consequently, that category is excluded from the estimation.

[13]As $Exp\_Goods\_WR_{DE}$ data is available from 2014 to 2020, the value for the previous years is calculated as $Exp_{t-1} = Exp_t - \hat{\beta}_1$, in which $\hat{\beta}_1$ is obtained from a simple regression: Exp=β_0+β_1Year. Also $Gross\_margin\_WR$ and $Turnover\_WR$ data is available from 2008 to 2020, therefore the value for the previous years (2006 and 2007) is calculated as: $X_{t-1} = X_t - \hat{\beta}_1$, in which $\hat{\beta}_1$ is obtained from a simple regression: X=β_0+β_1Year

In the same way, the services exports for WR destined to the UK is approximated as the product of equation 1 (German services exports for WR sector) with the German manufacturing export share to UK, as shown in equation 2.

$$Exp\_serv\_WR_{DE}\_to\_UK = Exp\_serv\_WR_{DE} * Sh\_exp\_goods\_to\_UK \tag{2}$$

3 Descriptive statistics

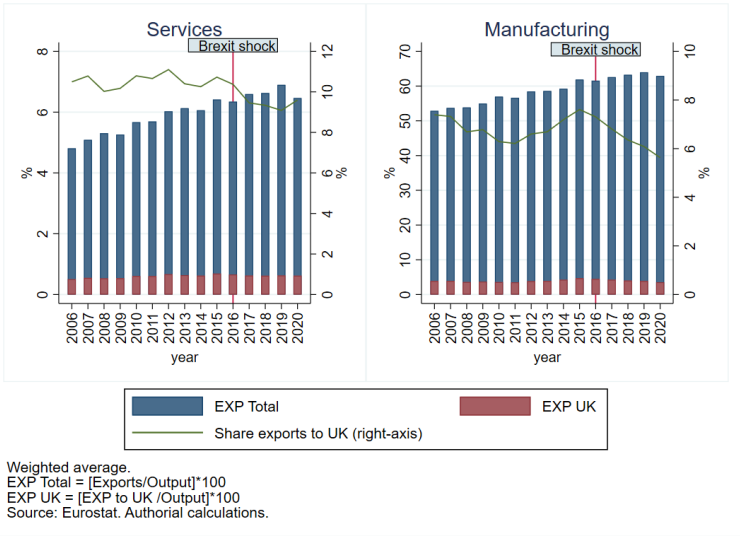
Figure 2 shows the share of German exports to the UK relative to total exports and production from 2006 to 2020 for the services and manufacturing industries. For manufacturing industries, the share of exports relative to total exports remained almost stable during the pre-Brexit period, between 7.4% in 2006 and 7.3% in 2016, although this masks a slump in the share between 2006 and 2010 and a subsequent recovery. However, in the aftermath of the 2016 Brexit referendum the export share decreased continuously to 5.6% in 2020. This is somewhat similar for services industries, where the share of German exports to the UK was 10.2% in 2006 and 10.4% in 2016. After the Brexit referendum there is a clear downward trend, leaving the share of German services exports to the UK at 9.6% in 2020. Figure 14 in the Appendix shows the equivalent picture for imports from the UK to Germany. There is no clear impact of Brexit visible, hence we focus on exports in the rest of the paper.

Table 2 illustrates that i) basic pharmaceutical products and pharmaceutical preparations, ii) motor vehicles, trailers and semitrailers, and iii) computer, electronic, and optical products, are the goods exports most affected by Brexit with the highest declines in their export share to the UK between 2020 and 2016. In terms of services, i) construction, ii) wholesale and retail trade, and iii) technical, trade-related, and other business, are most severely hit.[14]

An econometric analysis suggests that Brexit generated a structural break in German

[14]Figures 15 and 16 in the Appendix detail the evolution of the export share for all years between 2006 and 2020 for each manufacturing and services industry. Finally, Table 14 in the Appendix shows the export share to UK relative to production by industry in 2006, 2016 and 2020.

Figure 2: German exports to UK relative to total exports and production, 2006-2020.



exports to the UK. The coefficient of year in a regression in which export share to the UK relative to total exports is the dependent variable (including industry fixed effects) structurally changed from positive statistically insignificant (0.063, pi-value = 0.312) between 2006 and 2015 to negative statistically significant (-0.20, pi-value = 0.004) between 2016 and 2020. The rejection of the null hypothesis (pi value = 0.07) of the test for breaks at known dates described by Karavias et al. (2023) confirms the structural break in 2016. [15]

Table 3 shows basic descriptive statistics for the companies listed in the DAX and MDAX stock indices and the remuneration of their executives between 2006 and 2020.[16] The simple average of the variables is reported in parentheses next: number of employees (65 thousand), total assets (81 thousand million EUR), average wage (74 thousand EUR), net sales (23 thousands million EUR), return on assets (4.7%), CAPEX rate (4.4%), leverage rate (25.1%) and dividends declared per share (1.3). As a benchmark to show how big these companies

[15]By contrast, there is no evidence of a structural break in German imports from the UK relative to total imports due to Brexit (Figure 14 in the Appendix). Although the coefficient of year in a regression with the import share from the UK relative to total imports as dependent variable increased in absolute value after Brexit (the coefficient varied from -0.10 (pi-value = 0.045) between 2006 and 2015 to -0.13 (pi-value = 0.031) between 2016 and 2020), the Karavias et al. (2023) test for breaks at known dates does not reject a null structural break in 2016 (pi-value=0.47). Consequently, the econometric analysis focuses on Brexit impact on the dependent variables defined before through exports, not imports.

[16]Real measures are calculated based on the consumer price index from Destatis Statistisches Bundesamt. 2020 is the base year.

are, the average German firm in 2021 has just 10.3 employees, 2.8 million turnover, and the full time worker earns 56 thousand EUR, according to the Statistisches Bundesamt.[17] In addition, the simple average of executive compensation is 2.31 million EUR, of which 66% is obtained by variable components: one-year bonus (29%), multi-year bonus (13%) and equity (24%).

Table 4 shows the simple average of the median per year of the same variables described before across industries. In descending order, the largest firms in terms of total assets operate in the financial industry (354 thousand millions EUR), insurance pension (322 thousand millions EUR), and manufacture of motor vehicles, trailers, and semi-trailers (192 thousand millions EUR). The biggest firms in terms of employees operate in the manufacture of motor vehicles, trailers and semitrailers industry (201,396), manufacture of rubber and plastic products (189,886) and manufacture of electrical equipment (86,518). The most profitable firms in terms of return on assets operate in the manufacture of coke and refined petroleum products (14.4%), the manufacture of textiles (9.9%) and the manufacture of chemicals products (6.80%). Finally, the firms with larger CEO-to-avg worker pay ratio operate in the wholesale and retail industry (105), manufacture of textiles, wearing apparel, and leather products (99), and manufacture of electrical equipment (86).

Table 5 shows the simple average of the median per year of the executive compensation across industries. The top executives in terms of compensation operate in the motor vehicles, trailers and semi-trailers (3.5 EUR million), electrical equipment (2.8 EUR million), basic pharmaceutical products and pharmaceutical preparations (2.7 EUR million), and insurance and pension (2.4 EUR million). In these industries, the variable component accounts for around 70% of the total compensation.

[17] See *"Business Register"* statistics from the Statistisches Bundesamt: `https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Enterprises/Business-Register/Tables/business-register.html#fussnote-3-58834` and *"Earnings and earning differences"* statistics from the Statistisches Bundesamt: `https://www.destatis.de/EN/Themes/Labour/Earnings/Branch-Occupation/Tables/yearly-gross-earnings.html`

Table 2: German export share to UK relative to total exports, 2006, 2016, and 2020

Sector	Description	Shares			Δ%	
		2006	2016	2020	20-06	20-16
Goods	Basic pharmaceutical products and pharmaceutical preparations	5.0	8.9	4.1	-18.7	-54.5
Services	Construction	7.7	13.0	7.3	-5.3	-43.6
Goods	Motor vehicles, trailers and semi-trailers	10.7	11.8	8.1	-23.8	-31.3
Goods	Computer, electronic and optical products	8.9	5.9	4.4	-50.6	-25.5
Goods	Fabricated metal products, except machinery and equipment	6.0	5.9	4.6	-23.9	-23.1
Services	Wholesale and retail trade	7.4	7.3	5.6	-23.9	-22.9
Goods	Textiles, wearing apparel, and leather products	4.9	5.8	4.6	-6.5	-21.1
Services	Technical, Trade-related and other business services	10.6	10.0	7.9	-25.3	-20.7
Goods	Paper products	9.1	7.4	5.9	-35.2	-20.5
Goods	Machinery and equipment n.e.c.	5.3	5.4	4.3	-18.4	-19.2
Goods	Electrical equipment	5.0	4.6	3.8	-24.5	-18.3
Goods	Rubber and plastic products	7.6	6.6	5.6	-26.9	-15.6
Services	Insurance and pension	5.3	22.6	19.2	261.6	-15.3
Goods	Other non-metallic mineral products	5.8	5.7	4.9	-16.5	-15.2
Goods	Furniture and other manufacturing	6.7	7.0	6.1	-8.9	-12.8
Goods	Chemicals and chemical products	6.1	5.4	4.7	-22.6	-12.8
Services	Professional and management consulting services	16.0	12.8	11.2	-29.6	-12.0
Services	Telecommunication, computer and information services	10.1	13.7	12.4	23.0	-9.3
Goods	Wood and of products of wood and cork, except furniture	6.1	6.0	5.7	-7.0	-5.0
Goods	Food, beverages and tobacco products	7.4	7.2	6.8	-8.2	-4.5
Goods	Coke and refined petroleum products	7.0	2.5	2.4	-65.4	-3.5
Services	Financial	33.9	21.2	21.0	-38.1	-1.2
Services	Research and development services	4.9	5.1	5.2	6.5	2.1
Goods	Basic metals	6.6	8.4	9.1	38.8	8.2
Services	Transport	8.5	4.9	5.4	-36.6	11.2
Goods	Other transport equipment	10.1	5.8	8.7	-13.9	48.7
Services	Personal, cultural and recreational services	5.2	11.8	18.1	245.3	53.0
Goods	Printing and reproduction of recorded media	4.3	3.8	6.1	42.1	61.4

Simple averages, pre and post Brexit

Sector	2006-2015	2016-2020	Δ	Δ%
Services	11.7	11.2	-0.5	-4.2
Goods	6.1	5.8	-0.3	-4.4

Table 3: Firm and executives descriptive statistics, 2007-2020

Var	Mean	Median	SD	Min	Max	N
Descriptive statistics at firm level						
L	64,811	21,051	105,265	4	671,205	1,038
Total assets[1]	81,242	9,103	250,027	333	2,524,687	1,050
Avg wage[2]	74	68	61	4	954	930
Return on assets (ROA)[3]	4.7	4.7	6.6	-49.5	80.1	1,049
CAPEX rate[3]	4.4	3.6	4.1	0.0	61.7	1,050
Leverage rate[3]	25.1	22.9	16.4	0.0	98.0	1,050
Dividend per share	1.3	0.8	1.5	0.0	9.8	1,043
Net sales[1]	22,930	6,819	36,215	69	253,902	1,051
CEO(max)[4]-to-avg worker pay ratio	63.3	44.0	82.9	1.5	1,560	930
CEO(mean)[5]-to-avg worker pay ratio	39.7	28.3	70.1	1.1	1,560	930
Descriptive statistics at executive level						
Total compensation[1]	2.31	1.92	1.78	0.02	23.90	5,357
Fixed compensation[1]	0.78	0.69	0.50	0.01	7.77	5,357
Variable compensation[1]	1.53	1.20	1.50	0.00	22.62	5,357
One-year bonus[1]	0.66	0.48	0.72	0.00	6.95	5,357
Multi-year bonus[1]	0.31	0.00	0.84	0.00	21.41	5,357
Total equity grants[1]	0.56	0.31	0.88	0.00	19.52	5,357

Notes: Descriptive statistics at firm level are calculated on the sample of the net sales regression (table 10). Descriptive statistics at executive level are calculated on the sample of the total compensation regression (table 6). [1] Million real EUR. [2] Thousand real EUR. [3] Relative to assets. [4] Total compensation of the top earner executive. [5] Average compensation of all executives.

Table 4: Firm descriptive statistics by industry sector

Sector	No. firms	L	Total $Assets^1$ (million)	Avg $wage^1$ (thousands)	CAPEX $rate^2$	ROA^2	Leverage $rate^2$	Dividend per share	CEO(max)^3-to -avg worker pay ratio
Financial	4	26,377	353,524	112	0.1	0.8	20.9	0.4	32
Insurance and pension	3	54,107	321,747	74	0.1	1.0	4.0	5.9	63
Manufacture of motor vehicles, trailers and semi-trailers	4	201,396	192,481	80	4.0	3.3	44.8	2.4	78
Manufacture of other transport equipment	2	60,562	41,288	85	3.0	3.9	13.1	1.0	40
Manufacture of rubber and plastic products	1	189,886	32,321	45	7.1	4.9	27.5	2.3	81
Manufacture of pharmaceutical products	3	44,582	28,610	81	2.5	5.3	29.5	1.0	55
Transport	4	82,495	23,882	52	7.0	3.8	26.2	0.7	54
Telecommunication, computer and information services	6	41,440	17,460	78	3.2	5.7	34.1	0.7	51
Manufacture of electrical equipment	3	86,518	16,668	50	6.6	4.9	24.0	1.2	86
Personal, cultural and recreational services	4	78,518	16,529	47	3.8	6.2	32.1	0.5	81
Construction	2	59,185	12,025	66	3.7	2.3	21.1	2.5	51
Manufacture of other non-metallic mineral products	2	21,415	11,274	55	6.5	4.6	32.5	0.7	83
Manufacture of basic metals	3	30,325	10,635	67	4.6	3.5	12.9	0.5	25
Technical, trade-related and other business services	8	1,538	10,473	73	4.2	5.1	45.0	0.7	25
Manufacture of chemicals	9	17,126	8,052	76	5.2	6.8	22.4	1.0	49
Manufacture of textiles, wearing apparel, and leather products	2	30,877	8,023	42	5.2	9.9	17.0	1.4	99
Manufacture of computer, electronic and optical products	2	22,431	5,294	63	9.2	6.6	12.8	0.2	41
Retail	5	17,032	5,048	38	3.5	4.6	20.6	0.8	105
Manufacture of fabricated metal products	2	15,714	4,219	65	4.6	4.7	17.4	1.5	40
Manufacture of machinery and equipment n.e.c.	5	11,974	3,225	67	2.8	4.9	17.8	0.5	39
Professional and management consulting services	1	6,974	2,074	41	7.0	4.2	25.2	1.3	69
Manufacture of wood and of products of wood and cork	1	5,648	1,971	53	8.7	-7.0	66.0	0.1	27
Manufacture of coke and refined petroleum products	1	5,378	1,904	62	6.8	14.4	0.8	0.9	40
Research and development services	1	424	751	159	0.5	-9.3	7.4	0.0	15

Notes: We report the simple average of the total number of firms per year. For the rest of variables, it is reported the simple average of the median per year. Descriptive statistics at firm level are calculated on the sample of the net sales regression (table 10). [1] Real EUR. [2] Relative to assets. [3] Total compensation of the top earner executive.

Table 5: German executive compensation by industry

Panel A: Simple average (of the median per year) by industry.					
Sector description	Sector	Compensation			
		Total	Fixed	Variable	Sh_var
Motor vehicles, trailers and semi-trailers	Goods	3.5	0.9	2.6	0.7
Electrical equipment	Goods	2.8	0.9	2.0	0.7
Basic pharmaceutical products and pharmaceutical preparations	Goods	2.7	0.9	1.7	0.6
Insurance and pension	Services	2.4	0.8	1.7	0.7
Personal, cultural and recreational services	Services	2.4	0.6	1.7	0.7
Chemicals and chemical products	Goods	2.2	0.7	1.4	0.7
Rubber and plastic products	Goods	2.0	0.7	1.3	0.6
Other non-metallic mineral products	Goods	2.0	0.7	1.5	0.7
Textiles, wearing apparel, and leather products	Goods	2.0	0.7	1.3	0.7
Telecommunication, computer and information services	Services	1.9	0.7	1.1	0.6
Financial	Services	1.8	0.9	0.8	0.4
Transport	Services	1.8	0.7	1.1	0.6
Construction	Services	1.8	0.6	1.1	0.6
Other transport equipment	Goods	1.7	0.7	1.0	0.6
Fabricated metal products, except machinery and equipment	Goods	1.6	0.5	1.1	0.7
Computer, electronic and optical products	Goods	1.5	0.7	0.7	0.5
Machinery and equipment n.e.c.	Goods	1.5	0.6	0.9	0.6
Research and development services	Services	1.5	0.4	1.0	0.7
Retail	Services	1.4	0.6	0.8	0.6
Coke and refined petroleum products	Goods	1.4	0.5	0.8	0.6
Technical, Trade-related and other business	Services	1.3	0.5	0.8	0.6
Basic metals	Goods	1.2	0.6	0.7	0.5
Professional and management consulting	Services	1.0	0.6	0.3	0.3
Wood and of products of wood and cork	Goods	0.9	0.5	0.4	0.5
Panel B: Simple averages across time					
Variable	Sector	2007	2016	2020	Δ%20 − 16
Total compensation	Services	2.3	2.3	2.1	-6.5
Variable compensation	Services	1.6	1.4	1.3	-8.2
Fixed compensation	Services	0.6	0.9	0.8	-3.7
Total compensation	Goods	2.4	2.5	2.2	-10.1
Variable compensation	Goods	1.7	1.7	1.4	-18.2
Fixed compensation	Goods	0.7	0.8	0.9	6.5

Notes: Million real EUR. Descriptive statistics at executive level are calculated on the sample of the total compensation regression (table 6).

4 Methodology

Recall that the aim of the paper is to examine the link between the Brexit referendum in 2016 and executive compensation. To do so we exploit the fact that industries that had a higher export exposure to the UK pre-Brexit are likely to be more strongly affected than others. This allows us to implement a difference-in-differences methodology (similar in spirit to Liu & Ma, 2020 and Pierce & Schott, 2016) which essentially compares executive compensation of firms in industries being highly exposed to the UK market (the treatment group) relative to industries with less exposure (the control group), before and after the 2016 Brexit referendum.

Equation 3 shows the baseline diff-in-diff specification:

$$w_{i,f,s,t} = \beta_0 + \beta_1 Exp\_UK_s * Post\_Brexit_t + \Gamma X_{f,s,t-1} + \delta_{i,f} + \delta_t + \epsilon_{i,f,s,t} \tag{3}$$

where i denotes executive, f firm, s industry, t year. The dependent variable w denotes executive compensation. Exp_UK_s measures the average export share to the UK in relation to total exports of industry s before the Brexit referendum (pre 2016).[18] Export exposure is measured at the industry level since firm-level exports could be endogenous due to non-observable firm shocks (Keller & Olney, 2021). Also, the German "Act of Appropriateness" suggests that compensation should follow industry trends (Beck et al., 2020), which implies that industry-level export exposure, rather than the value for the individual firm, may be particularly important for executive compensation. $Post\_Brexit_t$ denotes the post-Brexit referendum time period, which takes a value of 1 for years from 2016 onward and 0 otherwise.

X covers covariates at firm level: log total assets, leverage, CAPEX, and return (ROA) rates relative to assets. The δs capture fixed effects for each executive-firm pair (if) and time (t). The firm-executive fixed effect implies that identification comes only from within-pair changes over time. Robust standard errors are clustered at industry-year level. In this

[18] Results are robust when export share is measured relative to production, see below.

specification, $\hat{\beta}_1$ in equation 3 represents the effect of Brexit on executive compensation.

The richness of our compensation data allow us to use alternative variables as dependent variable w that capture different aspects of the compensation package: log total compensation, log fixed compensation, log variable compensation, the values of different components of variable compensation (one-year bonus, multi-year bonus, and total equity), and the probability to receive each component of the variable compensation. Furthermore, given that the compensation data is linked to firm level data, we can also calculate the CEO-to-average-worker pay ratio, which we use in an extension to our baseline model.

Equation 3 with log compensation as dependent variable is estimated using a fixed effects estimator. However, given that the values for each variable compensation component (one-year bonus, multi-year bonus, and equity remuneration) contain high shares of zero values, we use Poisson pseudo-maximum likelihood (PPML) regression in levels in those cases.

Finally, the same econometric approach is implemented for the firm-level dependent variables in which there is only one observation per firm; therefore, executive-firm fixed effects are replaced by firm fixed effects.

$$ln(Y)_{f,s,t} = \beta_0 + \beta_1 Exp\_UK_s * Post\_Brexit_t + \Gamma X_{f,s,t-1} + \delta_f + \delta_t + \epsilon_{f,s,t} \tag{4}$$

where Y covers the log net sales, the log average wage, and the log dividend declared per share. X vector is the same as in equation 3. The heterogeneous effects disaggregated by sector (services and manufacturing) are estimated calculating the baseline equation by sub-samples.

5 Results

Estimating equation 3 for the various measures of executive compensation yields the results presented in Table 6.[19] We estimate the model firstly for all firms, and then separately for

[19] In a recent working paper, Ciccia et al. (2024) establish that the standard two-way fixed effects estimator – as used here – is consistent if: i) the groups receiving large and low treatment 'doses' would not have

manufacturing and services firms. Results show that this is important: while executives in manufacturing firms do not experience any impact on their total compensation, executives in services firms do (columns (1) to (3)). The coefficient on the DID term is not only statistically significant in column (2), but the implied magnitude is also economically meaningful: a 0.5 decrease in the export share to UK, which is the difference of the average export share to UK before Brexit (11.74) and after Brexit (11.24) in the services sector, accounts for 7.6% of the decline in total executive compensation in the services sector between 2016 and 2020 (post Brexit).[20]

We split total compensation into its variable and fixed components and estimate the effect of Brexit on these separately. The results in columns (4) to (9) indicate that only variable compensation is affected for executives in services firms. Taking the point estimate at face value in this case suggests that the decline in services exports to the UK after Brexit accounted for 17.4% of the decline in variable executive compensation in the services sector between 2016 and 2020[21] (see figures 18 and 19 in the Appendix). The fact that only the variable component is affected is not surprising. By its very nature, this is the part of compensation that can be easily adjusted in the short-term.

In our data we can also distinguish different components of variable compensation: one-year bonuses, multi-year bonuses, and equity stock and options. We analyse the Brexit effect on these individually, distinguishing the value of bonuses or equity received (Table 7) and the probability of receiving one (Table 8). In other words, we distinguish the intensive and extensive margin for these different components of variable compensation. Results in Table 7 illustrate that the negative Brexit effect on the value of variable compensation in the services sector is driven by a fall in the value of one-year (column 2) and multi-year (column

experienced systematically different outcome trends in the absence of treatment (*parallel trend*), ii) the effect is linear and iii) the design contains quasi-stayers (groups whose treatment doses are very low). In the Appendix – Section 9.1 – we look at these requirements and provide evidence suggesting that these conditions are met in our analysis.

[20]This is calculated as 0.076=0.5*(exp(-0.01)-1)/-0.065), where -0.065 is the total change in total compensation between 2016 - 2020 from Table 5 above.

[21]Calculated as 0.174=0.5*(exp(-0.029)-1)/-0.082)

5) bonuses, while it did not impact on the value of equity. Table 8 additionally shows that executives in services firms experienced a reduction in the probability of receiving a multi-year bonus as a result of Brexit. Hence, for services firms, the adjustment in terms of variable compensation for executives happened at both the intensive and extensive margins.

Interestingly, even though we did not find any effects on aggregate compensation of executives in manufacturing firms we now see a re-adjustment in terms of components of variable pay. In particular, columns (6) and (9) in Table 7 show that the value of multi-year bonuses was impacted negatively, while the value of equity compensation increased as a result of Brexit. In fact, equity payments were also affected at the extensive margin for manufacturing executives (Table 8) where we find that they are more likely to receive one in the Brexit aftermath.

These baseline results are robust to different alternative specifications: i) export share is measured relative to total production and not total exports (see table 15, 16, 17 in the Appendix), ii) the estimation sample is the balanced panel for the 15 sample years (2006-2020), iii) 2020 year is omitted from the estimation sample due to Covid, iv) executive compensation regressions include executive and firm fixed effects separately, instead of executive-firm fixed effects, in order to keep the executive identity if they change firm, v) the sectoral share of imports from UK at the sectoral level is included as an additional covariate in order to control for the potential Brexit effect via imports, vi) the lag of the sectoral share of imports from UK at the sectoral level is included as an additional covariate in order to control for the potential Brexit effect via imports, and vii) wholesale and retail industry are excluded from the estimation. Results from ii) to vii) are available upon request.

Hence, our overall results suggest that, while there appears to be some reallocation across payment components for manufacturing executives, their overall compensation levels appear unaffected by Brexit. Not so for executives in services firms who, on average, experience decreases overall, in particular due to reduced payments through bonuses. Why this difference between manufacturing and services firms? Does it merely reflect that services executives

are hit by "bad luck" (Garvey & Milbourn, 2006; Bertrand & Mullainathan, 2001) or is there some other reason?

If executive pay is tied to firm-specific performance (Ma & Ruzic, 2020) then the difference between manufacturing and services firms should reflect some differences in the impact of Brexit on firm performance. However, as we showed in Figure 2, both services and manufacturing firms experienced a decline in exports to the UK after the Brexit referendum. But that does not necessarily imply an effect on firm performance, if firms are able to redirect exports to other destinations. In order to see whether this might have been the case, we present in Table 9 results from estimations of variants of equation 4 at the industry level, where the dependent variable is total exports to other trade partners: the US, other EU countries, China, and EFTA countries.

The results are illuminating. We find that goods trade with China increased significantly after Brexit, while trade with the US declined. Hence, exporters of manufacturing goods were able to readjust their export portfolio as a result of Brexit, possibly alleviating any potential negative impact due to the decline in exports to the UK. Services exporters were not able to do so. We do not find any statistically significant positive effect in any of the markets; in fact, we find a slight decrease in exports to EFTA countries as a result of Brexit. Hence, services firms do not appear to have been able to divert exports – possibly reflecting higher barriers to trade in services (see Fernandez et al., 2022) – and were, thus, hit fully by the drop in exports to the UK.

This is supported when looking at the impact of Brexit on overall firm performance. Estimation of equation 4 with average wages as a proxy for labor productivity on the left hand side (Table 10) shows that services firms experience a reduction, while this is not the case for manufacturing firms (see columns (5) and (6)). Similarly, the coefficient of Brexit on net sales for services firms is negative (but statistically insignificant). Taken together, this evidence may offer one possible explanation for the negative impact on executive compensation for services firms.

Finally, columns (7), (8) and (9) in Table 10 indicate that the declared dividends per share were not modified due to Brexit in either sector. This finding suggests that these large firms behave according to the dividend policy pattern documented in the literature for the firms listed in the stock market, in which firms avoid to cut dividends and aim to smooth dividend payments across time due to 'signaling' costs: *"A stable dividend policy helps to protect the equity value of the firm."* (Wu, 2018, p.3980). The 'signaling' costs of volatile dividend policy and/or cutting dividends generated that shareholders were unaffected due to Brexit.

Table 6: Brexit shock impact on executive compensation for the biggest German firms

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$ln(Total\_Comp)_{f,i,s,t}$			$ln(Variable\_comp)_{f,i,s,t}$			$ln(Fixed\_comp)_{f,i,s,t}$		
Sample	Total	Services	Goods	Total	Services	Goods	Total	Services	Goods
Avg_sh_exp_UK(<2016)	-0.002	-0.011*	-0.008	-0.011*	-0.03***	-0.017	0.005	0.002	0.006
*D_Brexit(t>=2016)$_{s,t}$	(0.005)	(0.005)	(0.024)	(0.006)	(0.006)	(0.026)	(0.003)	(0.003)	(0.023)
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1								
FE	Executive-firm, year								
Observations	5,357	2,695	2,662	5,058	2,480	2,578	5,357	2,695	2,662
Dep var mean	14.4	14.3	14.4	13.9	13.8	14.0	13.4	13.4	13.4

Robust standard errors clustered at industry-year in parentheses. Sh_exp_UK=Exports to UK/Total exports.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Brexit shock impact on variable executive compensation - PPML estimation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$One\_year\_bonus_{f,i,s,t}$			$Multi\_year\_bonus_{f,i,s,t}$			$Equity_{f,i,s,t}$		
Sample	Total	Services	Goods	Total	Services	Goods	Total	Services	Goods
Avg_sh_exp_UK(<2016)	-0.003	-0.016**	-0.044	-0.07***	-0.09***	-0.176**	0.007	-0.010	0.063***
*D_Brexit(t>=2016)$_{s,t}$	(0.006)	(0.007)	(0.030)	(0.015)	(0.011)	(0.069)	(0.006)	(0.007)	(0.016)
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1								
FE	Executive-firm, year								
Observations	4,888	2,379	2,509	3,318	1,616	1,702	4,235	2,120	2,115
Dep var mean	716,944	649,834	780,577	490,798	331,268	642,267	696,094	755,401	636,648

Robust standard errors clustered at industry-year in parentheses. Sh_exp_UK=Exports to UK/Total exports.
Singleton observations are dropped iteratively.
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Brexit shock impact on probability to receive variable compensation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$D(One\_year\_bonus = 1)_{f,s,t}$			$D(Multi\_year\_bonus = 1)_{f,s,t}$			$D(Equity = 1)_{f,s,t}$		
Sample	Total	Services	Goods	Total	Services	Goods	Total	Services	Goods
Avg_sh_exp_UK(<2016)	-0.002	-0.004	0.010	-0.010	-0.014**	-0.006	-0.002	-0.003	0.038***
*D_Brexit(t>=2016)$_{s,t}$	(0.003)	(0.004)	(0.008)	(0.006)	(0.006)	(0.024)	(0.003)	(0.004)	(0.013)
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1								
FE	Executive-firm, year								
Observations	5,058	2,480	2,578	5,058	2,480	2,578	5,058	2,480	2,578
Dep var mean	0.89	0.90	0.88	0.42	0.41	0.43	0.73	0.77	0.69

Robust standard errors clustered at industry-year in parentheses. Sh_exp_UK=Exports to UK/Total exports.
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Brexit impact on export value to other destination, sectoral regression

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$ln(Exp\_US)_{f,s,t}$		$ln(Exp\_EU27^{1})_{f,s,t}$		$ln(Exp\_China)_{f,s,t}$		$ln(Exp\_EFTA^{2})_{f,s,t}$	
Sample	Services	Goods	Services	Goods	Services	Goods	Services	Goods
Avg_sh_exp_UK(<2016)	0.00602	-0.0306***	0.00550	-0.00284	-0.00904	0.0398**	-0.0127*	-0.000655
*D_Brexit(t>=2016)$_{s,t}$	(0.00665)	(0.0115)	(0.00606)	(0.00773)	(0.0125)	(0.0174)	(0.00765)	(0.0111)
FE	Industry, year							
Observations	149	270	150	270	149	270	150	270
Dep var mean	7.38	7.38	8.38	9.72	5.41	6.74	6.52	7.47

Notes: Robust standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1. Sh_exp_UK=Exports to UK/Total exports.
Regression weighted by export value relative to total annual export value.
Calculation of exports of services involved in the wholesale and retail trade by country is explained in equation 2.
[1] EU27: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden. (Germany is the exporter).
[2] EFTA: Iceland, Norway, Liechtenstein, Switzerland.

Table 10: Brexit shock impact on sales, average wage, and dividend per share for the biggest German firms

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$ln(net\_sales)_{f,s,t}$			$ln(avg\_wage)_{f,s,t}$			$ln(div\_per\_share)_{f,s,t}$		
Sample	Total	Services	Goods	Total	Services	Goods	Total	Services	Goods
Avg_sh_exp_UK(<2016)	0.000	-0.001	0.014**	-0.01***	-0.013**	0.004	-0.012	-0.015	0.008
*D_Brexit(t>=2016)$_{s,t}$	(0.003)	(0.004)	(0.006)	(0.004)	(0.005)	(0.007)	(0.011)	(0.012)	(0.033)
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1								
FE	Firm, year								
Observations	1,051	515	536	929	475	454	908	430	478
Dep var mean	22.7	22.52	22.87	11.07	11.10	11.03	-0.01	-0.08	0.06

Robust standard errors clustered at industry-year in parentheses. Sh_exp_UK=Exports to UK/Total exports.
*** p<0.01, ** p<0.05, * p<0.1

6 Extensions

An extension to our analysis considers the role of corporate governance structures, which may have an impact on executive compensation (Choi et al., 2024). Most German firms implement a two-tier board structure in which executives and directors are separated organizationally (Andres et al., 2014), contrasting with the American one-tier system.[22] However, there is an exception to this two-tier board rule that allows us to exploit econometrically some variation in corporate governance: the governance structure of *Societas Europaea – SE* companies (which account for 18% of the sample) allows flexibility in the board system, and the two-tier system is not mandatory.

Table 11 shows estimations considering variable compensation separately for *Societas Europaea – SE* firms and the rest of the companies. The results, which relate to services firms only, indicate that Brexit impacted variable compensation in the services sector in a similar magnitude independently of the firm governance structure (-0.031 statistically significant at 1% for services firms with non-mandated two-tier boards and -0.028 statistically significative at 1% for services firms with mandatory two-tier boards). This suggests that the baseline results described above are robust to the inclusion of corporate governance.[23]

In another extension, we look at the CEO-to-worker pay ratio as dependent variable, as in Ma and Ruzic (2020). They show that globalization (in their case measured by exports to China) increased this pay ratio, and thus, fostered inequality. Our regressions in Table 12 show that Brexit also had a statistically significant and positive effect on the CEO-to-worker pay ratio but only for firms in the services sectors. This increase in the CEO-to-worker pay ratio suggests that the negative Brexit effect on average wages was proportionally higher than its negative effect on executive compensation, which is also indicated by our results

[22] See Block and Gerstner (2016) for a comparison between the United States (one-tier) and Germany (two-tier) board structure.

[23] In addition, the baseline model in equation 3 already includes executive-firm invariant characteristics and, since corporate governance structures vary slowly across time in Germany (Beck et al., 2020), controls for some differences in corporate governance.

on the average wage (Table 10, column 5) and executive compensation (Table 6, column 2). This, thus, raises the pay gap vis-a-vis the average worker in the service firm, increasing inequality. Hence, while Ma and Ruzic (2020) show that positive trade shocks can increase inequality, we find that this is also the case for a negative shock to economic integration at least in the services sector. In contrast, neither workers nor executives in the manufacturing sector were affected in their remuneration due to Brexit, keeping the CEO-to-worker pay ratio intact.

Finally, Table 13 shows estimates considering the CEO-to-worker pay ratio separately for *Societas Europaea – SE* firms (non-mandatory two-tier) and the rest of the companies. The results, which relate to services firms only, show that Brexit fostered the inequality in the *Societas Europaea – SE* firms, while there was no effect in two-tier firms. These findings suggest that some characteristics of the two-tier board structure, such as the representation of employees on the supervisory board and the separate board that monitors executive actions, may contribute to firms taking into account equality criteria when they adapt to an exogenous adverse shock.[24]

[24]Expanding the scope of these results, the differences in the board structure in Germany, where the average firm implements the two-tier system, and US, where the one-tier system prevails, could be one of the reasons why US has a higher Gini and income share of the top 1 percent than Germany.

Table 11: Brexit shock impact on variable executive compensation in the services sector disaggregated by board structure

Variables	(1)	(2)
	$ln(Variable\_comp)_{f,s,t}$	
Sample	*Societas Europaea firms*[1]	Two-tier firms
Avg_sh_UK(<2016)	-0.031***	-0.028***
*D_Brexit(t>=2016)	(0.011)	(0.007)
Observations	773	1,707
Dep var mean	14.10	13.70
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1	
FE	Executive-firm, year	

Robust standard errors clustered at industry-year in parentheses.*** p<0.01, ** p<0.05, * p<0.1
Sh_exp_UK=Exports to UK/Total exports.
[1]The two-tier board system is not mandatory for the *Societas Europaea – SE* firms.

Table 12: Brexit shock impact on CEO-to-worker pay ratio

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	ln ($CEO(max)$[1]-to-worker pay ratio)			ln ($CEO(avg)$[2]-to-worker pay ratio)		
Sample	Total	Services	Goods	Total	Services	Goods
Avg_sh_UK(<2016)	0.0167**	0.0141**	-0.0218	0.0169***	0.0114*	-0.00518
*D_Brexit(t>=2016)$_{s,t}$	(0.00461)	(0.00610)	(0.0243)	(0.00476)	(0.00624)	(0.0260)
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1					
FE	Firm, year					
Observations	929	475	454	929	475	454
Dep var mean	3.77	3.67	3.87	3.32	3.21	3.42

Robust standard errors clustered at industry-year in parentheses. Sh_exp_UK=Exports to UK/Total exports.
*** p<0.01, ** p<0.05, * p<0.1

[1] Total compensation of the top earner executive.

[2] Average compensation of the executives.

Table 13: Brexit shock impact on CEO-to-worker pay ratio in the services sector disaggregated by board structure

Variables	(1)	(2)
	ln ($CEO(avg)^1$-to-worker pay ratio)	
Sample	*Societas Europaea firms*[2]	Two-tier firms
Avg_sh_UK(<2016)	0.030**	0.005
*D_Brexit(t>=2016)	(0.014)	(0.007)
Observations	134	341
Dep var mean	3.449	3.122
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1	
FE	Firm, year	

Robust standard errors clustered at industry-year in parentheses.*** p<0.01, ** p<0.05, * p<0.1
Sh_exp_UK=Exports to UK/Total exports.
[1] Average compensation of the executives.
[2] The two-tier board system is not mandatory for the *Societas Europaea* – *SE* firms.

7 Conclusion

This paper looks at the impact of an announcement of an adverse trade shock (Brexit referendum) on executive compensation for German companies listed in the DAX and MDAX stock indices. We analyse data for the 2006-2020 period through a difference-in-differences specification. In particular, we look at heterogeneous effects of Brexit on executives in firms in services and manufacturing sectors.

The main finding is that Brexit impacted negatively the compensation of executives in the services sector. These results are not only statistically significant but also economically meaningful. We show that they are driven by a fall in the variable part of compensation (bonuses), rather than the fixed components. In contrast, executive compensation in the manufacturing sector was not affected (although there was a replacement of bonuses by equity).

Looking at mechanisms, our evidence suggests that executives in the manufacturing sector redirected exports from the UK to other customer countries, and they were able to maintain overall output levels. By contrast, services firms experienced reductions in overall output and failed to readjust their export destination portfolio. These is likely due to higher regulations in services industry which makes switching export markets more difficult.

We also find that Brexit increased the CEO-to-worker pay ratio in the services sector, while this was not the case in manufacturing. Brexit implied a proportionally higher reduction in wages than in executive compensation for services firms, raising the CEO-to-worker pay ratio. While Ma and Ruzic (2020) show that positive trade shocks can foster inequality, our result implies that negative shocks to globalization can also do so.

Overall, this is the first paper that we are aware of that looks at the implications of a negative shock to trade integration on executive compensation and firm performance. Given the current geopolitical situation, more of such "natural experiments" are - unfortunately - likely to be generated in the years to come.

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9 Appendix

9.1 Appendix A: Differences-in-differences in heterogeneous adoption designs without stayers

In a recent working paper, Ciccia et al. (2024) analyzes heterogeneous adoption designs without stayers (no group is treated at period one and all groups receive a positive treatment dose in the next period), which describe universal policies, like Brexit, in which all groups are exposed to a different degree to the policy. They constructed new estimators robust to heterogeneous treatment effects, since the ones proposed so far (de Chaisemartin & D'Haultfœuille, 2018, 2020, 2023; Callaway et al., 2024) cannot be implemented in these designs (Ciccia et al., 2024). They also established that the standard two-way fixed effects estimator is consistent if: i) the groups receiving large and low treatment 'doses' would not have experienced systematically different outcome trends in the absence of treatment (*parallel trend*), ii) the effect is linear and iii) the design contains quasi-stayers (groups whose treatment doses are very low). These conclusions can be generalizable to applications with several time periods.

One way to verify partly the first requirement is to calculate a pre-tend specification as in Pierce and Schott (2016), in which $Post\_Brexit_t$ is replaced by a set of year dummies in the baseline equation.[25] For the variation in the dependent variables to be attributable to Brexit, Exp_UK_s should be correlated with executive compensation after Brexit, not before. Figure 3 displays the coefficients of the interaction of Exp_UK_s with the year dummies for variable compensation in the services sector; the coefficients become negative statistically significant since 2016 when Brexit occurred. In the same way, the coefficients of the interaction of Exp_UK_s with the year dummies for the probability to receive equity compensation in

[25]
$$ln(W)_{i,f,s,t} = \beta_0 + \sum_{y=2008}^{2020} \beta_y 1\{y = t\} Exp\_UK_s + \Gamma X_{f,s,t-1} + \delta_{i,f} + \delta_t + \epsilon_{f,s,t} \quad (5)$$

the manufacturing sector become positive statistically significant since 2016 when Brexit occurred (figure 4). More generally, the figures 5-13 show the coefficients of the interaction of Exp_UK_s with the year dummies for all dependent variables. Around 64% of the figures show the expected pattern with the econometric results, consequently, the results are on average consistent with the parallel trend assumption.

In order to verify the second requirement, we estimate the Jann (2008) linearity test for $Exp\_UK_s * Post\_Brexit_t$ in the baseline specification, not the Stute linearity test proposed by Ciccia et al. (2024), since it only works with balanced panel which would reduce 96% the sample (from 5,357 to 195).[26] Figures 5-13 show that it is not possible to reject the linearity hypothesis for 55% of the variables (assuming 3 bins). However, further research about linearity is suggested.

Finally, the export share to the UK for 3 sectors is below 5% after 2016, which could constitute the quasi-stayers group.[27] In conclusion, the diff-in-diff estimators are likely to be consistent and it is not necessary to estimate the new estimators robust to heterogeneous treatment effects proposed by Ciccia et al. (2024), which would also substantially reduce the estimation sample.

[26] An alternative Yatchew linearity test is recommended only with very large datasets.

[27] There is no a statistical software to calculate the quasi-stayers test proposed by Ciccia et al. (2024).

Figure 3: Brexit effect timing on Log variable compensation in the services sector

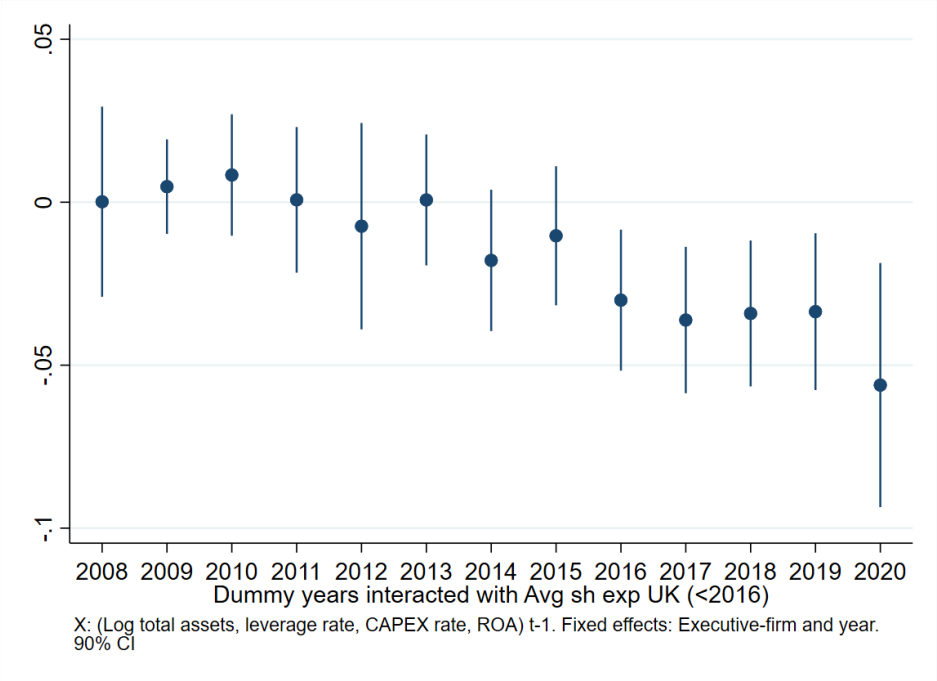


Figure 4: Brexit effect timing on probability to receive equity compensation in the manufacturing sector

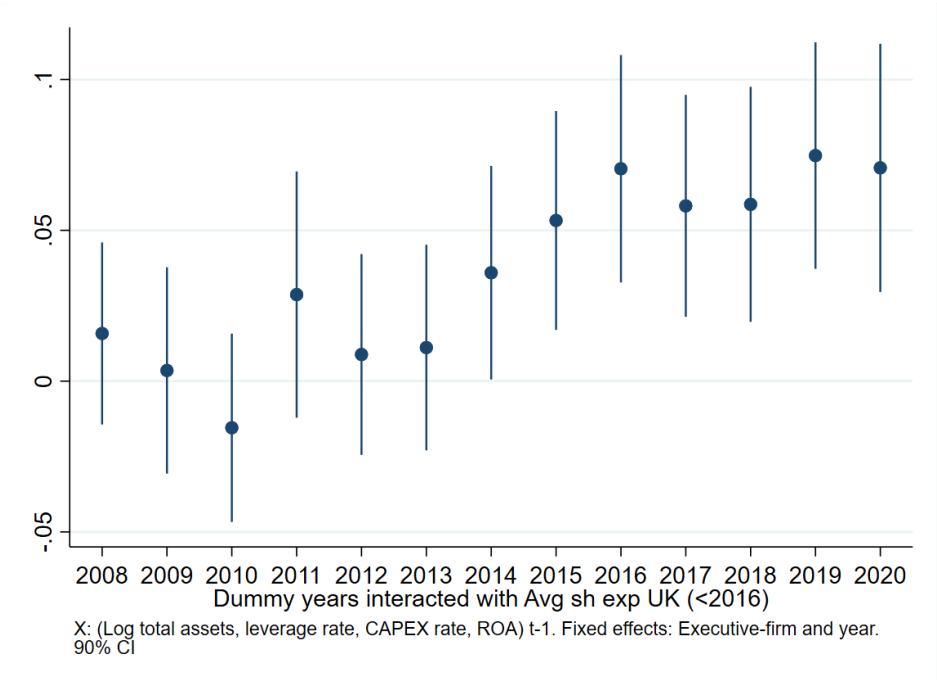
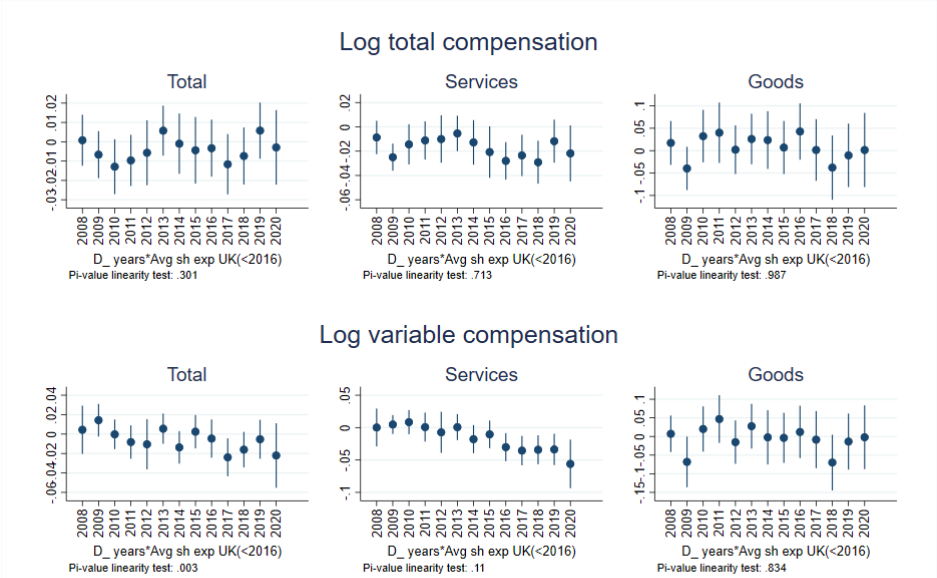
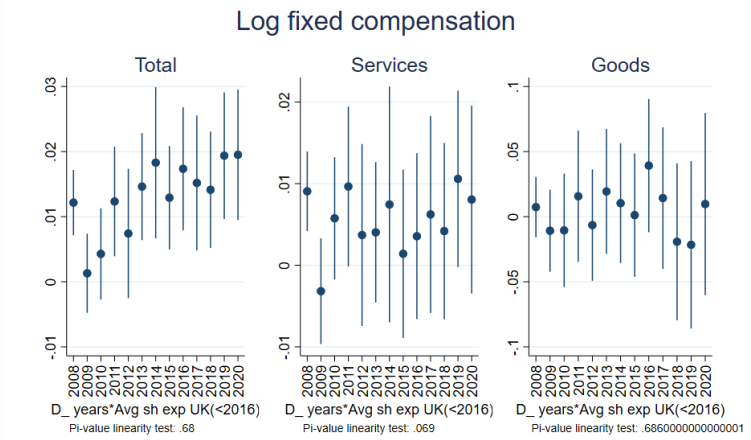


Figure 5: Brexit effect timing on dependent variables 1



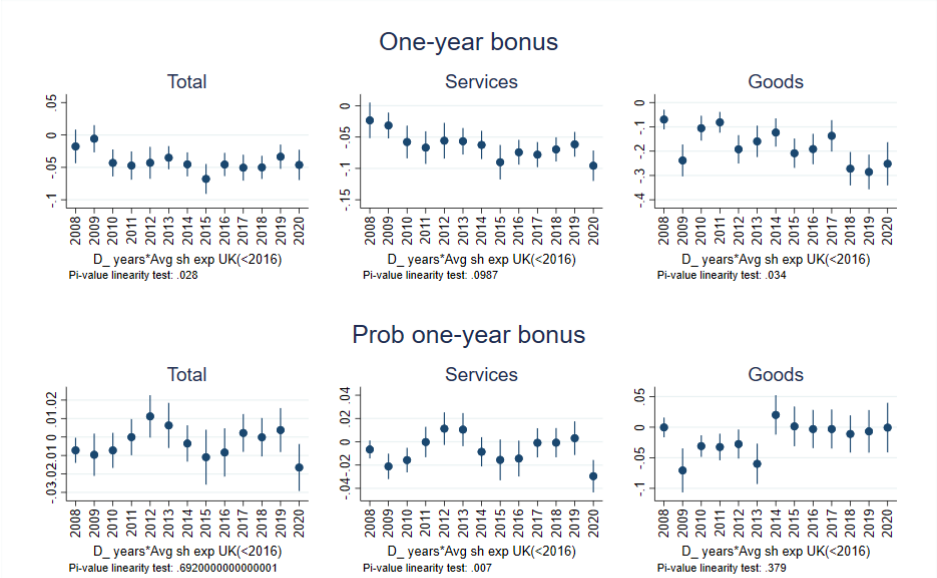
X: (Log total assets, leverage rate, CAPEX rate, ROA) t-1. Fixed effects: Executive-firm and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

Figure 6: Brexit effect timing on dependent variables 2



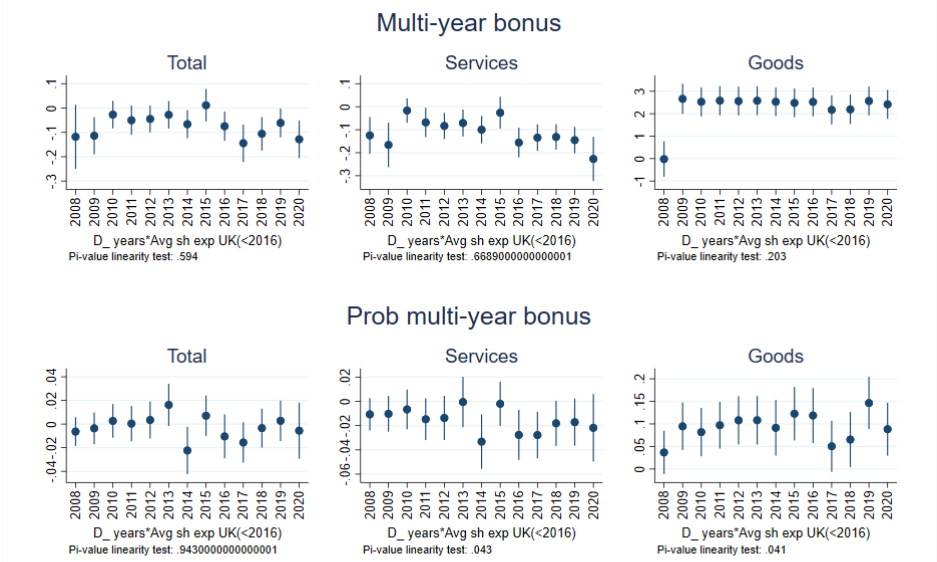
X: (Log total assets, leverage rate, CAPEX rate, ROA) t-1. Fixed effects: Executive-firm and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

Figure 7: Brexit effect timing on dependent variables 3



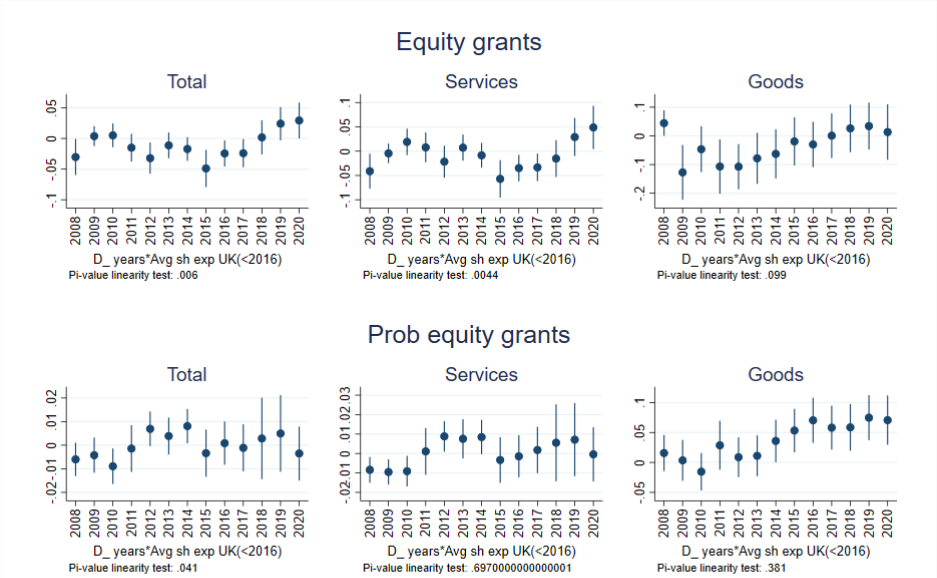
X: (Log total assets, leverage rate, CAPEX rate, ROA) t-1. Fixed effects: Executive-firm and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

Figure 8: Brexit effect timing on dependent variables 4



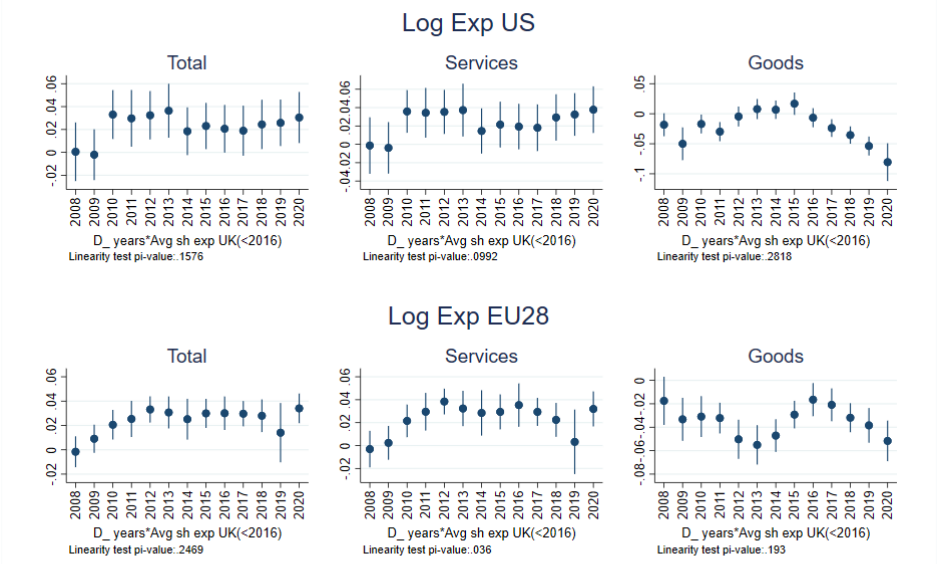
X: (Log total assets, leverage rate, CAPEX rate, ROA) t-1. Fixed effects: Executive-firm and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

Figure 9: Brexit effect timing on dependent variables 5



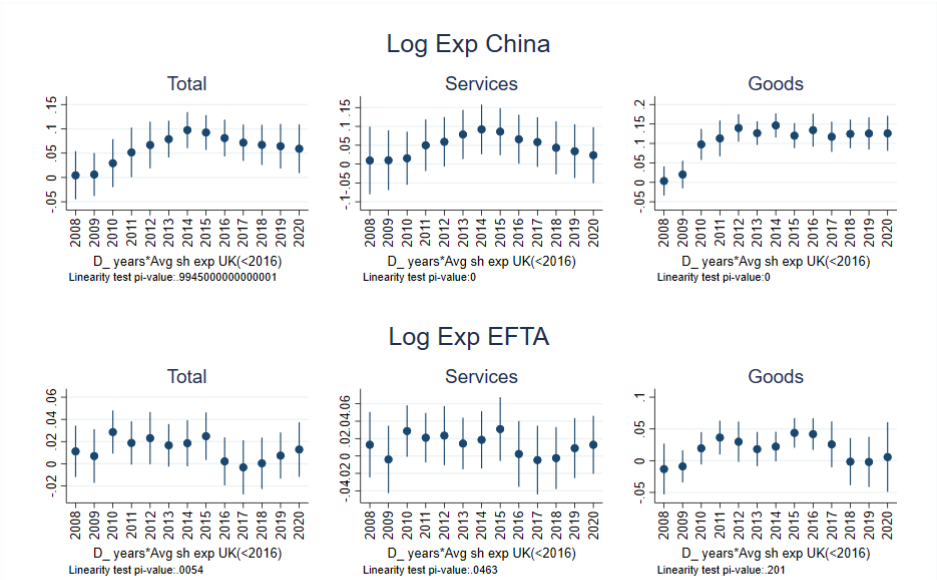
X: (Log total assets, leverage rate, CAPEX rate, ROA) t-1. Fixed effects: Executive-firm and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

Figure 10: Brexit effect timing on dependent variables 6



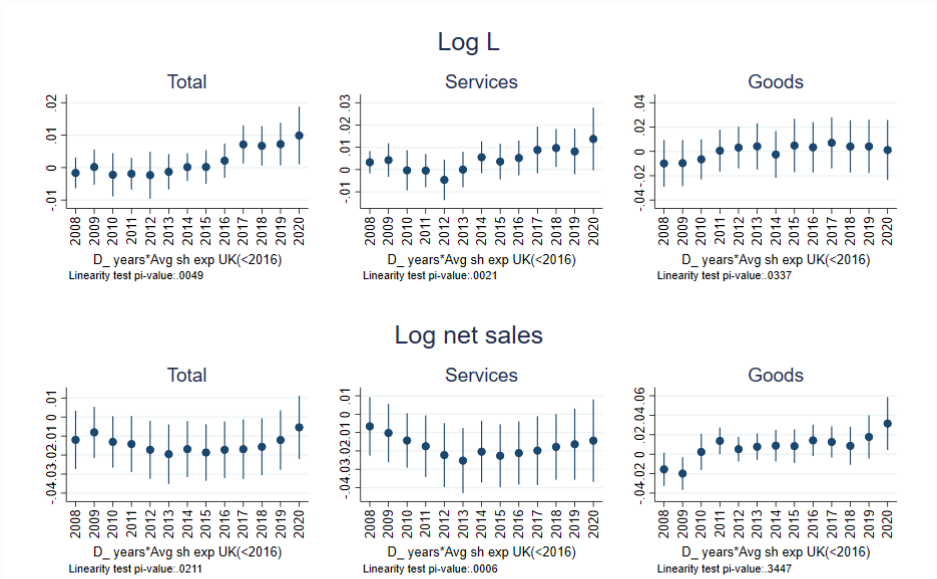
Fixed effects: Industry and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

Figure 11: Brexit effect timing on dependent variables 7



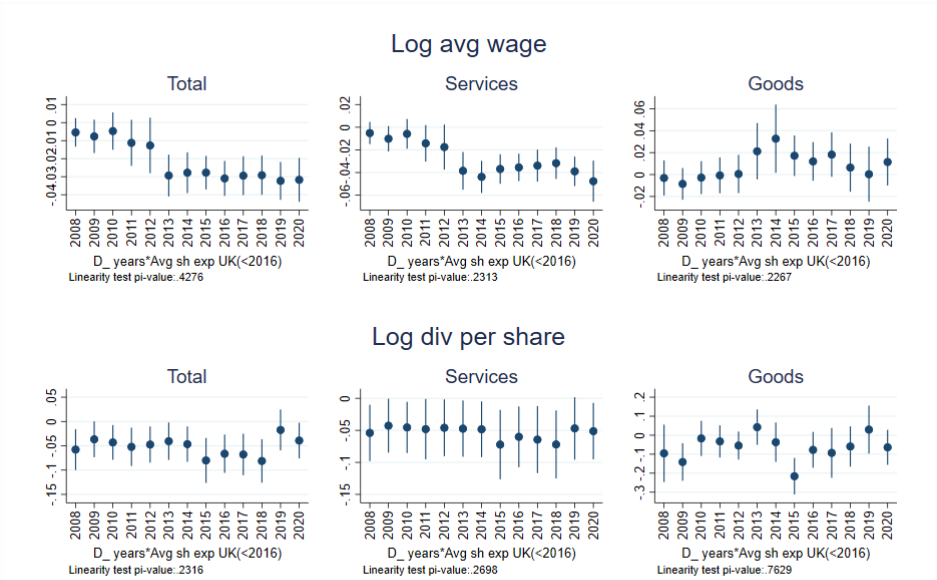
Fixed effects: Industry and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

Figure 12: Brexit effect timing on dependent variables 8



X: (Log total assets, leverage rate, CAPEX rate, ROA) t-1. Fixed effects: Firm and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

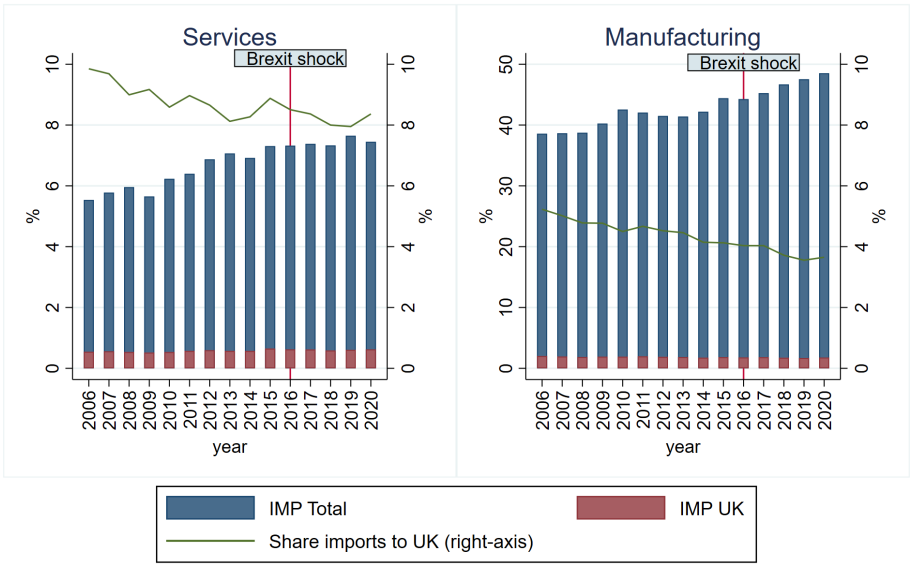
Figure 13: Brexit effect timing on dependent variables 9



X: (Log total assets, leverage rate, CAPEX rate, ROA) t-1. Fixed effects: Firm and year.
90% CI
Jann (2008) linearity test (no rejection implies linearity) for the baseline specification.

9.2 Appendix B: Additional tables and figures

Figure 14: German imports from UK as a share of total imports and production, 2006-2019.



Weighted average.
IMP Total = [Imports/Output]*100
IMP UK = [IMP to UK /Output]*100
Source: Eurostat. Authorial calculations.

Figure 15: Export share to UK relative to total exports and output by manufacturing industry, 2006-2019. Classification: CPA 2.1

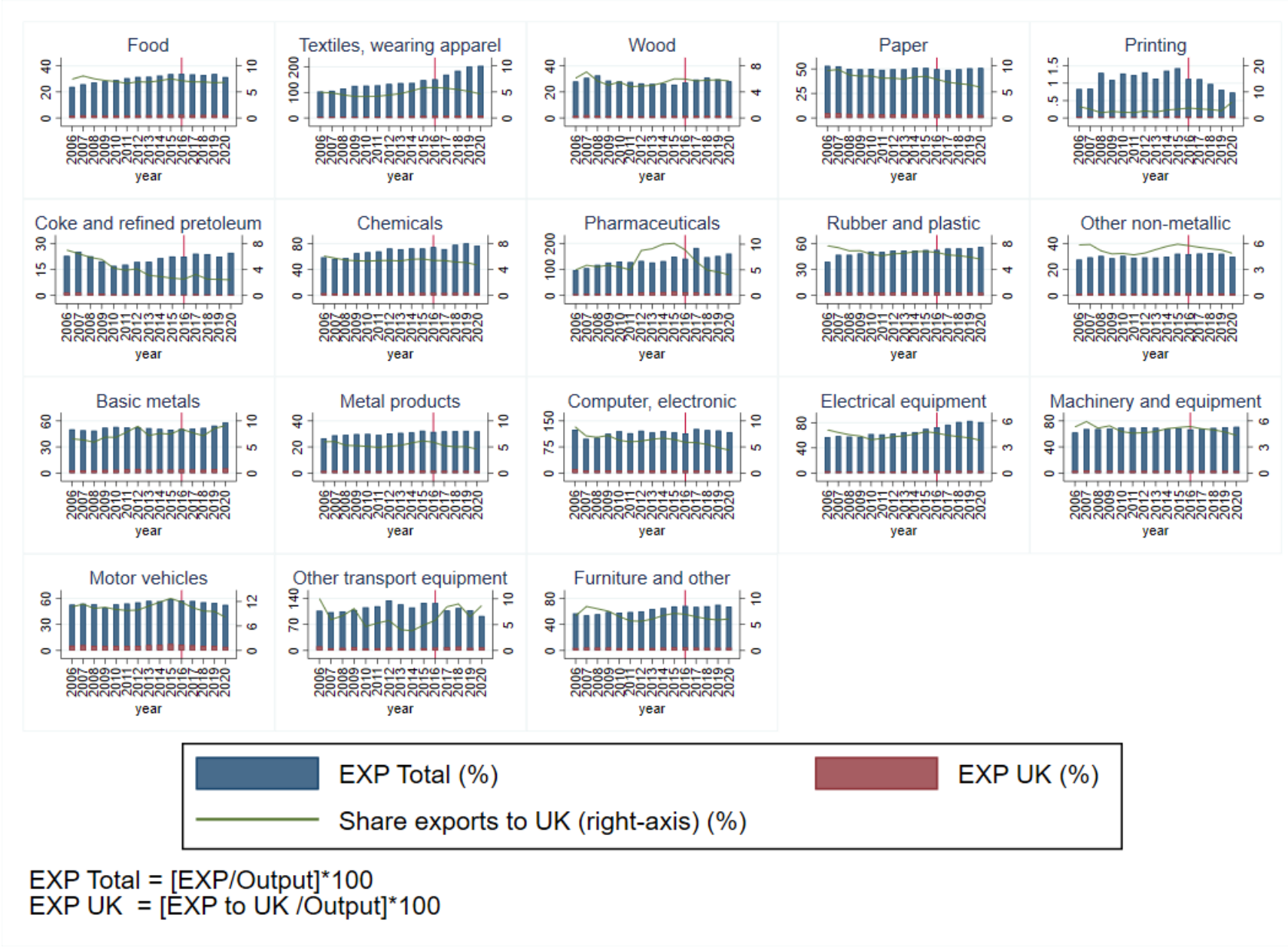
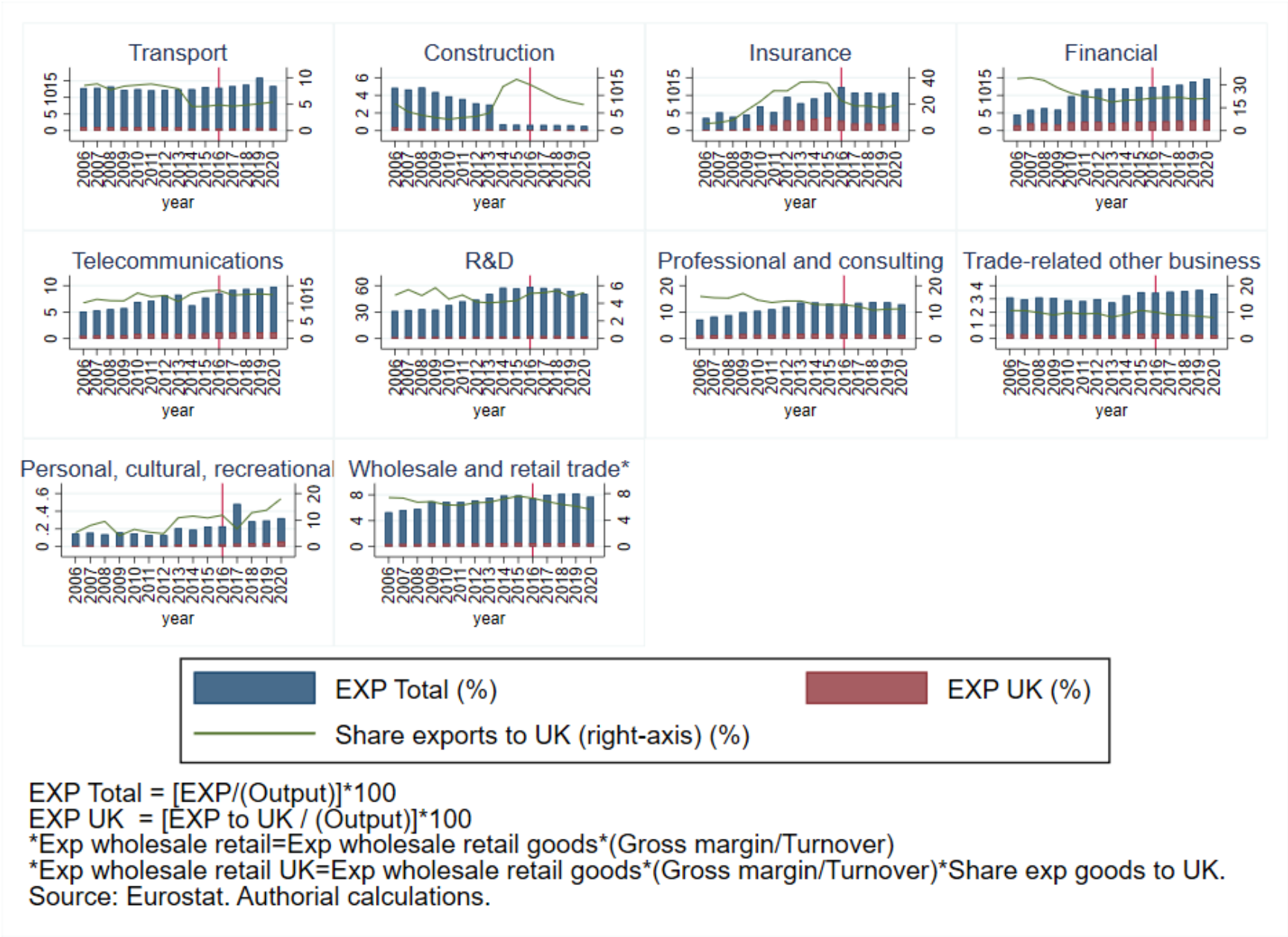
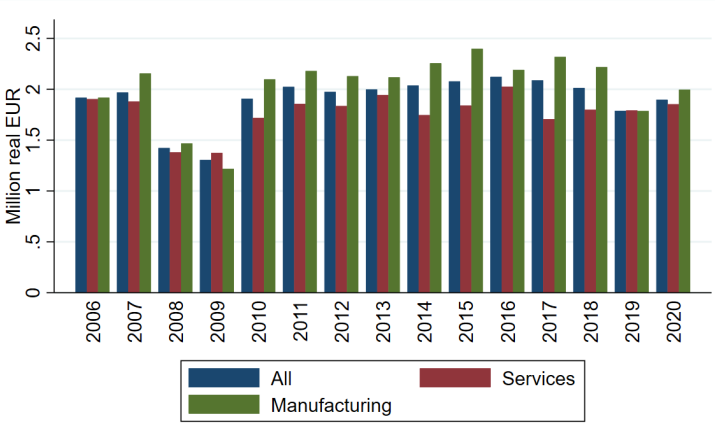


Figure 16: Export share to UK relative to total exports and output by services industry, 2006-2019. Classification: EBOPS 2010



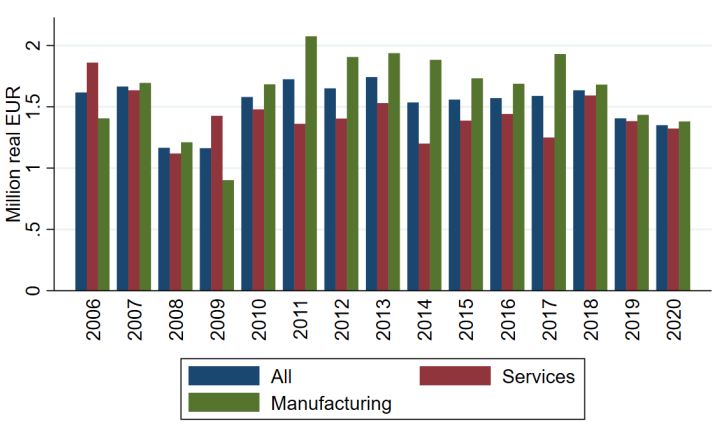
EXP Total = [EXP/(Output)]*100
EXP UK = [EXP to UK / (Output)]*100
Exp wholesale retail=Exp wholesale retail goods(Gross margin/Turnover)
Exp wholesale retail UK=Exp wholesale retail goods(Gross margin/Turnover)*Share exp goods to UK.
Source: Eurostat. Authorial calculations.

Figure 17: Total executive compensation (median), 2006-2020



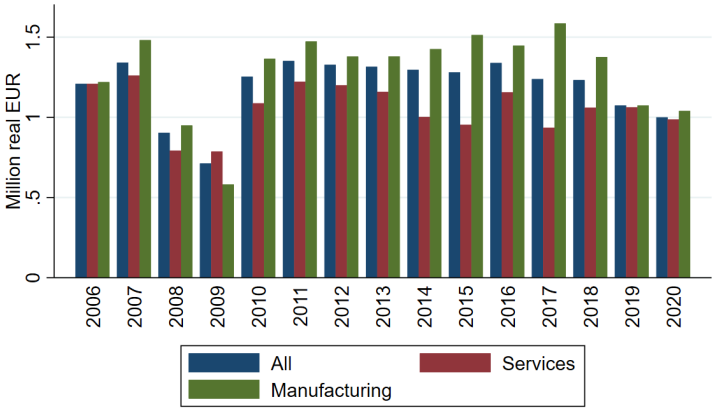
Real measures calculated based on the consumer price index from Destatis Statistisches Bundesamt. 2020 is the base year.
Initially, the sample of the graph is the sample of the total compensation regression (table 6), that covers the 2007-2020 period, since the independent variables are lagged one period (Xt-1). The sample of the initial year (2006) was added including the 2006 observations (executive-firm pairs) that are also present in the total compensation regression sample (2020-2007).

Figure 18: Variable compensation (simple average), 2006-2020



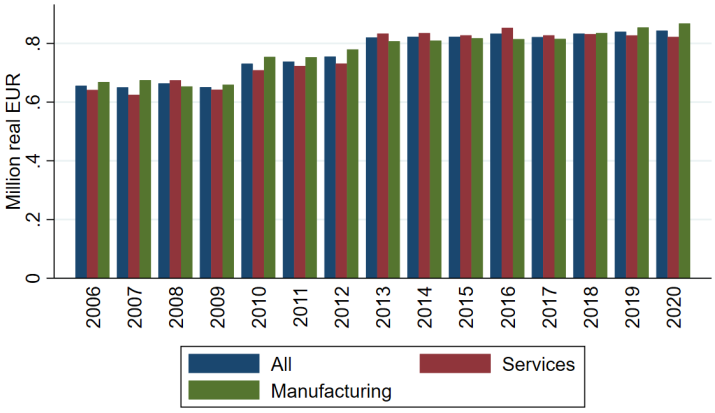
Real measures calculated based on the consumer price index from Destatis Statistisches Bundesamt. 2020 is the base year.
Initially, the sample of the graph is the sample of the total compensation regression (table 6), that covers the 2007-2020 period, since the independent variables are lagged one period (Xt-1). The sample of the initial year (2006) was added including the 2006 observations (executive-firm pairs) that are also present in the total compensation regression sample (2020-2007).

Figure 19: Variable compensation (median), 2006-2020



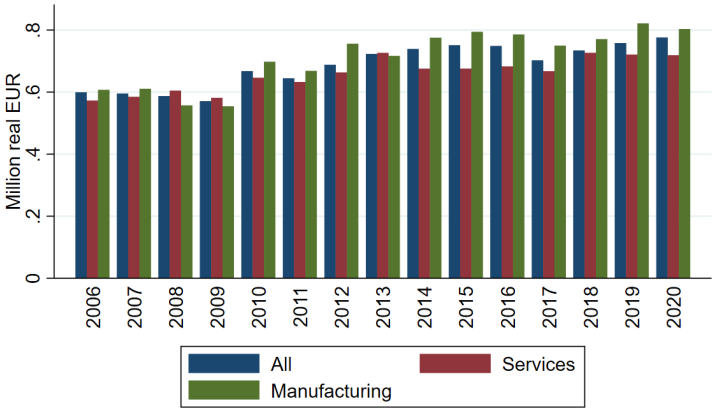
Real measures calculated based on the consumer price index from Destatis Statistisches Bundesamt. 2020 is the base year.
Initially, the sample of the graph is the sample of the total compensation regression (table 6), that covers the 2007-2020 period, since the independent variables are lagged one period (Xt-1). The sample of the initial year (2006) was added including the 2006 observations (executive-firm pairs) that are also present in the total compensation regression sample (2020-2007).

Figure 20: Fixed compensation (simple average), 2006-2020



Real measures calculated based on the consumer price index from Destatis Statistisches Bundesamt. 2020 is the base year.
Initially, the sample of the graph is the sample of the total compensation regression (table 6), that covers the 2007-2020 period, since the independent variables are lagged one period (Xt-1). The sample of the initial year (2006) was added including the 2006 observations (executive-firm pairs) that are also present in the total compensation regression sample (2020-2007).

Figure 21: Fixed compensation (median), 2006-2020



Real measures calculated based on the consumer price index from Destatis Statistisches Bundesamt. 2020 is the base year.
Initially, the sample of the graph is the sample of the total compensation regression (table 6), that covers the 2007-2020 period, since the independent variables are lagged one period (Xt-1). The sample of the initial year (2006) was added including the 2006 observations (executive-firm pairs) that are also present in the total compensation regression sample (2020-2007).

Table 14: German export share to UK relative to production, 2006, 2016, and 2020

Sector	Description	Shares			Δ%	
		2006	2016	2020	20-06	20-16
Services	Construction	0.4	0.1	0.0	-89.7	-53.3
Goods	Basic pharmaceutical products and pharmaceutical preparations	4.8	12.6	6.5	34.1	-48.3
Goods	Motor vehicles, trailers and semi-trailers	5.6	6.8	4.3	-24.3	-37.0
Services	Insurance and pension	0.2	2.8	2.1	985.2	-26.1
Goods	Computer, electronic and optical products	11.1	6.7	5.1	-53.5	-23.3
Services	Technical, Trade-related and other business services	0.3	0.3	0.3	-18.3	-22.0
Goods	Fabricated metal products, except machinery and equipment	1.6	1.9	1.5	-8.8	-22.0
Goods	Manufacture of other non-metallic mineral products	1.6	1.8	1.4	-9.7	-20.5
Services	Wholesale and retail trade	0.4	0.5	0.4	10.4	-20.4
Goods	Paper and paper products	4.8	3.7	3.0	-37.9	-18.7
Goods	Machinery and equipment n.e.c.	3.3	3.6	3.1	-7.1	-14.4
Goods	Furniture and other manufacturing	3.8	4.7	4.1	8.2	-13.7
Services	Professional and management consulting services	1.2	1.7	1.5	26.5	-12.6
Services	Research and development services	1.5	3.0	2.6	72.5	-11.9
Goods	Food, beverages and tobacco products	1.8	2.4	2.1	20.8	-11.4
Goods	Chemicals and chemical products	3.6	4.0	3.6	1.2	-10.3
Goods	Rubber and plastic products	3.0	3.5	3.1	4.9	-10.1
Goods	Electrical equipment	2.9	3.4	3.0	6.7	-9.3
Goods	Manufacture of wood and of products of wood and cork	1.7	1.6	1.6	-6.0	-1.5
Services	Telecommunication, computer and information services	0.5	1.2	1.2	135.2	4.0
Goods	Printing and reproduction of recorded media	0.0	0.0	0.0	24.9	5.1
Goods	Coke and refined petroleum products	1.6	0.6	0.6	-62.8	5.8
Goods	Textiles, wearing apparel, and leather products	5.1	8.8	9.4	84.7	6.4
Goods	Other transport equipment	10.8	7.4	8.0	-25.2	8.2
Services	Transport	1.1	0.6	0.7	-33.5	16.2
Services	Financial	1.5	2.6	3.1	98.8	16.9
Goods	Basic metals	3.3	4.3	5.3	60.6	24.0
Services	Personal, cultural and recreational services	0.0	0.0	0.1	659.8	115.1

Table 15: Brexit shock impact on executive compensation for the biggest German firms

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$ln(Total\_Comp)_{f,i,s,t}$			$ln(Variable\_comp)_{f,i,s,t}$			$ln(Fixed\_comp)_{f,i,s,t}$		
Sample	Total	Services	Goods	Total	Services	Goods	Total	Services	Goods
Avg_exp_Y_UK(<2016)	-0.019	-0.095*	0.019	-0.034*	-0.29***	0.032	-0.007	0.020	0.006
*D_Brexit(t>=2016)$_{s,t}$	(0.014)	(0.055)	(0.021)	(0.018)	(0.061)	(0.029)	(0.010)	(0.032)	(0.016)
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1								
FE	Executive-firm, year								
Observations	5,357	2,695	2,662	5,058	2,480	2,578	5,357	2,695	2,662
Dep var mean	14.37	14.30	14.44	13.91	13.83	13.98	13.38	13.35	13.41

Robust standard errors clustered at industry-year in parentheses. Avg_exp_Y_UK=Exports to UK/Production.
*** p<0.01, ** p<0.05, * p<0.1

Table 16: Brexit shock impact on variable executive compensation - PPML estimation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$One\_year\_bonus_{f,i,s,t}$			$Multi\_year\_bonus_{f,i,s,t}$			$Equity_{f,i,s,t}$		
Sample	Total	Services	Goods	Total	Services	Goods	Total	Services	Goods
Avg_exp_Y_UK(<2016)	-0.05***	-0.19***	-0.029	-0.003	-0.93***	-0.011	-0.020	-0.108	0.071***
*D_Brexit(t>=2016)$_{s,t}$	(0.019)	(0.063)	(0.026)	(0.048)	(0.149)	(0.063)	(0.016)	(0.077)	(0.026)
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1								
FE	Executive-firm, year								
Observations	4,888	2,379	2,509	3,318	1,616	1,702	4,235	2,120	2,115
Dep var mean	716,944	649,834	780,577	490,798	331,269	642,267	696,0945	755,401	636,648

Robust standard errors clustered at industry-year in parentheses. Avg_exp_Y_UK=Exports to UK/Production.
Singleton observations are dropped iteratively.
*** p<0.01, ** p<0.05, * p<0.1

Table 17: Brexit shock impact on probability to receive variable compensation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$D(One\_year\_bonus = 1)_{f,s,t}$			$D(Multi\_year\_bonus = 1)_{f,s,t}$			$D(Equity = 1)_{f,s,t}$		
Sample	Total	Services	Goods	Total	Services	Goods	Total	Services	Goods
Avg_exp_Y_UK(<2016)	-0.005	-0.038	-0.011	-0.011	-0.102	-0.025	0.015*	-0.061*	0.032**
*D_Brexit(t>=2016)$_{s,t}$	(0.005)	(0.042)	(0.008)	(0.014)	(0.064)	(0.024)	(0.008)	(0.036)	(0.013)
X	[Log total assets, leverage rate, CAPEX rate, ROA], t-1								
FE	Executive-firm, year								
Observations	5,058	2,480	2,578	5,058	2,480	2,578	5,058	2,480	2,578
Dep var mean	0.89	0.90	0.88	0.42	0.41	0.43	0.73	0.77	0.69

Robust standard errors clustered at industry-year in parentheses. Avg_exp_Y_UK=Exports to UK/Production.
*** p<0.01, ** p<0.05, * p<0.1

9.3 Appendix C: Concordance tables and list of firms

Table 18: Correspondence EBOP 2010 -EBOP 2002

EBOP 2010 Description	EBOP 2010 code	EBOP 2002 code
Maintenance and repair services not included	SB	160
Transport	SC	205
Transport	SC	246
Travel	SD	236
Construction	SE	249
Insurance and pension services	SF	253
Financial services	SG	260
Telecommunications, computer, and information services	SI	247
Telecommunications, computer, and information services	SI	262
Research and development services	SJ1	279
Professional and management consulting services	SJ2	274
Professional and management consulting services	SJ2	278
Technical, Trade-related and other business services	SJ3	280
Technical, Trade-related and other business services	SJ3	281
Technical, Trade-related and other business services	SJ3	284
Technical, Trade-related and other business services	SJ3	272
Technical, Trade-related and other business services	SJ3	271
Technical, Trade-related and other business services	SJ3	285
Personal, cultural, and recreational services	SK	287
Government goods and services n.i.e.	SL	291
Services not allocated	SN	982

Based on: https://unstats.un.org/unsd/tradeserv/TFSITS/newsletter/Conversion_Matrix_EBOPS_2010%20rf.htm

Table 19: Correspondance EBOP 2010 - NACE Rev 2

EBOP 2010 Description	EBOP 2010 code	NACE Rev 2	NACE Rev 2 Des	Share
Transport	SC	D	Electricity, gas, steam	0.5
Transport	SC	H	Transportation and storage	1
Construction	SE	F	Construction	1
Insurance and pension	SF	K65	Insurance, reinsurance and pension funding	1
Activities auxiliary to financial services and insurance	SF	K66	Activities auxiliary to financial services and insurance	0.5
Financial	SG	K64	Financial services activities, except insurance	1
Financial	SG	K66	Activities auxiliary to financial services and insurance	0.5
Intellectual property	SH	N77	Rental and leasing activities	0.25
Telecommunication, computer and information	SI	J61	Telecommunications	1
Telecommunication, computer and information	SI	J62_J63	Computer programming, consultancy; information service activities	1
Telecommunication, computer and information	SI	N77	Rental and leasing activities	0.25
Telecommunication, computer and information	SI	S95	Repair of computers, personal, household goods	0.5
Telecommunication, computer and information	SI	S96	Other personal service activities	0.5

Telecommunication, computer and information	SI	J58	Publishing activities	1
Research and development services	SJ1	M72	Scientific research and development	1
Professional and management consulting services	SJ2	M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities	1
Professional and management consulting services	SJ2	M73	Advertising and market research	1
Technical, Trade-related and other business services	SJ3	D	Electricity, gas, steam	0.5
Technical, Trade-related and other business services	SJ3	L	Real estate activities	1
Technical, Trade-related and other business services	SJ3	M71	Architecture and engineering activities; technical testing and analysis	1
Technical, Trade-related and other business services	SJ3	E	Water collection, treatment	1
Technical, Trade-related and other business services	SJ3	N77	Rental and leasing activities	0.25
Technical, Trade-related and other business services	SJ3	N78	Employment activities	1
Technical, Trade-related and other business services	SJ3	N79	Travel agency, tour operator reservation service and related activities	1

Technical, Trade-related and other business services	SJ3	N80-N82	Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support	1
Technical, Trade-related and other business services	SJ3	M74_M75	Other professional, scientific and technical activities; veterinary activities	1
Personal, cultural and recreational services	SK	I	Accommodation and food service	1
Personal, cultural and recreational services	SK	J59_J60	Motion picture, video and television and programming	1
Personal, cultural and recreational services	SK	N77	Rental and leasing activities	0.25
Personal, cultural and recreational services	SK	P	Education	1
Personal, cultural and recreational services	SK	Q	Human health and social work activities	1
Personal, cultural and recreational services	SK	R	Creative, arts and entertainment activities	1
Personal, cultural and recreational services	SK	S94	Activities of membership organisations	1

Based on: `https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Table_4_EBOPS_2010-NACE_Rev2_correspondence.PNG`

Table 20: List of firms

Company name	Type	Sector des	Sector code
Aareal Bank	Services	Financial	SG
Qiagen N.V.	Services	Research and development	SJ1
CTS Eventim	Services	Personal, cultural and recreational	SK
Zalando	Services	Retail	R
Gerry Weber International	Goods	Manufacture of textiles, wearing apparel, and leather products	C13-C15
Hugo Boss	Goods	Manufacture of textiles, wearing apparel, and leather products	C13-C15
Bilfinger	Services	Construction	SE
Praktiker	Services	Retail	R
Bechtle	Services	Telecommunication, computer and information	SI
Cancom	Services	Telecommunication, computer and information	SI
Axel Springer	Services	Telecommunication, computer and information	SI
Nemetschek	Services	Telecommunication, computer and information	SI
SAP	Services	Telecommunication, computer and information	SI
Ströer	Services	Professional and management consulting	SJ2
Scout24	Services	Technical, Trade-related and other business	SJ3

Grenke	Services	Technical, Trade-related and other business	SJ3
CompuGroup Medical	Services	Telecommunication, computer and information	SI
Delivery Hero	Services	Transport	SC
Software	Services	Telecommunication, computer and information	SI
TeamViewer	Services	Telecommunication, computer and information	SI
Kabel Deutschland	Services	Telecommunication, computer and information	SI
Sky Deutschland	Services	Telecommunication, computer and information	SI
Beiersdorf	Goods	Manufacture of chemicals and chemical products	C20
Lanxess	Goods	Manufacture of chemicals and chemical products	C20
Evotec	Goods	Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
Henkel	Goods	Manufacture of chemicals and chemical products	C20
Covestro	Goods	Manufacture of chemicals and chemical products	C20
Linde plc	Goods	Manufacture of chemicals and chemical products	C20

Merck KGaA	Goods	Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
Schwarz Pharma	Goods	Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
STADA Arzneimittel	Goods	Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
Altana	Goods	Manufacture of chemicals and chemical products	C20
BASF	Goods	Manufacture of chemicals and chemical products	C20
Bayer	Goods	Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
Evonik Industries	Goods	Manufacture of chemicals and chemical products	C20
K+S AG	Goods	Manufacture of chemicals and chemical products	C20
Symrise	Goods	Manufacture of chemicals and chemical products	C20
Wacker Chemie	Goods	Manufacture of chemicals and chemical products	C20
United Internet	Services	Telecommunication, computer and information	SI

11 Drillisch	Services	Telecommunication, computer and information	SI
Deutsche Telekom	Services	Telecommunication, computer and information	SI
Freenet	Services	Telecommunication, computer and information	SI
Telefonica Deutschland Holding	Services	Telecommunication, computer and information	SI
ProSiebenSat.1 Media	Services	Telecommunication, computer and information	SI
RTL Group	Services	Telecommunication, computer and information	SI
Bauer	Services	Construction	SE
IKB Deutsche Industriebank	Services	Financial	SG
Deutsche Bank	Services	Financial	SG
Wirecard	Services	Financial	SG
Deutsche Postbank	Services	Financial	SG
Commerzbank	Services	Financial	SG
Unicredit	Services	Financial	SG
Encavis	Services	Technical, Trade-related and other business	SJ3
RWE	Services	Technical, Trade-related and other business	SJ3
Innogy	Services	Technical, Trade-related and other business	SJ3

E.ON	Services	Technical, Trade-related and other business	SJ3
Gigaset	Goods	Manufacture of computer, electronic and optical	C26
Infineon Technologies	Goods	Manufacture of computer, electronic and optical	C26
SGL Carbon	Goods	Manufacture of other non-metallic mineral products	C23
Siemens	Goods	Manufacture of electrical equipment	C27
Varta	Goods	Manufacture of electrical equipment	C27
Hella KGaA Hueck Co.	Goods	Manufacture of motor vehicles, trailers and semi-trailers	C29
Osram Licht	Goods	Manufacture of electrical equipment	C27
Siltronic	Goods	Manufacture of computer, electronic and optical products	C26
Bertrandt	Services	Technical, Trade-related and other business	SJ3
Morphosys	Services	Research and development	SJ1
Norma Group	Goods	Manufacture of fabricated metal products, except machinery and equipment	C25
Südzucker	Goods	Manufacture of food, beverages and tobacco products	C10-C12
HelloFresh	Services	Retail	R
Metro AG	Services	Retail	R
Fresenius	Services	Personal, cultural and recreational	SK
Fresenius Medical Care	Services	Personal, cultural and recreational	SK

Rhön-klinikum	Services	Personal, cultural and recreational	SK
Hochtief	Services	Construction	SE
Rocket Internet SE	Services	Telecommunication, computer and information	SI
Ceconomy	Services	Retail	R
Steinhoff International Holdings	Services	Retail	R
DAR Metall	Goods	Manufacture of machinery and equipment n.e.c.	C28
DMG Mori	Goods	Manufacture of machinery and equipment n.e.c.	C28
Kuka	Goods	Manufacture of machinery and equipment n.e.c.	C28
Jungheinrich	Goods	Manufacture of machinery and equipment n.e.c.	C28
Deutz	Goods	Manufacture of motor vehicles, trailers and semi-trailers	C29
Krones	Goods	Manufacture of machinery and equipment n.e.c.	C28
GEA Group	Goods	Manufacture of machinery and equipment n.e.c.	C28
Medion	Goods	Manufacture of computer, electronic and optical products	C26
Rational	Goods	Manufacture of machinery and equipment n.e.c.	C28
Heidelberger Druckmaschinen	Goods	Manufacture of machinery and equipment n.e.c.	C28

Wincor Nixdorf	Services	Retail	R
Nordex	Goods	Manufacture of machinery and equipment n.e.c.	C28
Aixtron	Goods	Manufacture of machinery and equipment n.e.c.	C28
Demag Cranes	Goods	Manufacture of machinery and equipment n.e.c.	C28
Siemens Energy	Services	Technical, Trade-related and other business	SJ3
Kion Group	Goods	Manufacture of machinery and equipment n.e.c.	C28
Awd Holding	Services	Financial	SG
Hannover Rück	Services	Insurance and pension	SF
Allianz	Services	Insurance and pension	SF
Munich RE AG	Services	Insurance and pension	SF
Talanx	Services	Insurance and pension	SF
AMB Generali Holding AG	Services	Insurance and pension	SF
Puma	Goods	Manufacture of textiles, wearing apparel, and leather products	C13-C15
Adidas	Goods	Manufacture of textiles, wearing apparel, and leather products	C13-C15
Pfleiderer	Goods	Manufacture of wood , except furniture	C16
Carl Zeiss Meditec	Goods	Manufacture of computer, electronic and optical products	C26
Sartorius	Goods	Manufacture of computer, electronic and optical products	C26

Siemens Healthineers	Services	Personal, cultural and recreational	SK
Fielmann	Services	Retail	R
Douglas Holding	Services	Retail	R
Arcandor	Services	Retail	R
Shop Apotheke	Services	Retail	R
Techem	Services	Technical, Trade-related and other business	SJ3
Deutsche Pfandbriefbank	Services	Financial	SG
Hypo Real Estate Holding	Services	Financial	SG
Fuchs Petrolub	Goods	Manufacture of coke and refined petroleum products	C19
Leoni	Goods	Manufacture of electrical equipment	C27
Salzgitter	Goods	Manufacture of basic metals	C24
Aurubis	Goods	Manufacture of basic metals	C24
Vossloh	Goods	Manufacture of fabricated metal products, except machinery and equipment	C25
Vivacon	Services	Technical, Trade-related and other business	SJ3
IVG Immobilien	Services	Technical, Trade-related and other business	SJ3
Deutsche Euroshop	Services	Technical, Trade-related and other business	SJ3
TAG Immobilien	Services	Technical, Trade-related and other business	SJ3

Deutsche Wohnen	Services	Technical, Trade-related and other business	SJ3
Alstria Office Reit	Services	Technical, Trade-related and other business	SJ3
Vonovia	Services	Technical, Trade-related and other business	SJ3
GSW Immobilien	Services	Technical, Trade-related and other business	SJ3
LEG Immobilien	Services	Technical, Trade-related and other business	SJ3
Patrizia Immobilien	Services	Technical, Trade-related and other business	SJ3
Gagfag	Services	Technical, Trade-related and other business	SJ3
Grand City Properties S.A.	Services	Technical, Trade-related and other business	SJ3
Aroundtown	Services	Technical, Trade-related and other business	SJ3
Continental	Goods	Manufacture of rubber and plastic products	C22
Gerresheimer	Goods	Manufacture of other non-metallic mineral products	C23
Deutsche Borse	Services	Financial	SG
MLP	Services	Financial	SG
Heidelberg Cement	Goods	Manufacture of other non-metallic mineral products	C23
Fraport	Services	Transport	SC

Deutsche Lufthansa	Services	Transport	SC
BMW	Goods	Manufacture of motor vehicles, trailers and semi-trailers	C29
MAN	Goods	Manufacture of motor vehicles, trailers and semi-trailers	C29
Rheinmetall	Goods	Manufacture of fabricated metal products, except machinery and equipment	C25
Mercedes Benz	Goods	Manufacture of motor vehicles, trailers and semi-trailers	C29
Volkswagen	Goods	Manufacture of motor vehicles, trailers and semi-trailers	C29
ElringKlinger	Goods	Manufacture of electrical equipment	C27
MTU Aero Engines Holding	Goods	Manufacture of other transport equipment	C30
Tognum	Goods	Manufacture of machinery and equipment n.e.c.	C28
Knorr Bremse	Goods	Manufacture of other transport equipment	C30
Porsche Automobil Holding	Services	Financial	SG
Schaeffler	Goods	Manufacture of machinery and equipment n.e.c.	C28
Airbus Group	Goods	Manufacture of other transport equipment	C30
Deutsche Post	Services	Transport	SC
Hamburger Hafen und Logistik	Services	Transport	SC

ThyssenKrupp	Goods	Manufacture of basic metals	C24
Klckner	Services	Retail	R
BayWa	Services	Retail	R
Brenntag	Services	Retail	R
Celesio	Services	Retail	R
Uniper	Services	Technical, Trade-related and other business services	SJ3