Department of Labour Economics

Hochschule der Bundesagentur für Arbeit
University of Applied Labour Studies

HdBA Discussion Papers in Labour Economics

No. 24-03

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September 2024

Abstract

This paper finds that firms respond to trade shocks by adjusting outsourcing more than labor, altering their employment-to-outsourcing ratio, and thus mitigating potential employment consequences of trade. High labor adjustment costs may serve as an explanation in the short run, but we find that these effects are persistent. We develop a theoretical framework to show which properties production functions must fulfill to explain these empirical results and show that these conditions are met in our data. The shape of the production technology can explain why outsourcing persistently mitigates employment consequences of trade shocks.

Keywords: globalization, import competition, outsourcing, labor-market adjustment, employment

JEL Classification: E24, F14, F16, F66, J23, L60

*We are grateful for helpful comments by Daniel Arnold, Melanie Arntz, Laszlo Goerke, Jörg Lingens, Jochen Michaelis, Maarten de Ridder and Nicolas Ziebarth. We greatly acknowledge funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under the project "Local Labour Markets: The Causes and Consequences of Spatial Differences in Labour Market Outcomes Across Cities".

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1 Introduction

A large literature shows that the "China shock", i.e., the rapid expansion of trade with China and Eastern Europe, led to substantial labor market adjustments, which differ across countries (see Autor et al. (2016) for an overview). In the U.S., employment losses in import-competing industries are not compensated for by employment gains in other industries, highlighting a negative effect on aggregate employment (Acemoglu et al., 2016). In Germany, in contrast, the negative impacts of Chinese import competition in import-competing regions were offset by positive employment effects of rising trade with Eastern Europe after the Fall of the Iron Curtain because manufacturing industries could sharply raise their exports to Eastern Europe (Dauth et al., 2014). German firms have also substantially revised their production structures in the last decade, in particular by raising the use of intermediate inputs, i.e., (domestic or foreign) outsourcing (Dustmann et al., 2014). So far, the literature has not investigated the mitigating role of outsourcing for the labor market effects of trade shocks.

In this paper, we study the mediating role of re-structuring production processes on the employment effects of trade shocks in Germany. To that end, we rely on data at the 4-digit industry level on the production and cost structures of manufacturing firms in Germany for the time period 1995 to 2015, and estimate the effects of trade shocks with Eastern Europe and China following the instrumental variable proposed by Autor et al. (2013a). In particular, we analyze the consequences for employment, firms' outsourcing activities, and the employment-to-outsourcing ratio.

The key novel insight of our paper is that firms adjust outsourcing more elastically to trade shocks than they adjust employment, which implies that outsourcing dampens trade-induced employment shocks. Firms reduce both employment and outsourcing activities in response to import competition from Eastern Europe and China. However, they reduce their outsourcing activities more than they reduce employment, which results in an increase of the employment-to-outsourcing ratio. This implies a mitigation of the negative employment effects, meaning that workers would have been confronted with stronger negative employment effects if outsourcing was adjusted proportionally. Vice versa, firms that benefit from growing export opportunities to Eastern Europe raise both employment and outsourcing activities. However, they increase their outsourcing activities faster than they raise employment, reducing the employment-to-outsourcing ratio. Accordingly, outsourcing mitigates the (positive) employment consequences of raising export opportunities.

Faster adjustment of outsourcing activities relative to employment fluctuations would be no surprise in the short run under the assumption that e.g. labor protection legislation induce higher adjustment costs for labor than for outsourcing activities. However, we document that the adjustment of the employment-to-outsourcing ratio persists in the long run, which cannot be explained by short-run adjustment costs.

In oder to explain our findings, we develop a theoretical framework to study which properties a production technology has to fulfil to explain the long-run nature of changes in the employment-to-outsourcing ratio. In our theoretical model, firms use two input factors, labor and intermediates, to produce consumption goods. We label the latter as outsourcing, in accordance to the data, and assume that trade shocks change the demand for the respective goods. As our key result, we show that trade shocks can affect the employment-to-outsourcing ratio via output variations. In import-competing industries, for instance, trade reduces domestic demand and hence output. Depending on the technology pattern, the decline in production may imply that outsourcing shrinks more strongly than employment, raising thus the employment-to-outsourcing ratio. Put differently, outsourcing reacts more elastically than employment to trade shocks. This scenario is more likely to occur the higher, c.p., the marginal product of outsourcing is, provided that the use of outsourcing is higher than the employment level in absolute terms and that the cross derivation between both input factors is relatively small. Accordingly, one reason that outsourcing mitigates the employment effects of trade shocks can be the production technology itself, holding everything else, e.g. input prices, constant.

To empirically challenge our theoretical explanation, we estimate flexible production functions using our data set and find that the used technology in German firms matches the model's requirements for a more elastic reaction of outsourcing compared to employment changes. This indicates that the technology pattern plays a crucial role in explaining the persistence of variations in the employment-to-outsourcing ratio over time.

Our paper is related to three strands of literature. First, we contribute to studies which report substantial adjustment costs to trade shocks by exploiting the rapid growth of imports from China. Chinese import competition reduced employment and wages, while raising plant exit, job-displacement and dependence on social security benefits in the U.S. (Acemoglu et al., 2016, Autor et al., 2013a,b, 2014, Bernand et al., 2006).[1] Acemoglu et al. (2016) show that these employment losses in import-exposed industries are not compensated by employment gains in other industries, highlighting that adjustment to trade shocks is slow and costly.[2] While similar findings have been reported in other countries,[3] the German experience differs. Dauth et al. (2014) find negative employment impacts of Chinese import competition in import-competing German regions which were offset by positive employment effects of rising trade with Eastern Europe after the Fall of the Iron Curtain. German manufacturing industries were able to sharply raise their exports to Eastern European countries after the collapse of the Soviet Union and once trade barriers to these countries fell. We contribute to this literature by showing how the employment effects of trade shocks depend on firms' response in their production structure. In particular, we show that outsourcing mitigates employment effects of trade shocks, which helps explaining differences in countries' experiences.

Second, another strand of papers analyzes how firms adjust to the exposure of import competition. This literature shows that trade liberalization induces innovation and technology adoption (Bustos, 2011, Lileeva and Trefler, 2010, Verhoogen, 2008). For example, Bloom et al. (2016) find that import competition raises investments into innovation. Import-competing firms buy new technologies and raise their productivity. Trade further raises productivity by enabling offshoring production (Grossman and Rossi-Hansberg, 2008) and by lower prices for intermediate inputs (Auer et al., 2013). In this paper, we show that firms adjust their input structure as well, which is a potential mechanism by

[1] Large and long-lasting adjustment costs are confirmed by structural estimates, see Artuc et al. (2010), Ashournia (2018), Dix-Carneiro and Kovak (2014).

[2] In contrast to classical trade theory, these employment reductions are not compensated by employment increases in non-manufacturing industries but, instead, the trade shock even had negative spillovers on employment among non-college educated workers in non-manufacturing industries. This constitutes a negative labor demand shock, which has reduced workers' wages, particularly at the lower tail of the wage distribution (Chetverikov et al., 2016), and which has resulted in lower earnings, higher job churning, higher unemployment and increased transfer benefits (Autor et al., 2014).

[3] See e.g. Balsvik et al. (2015) for Norway or Donsono et al. (2014) for Spain.

how firms raise their productivity to remain competitive when facing import competition.

Third, our paper links to a literature which provides explanations for limited consequences of economic shocks for employment. One explanation for limited employment consequences of economic shocks (such as trade shocks) might be that adjustment costs are relatively large for changes in employment, e.g. due to employment protection. A large literature documents that strict labor protection legislation reduces the rate of job reallocation (see e.g. Alpysbayeva and Vanormelingen, 2022, Autor et al., 2004, Haltiwanger et al., 2014, Nickell and Layard, 1999). Most closely, our paper relates to a recent paper by Li and Wong (2022), who show that outsourcing smoothes labor demand in a dynamic search model which they apply to Brazilian data. The key contribution of our paper to this debate is to show that outsourcing reduces the response of employment to trade shocks not only in the short-, but also in the long run. It is the long-run nature of the results which is particularly interesting, as it highlights that there exist deeper mechanisms in the production technology that generate long-run changes in the employment-to-outsourcing ratio in response to trade shocks.[4]

The rest of our paper is organized as follows. In Section 2, we introduce our data sources and provide descriptive evidence on the rise of German trade with China and Eastern Europe as well as on trends in outsourcing. Section 3 develops our empirical strategy and provides our main results on the employment, output, and sourcing responses to trade. In Section 4, we develop a theoretical framework to show under which conditions outsourcing mitigates the employment effects of trade shocks. We also show here that the conditions of our proposed theoretical explanation match with the data, that is, our proposed mechanism is consistent with our empirical findings. We conclude in Section 5.

[4]Our paper also links to a large debate on the role of offshoring for labor markets (see Hummels et al. (2018) for a review). This large body of literature provides a wide range of important findings. Several authors have shown that offshoring raises wages and employment shares of skilled workers relative to unskilled workers (Feenstra and Hanson, 1997, 1999, Hsieh and Woo, 2005). This is associated with declining firm employment especially among low educated workers (Biscourp and Kramarz, 2007) and wages declines predominantly for these workers (Amiti and Davis, 2011, Ebenstein et al., 2014, Hummels et al., 2014), as well as increased up- and downward mobility (Liu and Trefler, 2019). While these authors focus on offshoring, i.e., international outsourcing, we do not distinguish between the destination of outsourcing and show that – beyond the direct effects on labor markets provided by the authors above – outsourcing also acts as a mediator for the effects of trade on labor markets.

2 Data and Descriptive Statistics

In this paper, we combine two main data sets: We rely on the German Structure of Costs Survey (KSE,"Kostenstrukturerhebung") to measure key industry statistics such as employment, output, and input structure. Further, we measure exposure to imports and exports using the United Nations (UN) Comtrade Database.

2.1 Structure of Costs Survey

The KSE is a mandatory yearly survey among firms, covering 45 % of all active firms with at least 20 employees in Germany in the manufacturing, mining and quarrying industry.[5] The data is available at the 4-digit industry level, allowing us to differentiate between roughly 250 industries on a yearly basis. We focus on the years 1995-2015 and harmonize the industry codes.[6] There is a break of the classification in the year 2008 and we perform robustness checks to test whether this break affects our results. Out of the roughly 250 industries, we can consistently track 215 industries in all years.

The KSE data set contains industry-year level information on the number of firms, the number of employees, sales, production, and gross value added. More importantly, this data contains detailed information on the cost structure of the firms, in particular, on labor costs (i.e. wages and social security contributions) and costs of other types of inputs. This allows us to measure the firms' outsourcing behavior.

To do so, we define outsourcing as the sum of (i) intermediate inputs, (ii) contract work, and (iii) agency workers. Intermediate inputs cover the consumption of raw materials and supplies as well as the costs for commodities. Contract work covers all payments for services that have been subcontracted to other firms (contracting out). Agency workers refer to costs for employing temporary agency workers and other costs.[7] While contract work and agency workers both rely on labor, these workers are not hired by the firm but

[5]We define these industries as NACE Rev. 1.1 Sections C and D.

[6]Our data is coded by NACE Rev. 1 industry codes until 2002. Data from 2003-2007 is coded by NACE Rev. 1.1, and data from 2008 onwards is coded by NACE Rev. 2 codes. NACE Rev. 1 and NACE Rev. 1.1 codes are virtually identical at our level of aggregation. We convert NACE Rev. 2 codes to NACE Rev. 1.1 using the correspondence table of the German Statistical Office.

[7]Agency workers unfortunately are relatively loosely defined in the data as agency workers and other service costs, such as e.g. consulting costs, licences, insurances, etc. We check the robustness of our results by zooming in on intermediate inputs, only.

instead the firms decided to source these inputs from other firms. Whenever we refer to labor in this paper, we mean dependent employees hired by the producing firms – all other types of labor (self-employment, agency workers) are instead classified as outsourcing, because firms decided to source out these activities to other companies. Having data on outsourcing activities that go beyond classical input measures is a key advantage of our data. In our empirical analysis, we test the relevance of contract work and agency workers in total outsourcing activities.

Formally, outsourcing can hence be expressed as

$$\text{outsourcing}_{it} = \text{intermediate inputs}_{it} + \text{contract work}_{it} + \text{agency workers}_{it}, \tag{1}$$

where i are industries and t are years. This is a "wide" concept of outsourcing, because we rely on both, inputs from the same as well as from other industries to measure outsourcing activities. This differs from "narrow" concepts of outsourcing which rely only on inputs from the same industry (see Feenstra, 2017).

We deflate the indicators of the KSE using the industry-level producer price index provided by the German Federal Statistical Office. Reallocation among different inputs could also be caused by changes in relative prices between inputs. While prices for labor (wages) are readily available in the KSE, it does not contain a direct indicator in the costs of other inputs. We therefore combine detailed information on intermediates use by industry[8] with commodity prices[9] to construct an industry-specific price index for the intermediates used by that industry.

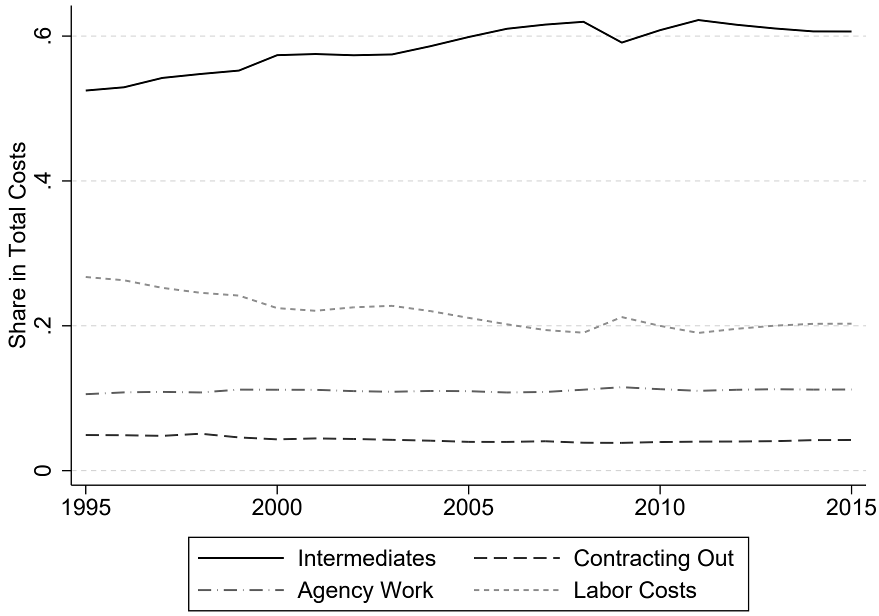
Figure 1 illustrates the change in firms' sourcing behavior. While the share of labor in total costs of production declined, the share of intermediates increased over time. Firms reduce their labor share by outsourcing via making larger use of intermediates. The shares of contract work and agency work remained relatively constant.

While Figure 1 refers to the average change across all industries, there exists considerable variation across industries, summarized in Table 1. The median industry raised

[8] We depict this information from the Survey of Materials and Goods Received of the German Federal Statistical Office.

[9] Specifically, we rely on the producer price index of industrial products at the 6-digit commodity level of the German Federal Statistical Office.

Figure 1: Sourcing



Notes: Average share of different types of costs in firms' total costs across German industries, weighted by total industry costs. Converted to € and deflated to the base year 2000. Note that "agency work" also covers "other costs" such as e.g. consulting, insurances, licences, etc.. Sources: German Federal Statistical Office.

their intermediates share by 4 %-age points (pp), whereas the industry at the 95th percentile raise this share by 16.1 pp. Vice versa, the median industry reduced their labor share by 4.2 pp, while the 5th percentile industry reduced it by 12.5 pp. There also exists considerable variation in changes of contract work and agency work shares across industries.

2.2 UN Comtrade

The UN Comtrade database contains information on the shipment of commodities at the level of exporter- and importer-country, commodities, and years. We use the data for the years 1995-2015 and convert 6-digit HS commodity data to 4-digit NACE Rev. 2 codes using the UN correspondence tables. We focus on the trade flows of Germany with its trading partners. The data is available in current US Dollars, which we convert to Euros. We then define the import exposure, IE, and export exposure, EE, of a German industry

Table 1: Descriptive Statistics for the Strucutre of Cost Survey

	mean	s.d.	5th pct	median	95th pct	N
			Levels, 1995			
Employment (#)	28733	49141	1112	13264	104720	215
Firms (#)	158	235	7	64	670	215
Gross Value Added (T€)	1570.3	3075.9	54.1	651.5	4989.0	210
Cost Shares						
Intermediates	0.519	0.118	0.323	0.515	0.717	215
Contracting	0.047	0.030	0.017	0.039	0.107	215
Agency Workers	0.111	0.044	0.057	0.100	0.204	215
Labour	0.267	0.091	0.125	0.260	0.410	215
			Changes, 1995-2015			
Employment (#)	-2832	30635	-40067	-1819	23364	215
Firms (#)	-9	176	-266	-6	185	215
Gross Value Added (T€)	313.3	3530.0	-1679.0	-20.2	2856.0	210
Cost Shares						
Intermediates	0.041	0.070	-0.079	0.040	0.161	215
Contracting	0.007	0.028	-0.025	0.004	0.052	215
Agency Workers	0.013	0.036	-0.058	0.018	0.059	215
Labour	-0.042	0.051	-0.125	-0.042	0.041	215

Notes: Unweighted industry statistics. 4-digit German manufacturing industry level. Converted to € and deflated to the base year 2000. Sources: German Federal Statistical Office.

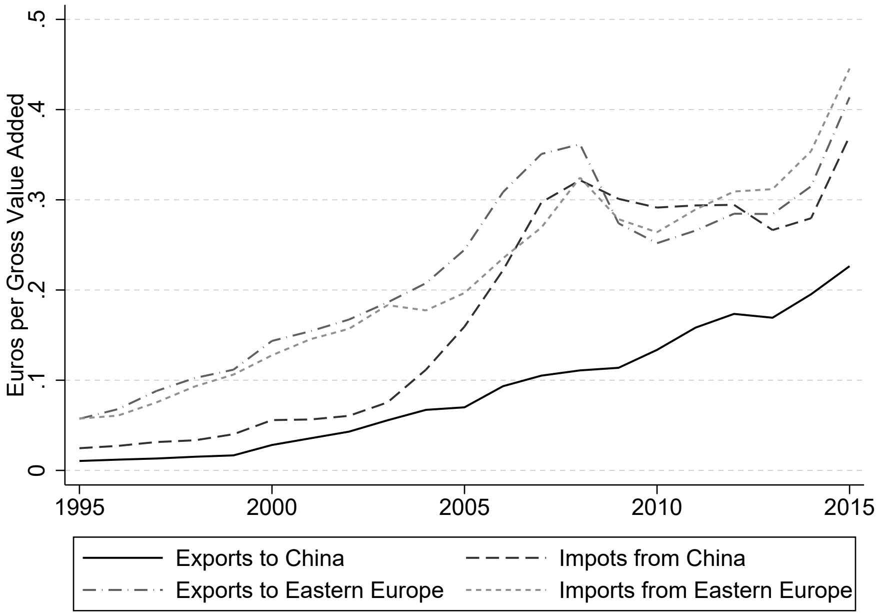
i in year t as

$$\begin{aligned} IE_{it} &= \frac{Im_{it}}{GVA_{it_0}}, \\ EE_{it} &= \frac{Ex_{it}}{GVA_{it_0}}, \end{aligned} \tag{2}$$

where Im_{it} are imports of industry i in year t to Germany, Ex_{it} are exports of German industry i in year t, and GVA_{it_0} is gross value added (GVA) in the initial year t_0 in industry i in Germany. We deflate all nominal data to the base year 2000 using the industry-specific importer and exporter price indices provided by the German Federal Statistical Office. We focus on German trade with China and with Eastern Europe. The latter covers the Eastern member states of the European Union, namely Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovakia, and Slovenia.

Figure 2 illustrates the rise of import and export exposure of German industries since the 1990's. As it is well documented in the literature, German trade with Eastern Europe and China has strongly risen, whereas the rise in trade with Eastern Europe was more balanced compared to the trade with China, where imports from China rose faster than exports to China. Trade with Eastern Europe picked up earlier than trade with China.

Figure 2: Trade with the East



Notes: Average trade of German industries with Eastern Europe and China in €per gross value added, weighted by industry gross value added. Converted to € and deflated to the base year 2000. Sources: UN Comtrade and German Federal Statistical Office.

For both, trade with Eastern Europe and trade with China, trade temporarily declined after the financial crisis in 2008, but growth picked up again soon thereafter.

While on average across all industries import and export exposure rose significantly, there exist large differences between industries. Table 2 depicts the level and the increase in import and export exposure of industries with Eastern Europe and China. For example, the large average increase of exports to Eastern Europe per industry value added of 0.417 €per gross value added between 1995 and 2015 across all industries hides large differences at the 4-digit industry level, where the industry at the 5th percentile experienced a decline of export exposure by 0.110 whereas the industry at the 95th percentile experienced an increase of 1.926. The heterogeneity is also large for imports, as well as for trade with China. We exploit these differences in import and export exposure across industries to estimate the effects of trade on industry-level outcomes.

Table 2: Descriptive Statistics

	mean	s.d.	5th pct	median	95th pct	N
Levels, 1995						
Trade in €/GVA						
Exports Eastern Europe	0.359	1.556	0.006	0.068	1.657	203
Imports Eastern Europe	0.414	2.261	0.002	0.067	1.223	200
Exports China	0.023	0.063	0.000	0.003	0.085	201
Imports China	0.225	1.239	0.000	0.012	0.804	199
Changes, 1995-2015						
Trade in €/GVA						
Exports Eastern Europe	0.417	1.572	-0.110	0.177	1.926	209
Imports Eastern Europe	0.290	1.634	-0.147	0.135	1.357	205
Exports China	0.199	0.773	0.000	0.049	0.687	204
Imports China	0.749	2.992	0.000	0.089	2.635	203

Notes: Unweighted industry statistics. 4-digit German manufacturing industry level. Converted to € and deflated to the base year 2000. Sources: UN Comtrade and German Federal Statistical Office.

3 Empirical Analysis

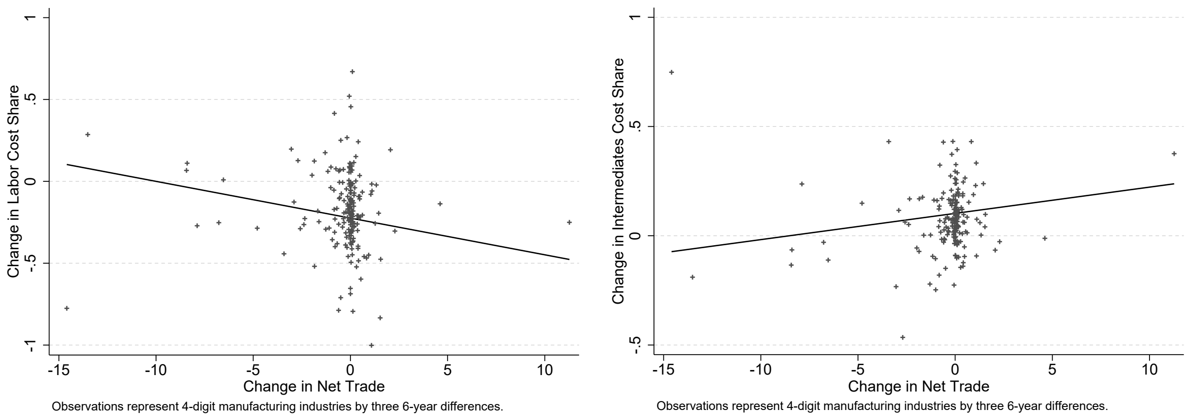
In this paper, we study how firms adjust their factor composition to trade shocks. Figure 3 provides a descriptive analysis of the relationships by comparing changes in net trade with the East to both, changes in the cost share of labor (Panel A) as well as changes in the cost share of intermediates (Panel B). The cost share of labor declines as net trade with the East rises – higher exports to the East are associated with lower shares of labor costs (Panel A) and higher share of intermediates costs (Panel B). Vice versa, import competition, i.e. declining net exports or rising net imports to the East, are associated with higher shares of labor cost, and lower shares of intermediates costs. Trade-induced expanding industries grow disproportional in intermediates, and trade-induced contracting industries shrink disproportional in intermediates. In the remainder of this section, we study whether this represents a causal relationship.

3.1 Estimation Strategy

In this paper, we are interested in the effects of a demand shock on employment, outsourcing, and the ratio of the two. We exploit the large import and export shocks of Germany's rising trade with China and Eastern Europe. We rely on trade exposure at the industry-level. We estimate how changes in our outcomes of interest respond to changes in import

Figure 3: Trade and Sourcing

(A) Trade vs. Labor (B) Trade vs. Intermediates



Notes: The graphs plot changes in net trade with the East against changes in the cost share of labor (a) and changes in the cost share of intermediates (b), respectively. Each dot represents a 4-digit industry over a 6-year time window. We pool all 6-year (non-overlapping) time windows.

and export exposure. Formally, we hence use

$$\Delta \ln Y_{ip} = \alpha + \beta \Delta \ln IE_{ip} + \gamma \Delta \ln EE_{ip} + \theta_p + \epsilon_{ip}, \quad (3)$$

where i are industries, p are time periods (stacked differences)[10], Y are various outcome variables (employment, number of firms, sales, gross value added, outsourcing), IE is import exposure, EE is export exposure, and θ_p are dummies for the time periods.

In addition, we estimate fixed effects panel models of the form

$$\ln Y_{it} = \alpha + \beta \ln IE_{it} + \gamma \ln EE_{it} + \nu_i + \theta_t + \epsilon_{it}, \quad (4)$$

where ν_i are industry fixed effects, θ_t are year dummies, and where we use levels instead of changes. We compare models for stacked differences with our fixed effects models throughout the paper. The fixed effects model exploits only year-by-year variation to identify the effects of trade on the industries, whereas the stacked differences models

[10] We either use (a) *one* long difference from 1995-2015; (b) *three* 6-year differences from 1995-2001, 2001-2007, and 2008-2015; or *seven* 3-year differences from 1995-1998, 1998-2001, 2001-2004, 2004-2007, 2008-2010, 2010-2012, and 2012-2015. Except for the long difference, we avoid mixing data from years before and after 2008 due to the structural break in the industry classification.

exploit variations over longer time periods.

The key identifying problem of our approach is that industry-level demand and supply shocks are likely to affect both, our outcome variables and industries' trade. To cope with this endogeneity, we adopt a well-established instrumental variable strategy from the literature. Autor et al. (2013a, 2016) document for China, and Dauth et al. (2014) similarly document for Eastern Europe, that the sudden rise in trade with the East came as a surprise for most observers, was caused by internal reforms in China and Eastern Europe, and is highly skewed by industries. The sudden increase of trade with the East is therefore a large shock to many economies in the world that has its roots in China and Eastern Europe and that is visible in many other countries. The size of this shock differs vastly across sectors.

Against this background, we follow the literature and use other countries' trade with Eastern Europe and China as an instrumental variable for German industries' trade.[11] We follow Dauth et al. (2014) and focus on two sets of IV countries. The first set (A) covers Australia, Canada, Japan, Republic of Korea, New Zealand, the second set (B) covers Brazil, India, Indonesia, Mexico, Taiwan, Malaysia. Country set A covers countries which have similar economic and social structures as Germany and thus are likely to predict well German industry-level trade. We do not use any countries from the European Union in set (A) since these countries have close trade links with Germany and their trade patterns with Eastern Europe and China could therefore be affected by Germany industry-specific shocks. We check the robustness of our results by using the alternative set of countries (B).

3.2 Employment, Output, and Outsourcing

In this section, we provide results for the aggregate response of industry-level employment, output and outsourcing to the shock of the sudden rise in trade of German industries with Eastern European and China. Regarding employment and output, comparable results are already well established in the literature, although typically focusing on the regional level,

[11] This strategy is widely adopted in the literature, see Autor et al. (2016) for an overview.

whereas we focus on the industry level.[12]

Table 3 shows the employment effects of trade on manufacturing industries. Export exposure raises industry employment whereas import exposure reduces employment, as expected. The effects tend to be larger when using longer differences, indicating that trade shocks need some time to unfold their employment effects. An increase of the export-to-GVA ratio by 10 pp raises employment (number of workers) by 1.3 % over six years, whereas an equally sized rise of imports reduces employment by 1 % over the same time period. In the fixed effects model, where we only exploit year-to-year changes, these effects are bigger. The negative effects of import exposure grow when we choose longer differences. The instruments are clearly relevant in the fixed effects and in the 3-year-differences models, but they do become weaker in the two models with longer time lags where we have fewer observations, naturally. Nevertheless, all main effects remain significant and large.[13]

Table 3: Effects of Trade on Employment

Log Employment	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.363***	0.148*	0.129**	0.473**
	(2.82)	(1.76)	(2.30)	(2.59)
Import E.	-0.247**	-0.058***	-0.103***	-0.250***
	(-4.01)	(-3.72)	(-9.07)	(-6.23)
N	4056	1330	572	192
F excl. Instr.				
Export E.	44.29	24.65	22.56	13.86
Import E.	52.35	16.48	26.08	21.70
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

We cluster standard errors at the level of 4-digit industries. Clustering standard errors at the level of 2-digit industries does not lead to different conclusions (see Appendix Table A.2). We weight results by the initial industry size to take into account size differences between industries. We receive qualitatively the same results when not weighting our results (see Appendix Table A.3). Effect sizes are smaller in the unweighted regressions,

[12] Acemoglu et al. (2016) also focus on the industry level.

[13] Appendix Table A.1 shows that the effects on the number of firms are analogous, which implies that the employment effects are not exclusively driven by firm growth or shrinkage.

indicating that smaller industries are less responsive to trade shocks. We focus on weighted results as our baseline since we are interested in the average effect of trade in Germany. Weighting further reduces sensitivity to outliers in small industries.

Our findings thus far are based on the first set of countries to construct our IV. These countries are similar in their economic structure to Germany and accordingly the instrumental variable is strong. We check the robustness of our results using an alternative set of developing countries in Appendix Table A.4. The results are comparable for the import shock, but loose significance for the export shock. This can be explained by the fact that the shock of Chinese import competition was shared by many economies, while not all countries could similarly gain from rising export opportunities to the new Eastern markets. The export shock turns significant only in the long-difference model. We conclude that our results for the import shock are robust to the choice of the instrumental variable, although the relationship between developing countries' exports to the East and Germany's exports to the East is strong enough in the first stage only when looking at longer time periods.

In obtaining our results, we take together all imports from Eastern Europe and China, as well as all export to these two destinations. Ideally, we would estimate the effects separately for both trading partners to check for heterogeneity, but unfortunately trade patterns are too closely correlated between both destinations to separate them. As an alternative, we compute net exports (i.e., exports minus imports per gross value added) to Eastern Europe and net exports to China and repeat our analysis. Appendix Table A.5 provides the results. In both cases, net exports raise employment, as expected, although net trade with Eastern Europe has a larger (but less precisely estimated) effect on employment than trade with China. The correlation of trade between the two trading partners imposes hurdles to separately identify the effects. We therefore refrain from further analyzing differences between the two trading partners.

The effects of trade on the labor costs (i.e. the wage bill) are analogous, though they are larger, as we show in Appendix Table A.6. That is, the marginal effect of exports on labor costs is more positive, and the marginal effects of imports is less negative, as compared to the employment effects of trade. The underlying reason is that exports raise wages, while imports have no negative effects on wages. If at all, wages tend to positively respond to import shocks at the industry level (see Appendix Table A.7). The latter indicates that the employment effects likely contain selection effects – import-competing industries likely lay-off low-wage workers or shift employment towards competitive highly productive and high-wage firms. This is in line with Dauth et al. (2014), who find that wages at the local level do not decline in the face of import competition. Exports raise workers' wages while attracting few new workers to the industry. Import competition mostly hurts low-wage workers who are induced to leave the exposed industries (Dauth et al., 2016). Only higher skilled, higher paid workers remain, leading to a rise in average wages of import-competing industries. Lacking wage-declines in response to import competition could also be explained by downward wage rigidity. Hence, both imports and exports induce labor demand shifts, but they play out differently in terms of employment and wages: exports raise both wages and employment, while imports reduce employment without reducing wages. We will return to these differences in how import vs. export driven labor demand shocks result in employment vs. wage effects when analyzing the response of the ratio between labor costs and outsourcing.

Table 4 shows that trade has an analogous effect on industries' GVA. An increase of exports relative to gross value added by 10 pp raises GVA by about 4-6 %, depending on the time horizon. Similarly, a rise of imports reduces GVA, although the effect is smaller. The results are analogous when using sales instead of GVA (see Appendix Table A.8). Industries with rising exports raise their output, whereas industries suffering from rising competition with Eastern Europe and China reduce their output, as expected.

Table 4: Effects of Trade on Gross Value Added

Log GVA	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.563***	0.443***	0.493***	0.598***
	(2.94)	(2.85)	(2.96)	(2.92)
Import E.	-0.125**	-0.0249	-0.0625***	-0.128***
	(-2.16)	(-1.15)	(-3.19)	(-2.82)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

While other papers already document comparable changes in employment and gross value added, we are the first to show that this goes hand-in-hand with analogous changes in firms outsourcing behavior. Firms raise their outsourcing as they face growing export opportunities while they reduce their outsourcing activities in the case of import competition, as highlighted by Table 5. Although these results refer to outsourcing in nominal terms, they remain comparable when focusing on real outsourcing as we show in Appendix Table A.9.[14] These results are only partly driven by changes in output. Effect sizes shrink but the sign and significance remain when conditioning the results on gross value added, i.e., firms still adjust their outsourcing activity to trade shocks (see Appendix Table A.10).

Table 5: Effects of Trade on Outsourcing

Outsourcing (nominal)	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.758***	0.396***	0.326***	0.692***
	(3.74)	(7.17)	(4.79)	(2.85)
Import E.	-0.242***	-0.0651***	-0.113***	-0.208***
	(-6.06)	(-3.68)	(-4.92)	(-3.59)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

3.3 Labor-Costs-to-Outsourcing Ratio

In this section, we focus on the labor-costs-to-outsourcing ratio to study how firms adjust their production structure to cope with the trade shock, and what that implies for workers.

Table 6 shows the effects of trade on the labor-costs-to-outsourcing ratio, defined as labor costs relative to outsourcing costs. The average labor costs to outsourcing costs ratio in the data is 0.346 – labor costs amount to 34.6 % of outsourcing costs. We find that a rise in exports relative to GVA by 10 pp reduces the labor-costs-to-outsourcing ratio by 0.6 pp in the fixed effects model. These effects turn insignificant but remain sizeable when focusing on longer-term changes. A rise of the import-to-GVA ratio by 10 pp, instead,

[14] Appendix Table A.9 refers to intermediates, only, because cost deflators are only available for this part of outsourcing. However, this also reflects the largest part of firms' outsourcing activities.

raises the labor-costs-to-outsourcing ratio by 0.25 pp to 0.38 pp, depending on the time period. Results are robust to clustering at the 2-digit level (see Appendix Table A.11) and to the alternative IV (see Appendix Table A.12).

As an alternative to stacked differences, we estimate dynamic specifications of our equation and confirm that the effects are persistent. In particular, in Appendix Table A.13, we find that the import effects persist when using lags up to four years of our trade measures. In Appendix Table A.14, we use both contemporary trade and lags of trade of up to four years and find that interestingly the long-term effects of imports remain significant, whereas the contemporaneous effects drop in size and turn insignificant (except for a time lag of 4 years, where both contemporaneous and lagged import effects are significant). This confirms the stacked difference results from Table 6, i.e., the effects are persistent.

Table 6: Effects of Trade on the labor-costs-to-Outsourcing Ratio

Labor Costs/Outsourcing Costs	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	-0.0617**	-0.00128	0.0501	-0.0977
	(-2.36)	(-0.03)	(1.12)	(-1.56)
Import E.	0.0252***	0.0318**	0.0339***	0.0383
	(3.75)	(2.15)	(2.76)	(1.17)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

These results are mostly driven by intermediate inputs and agency work, as we show in Appendix Table A.15, where we differentiate between types of outsourcing.[15] We find only smaller adjustments for contract work, which could be due to the small share of contract work in industry total costs. One worry could be that changes in the input structure are driven by size effects of the industries. We therefore add gross value added as a control variable and find that the results remain robust (see Appendix Table A.16). Changes in firms' sourcing behavior are thus not driven by size adjustments.

As our main result, we hence conclude that industries respond to trade shocks by

[15] Please note that we invert the ratios and regress outsourcing-to-labor cost ratios for the three outsourcing types on trade in the Appendix.

changing the composition of their inputs and do not adjust labor and outsourcing inputs proportionally. When industries shrink due to import penetration, they raise their labor-costs-to-outsourcing ratio, i.e., the decline in outsourcing costs is larger than the reduction of labor costs. This implies that outsourcing mitigates the labor effects of import shocks. Put differently, the import-driven labor cost decline would have been more severe had firms reduced their outsourcing costs proportionally to labor costs. In fact, the negative labor costs effects of imports are larger by about 10 % compared to the baseline specification when controlling for the level of outsourcing (see Appendix Table A.17).

Our results from Table 6 are based on labor costs. This implies that our results could be affected by wage responses to trade shocks. Appendix Table A.7 shows that exports indeed raise workers' wages whereas imports have (small) positive effects – potentially due to worker selection. We therefore next rely on the employment-to-outsourcing ratio, defined as number of workers relative to outsourcing costs, as our dependent variable in Table 7. We expect results to differ because the labor demand shifts caused by import and export shocks play out differently in terms of wage and employment responses.

Table 7: Effects of Trade on the Employment-to-Outsourcing Ratio

Employment/Outsourcing	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	-0.395***	-0.248***	-0.197**	-0.219**
	(-3.52)	(-3.53)	(-2.46)	(-2.43)
Import E.	-0.00463	0.00682	0.00929	-0.0414
	(-0.23)	(0.40)	(0.61)	(-1.04)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

The results highlight that exports reduce the number of workers per outsourcing costs. The fact that the labor-costs-to-outsourcing ratio only weakly responds to export shocks in Table 6 is thus due to wage adjustments, i.e., export-driven wage increases. We do not find clear effects of imports on the number of workers per outsourcing costs – in contrast to the results for the labor-costs-to-outsourcing ratio from Table 6. A potential explanation for the differences in the results is selection: In line with the findings from the literature, firms likely particularly reduce employment among low-skilled, low-wage workers. This implies that the decline in labor costs is slower than the decline in employment and explains why we find a change in the labor-costs-to-outsourcing ratio in Table 6, but not a change in the employment-to-outsourcing ratio in Table 7. That is, firms reduce employment in response to import shocks, but they do not reduce wages but even raise them, so that the labor-costs to outsourcing ratio increases in response to import penetration.

A potential confounder for our results are adjustments in the price of outsourcing as input in response to trade shocks. In order to check this explanation, we rely on an industry-specific price index for intermediate inputs (see Section 2) to deflate our outsourcing indicator. Our results in Appendix Table A.18 are hardly affected by that, indicating that input-price changes play hardly any role for our findings.

Overall, we therefore conclude that import shocks raise the labor costs-to-outsourcing costs ratio, although this is not accompanied by a rising employment-to-outsourcing costs-ratio, but instead due to wage increases, potentially explained by worker selection. This suggests that outsourcing mitigates import-induced negative labor demand shocks: imports reduce outsourcing more than they reduce labor demand, resulting in an increase of the labor costs-to-outsourcing costs ratio. Export shocks, on the other hand, reduce the employment-to-outsourcing costs ratio, but that only results in a smaller decline of the labor costs-to-outsourcing costs ratio due to rising wages. This similarly suggests that outsourcing influences export-induced labor demand shocks, i.e., firms increase outsourcing more than employment.

4 Theoretical Explanation: Technology Matters

Trade shocks lead to adjustments in the input structure by firms, implying that outsourcing mitigates the respective labor market effects. This empirical result is not a short-term phenomena but it is persistent even in the long-run. As such, differences in the adjustment costs of inputs cannot explain our findings because those differences should be decreasing over time and thus vanish when taking up a long-term perspective.

In this section, we therefore build a simple model in order to show that the production technology itself is the main driver for re-structuring the use of inputs in response to trade shocks. To that end, we first outline the model's framework. Secondly, we derive a condition which shows how the relative use of production factors is affected by changes in the output level. Thirdly, we model trade as an exogenous demand-decreasing (import) or demand-increasing (export) shock, which alters output choices and affects thereby the relative use of the production factors. As a last step, we check whether our proposed explanation is evident in our data.

4.1 Set-Up

We consider an industry with monopolistic competition at the goods market within an open economy. Firms produce unique varieties, but they are homogeneous in all other aspects (see Dixit and Stiglitz (1977) for similar assumptions).[16] The iso-elastic exogenously given demand function is $q = Ap^{-\sigma}$, $\sigma > 1$, $A > 0$, where p denotes the price of the produced variety, A is a demand shifter and σ represents the price elasticity. To save notations, we abstain from introducing a firm index.

Production depends on employment h and inputs that are purchased by external suppliers m.[17] We interpret the latter as outsourcing, where intermediates which are used in the production process are acquired either in the home or in the foreign country. In addition, total factor productivity ϕ has a positive impact on output. The production function reads $q = f(h, m, \phi)$, $f_h > 0 > f_{hh}$, $f_m > 0 > f_{mm}$, $f_{hm} \geq 0$, $f_\phi > f_{\phi\phi} = 0$, where subscripts denote partial derivatives.[18] Costs are defined as $c = wh + tm + F$, $w, t, F > 0$, with w representing wages, t being the (constant) unit costs of outsourcing and F denoting fixed production costs. All input prices are considered as exogenously given. Revenues are defined as $r = qp = Ap^{-(\sigma-1)}$.

[16]We abstract from firm heterogeneity in our model. Of course, a reallocation between firms that differ in their shares of using different inputs could be one potential mechanism that might explain our empirical finding. However, the data on sourcing is only available at the industry level, preventing the empirical analysis of identifying the role of firm heterogeneity for the labor market effects of trade shocks.

[17]We assume labor as homogeneous and thus disregard skill-specific labor demand effects, which might be caused by trade shocks as well and imply a reallocation of workers with different skill levels. The reason for this is that we want to highlight the role of the production technology and abstain, hence, from implementing further potential mechanisms.

[18]By assumption, we disregard capital as an production factor in our model. Once again, we do so because we have no information on capital use in our data, such that we were not able to validate potential theoretical results on the relationship between trade and capital.

4.2 Solution

The firm's optimization problem regarding input demand is

$$\min_{h,m} c = wh + tm + F \qquad \text{subject to} \qquad q = f(h, m, \phi).$$

The first-order conditions are

$$B_1 \equiv w - \lambda f_h(h, m, \phi)) = 0, \tag{5}$$

$$B_2 \equiv t - \lambda f_m(h, m, \phi)) = 0, \tag{6}$$

$$B_3 \equiv q - f(h, m, \phi)) = 0, \tag{7}$$

where λ (> 0) denotes the Lagrange multiplier. The second-order condition, $|H| = \lambda(f_{hh} f_m^2 + f_{mm} f_h^2 - 2 f_{mh} f_m f_h) < 0$, is fulfilled. Solving the equation system with respect to h and m (and λ) yields the (conditional) demand for labor and outsourcing, $h = h(w, t, \phi, q)$ and $m = m(w, t, \phi, q)$, respectively.

The cost function can then be expressed as

$$c(w, t, F, \phi, q) = \min_{h,m|q=f(h,m,\phi)} wh + tm + F. \tag{8}$$

Marginal costs mc are given by $mc(w, t, \phi, q) = dc(w, t, F, \phi, q)/dq > 0$ with $mc_q \geq 0$.

Given the cost function, the firm maximizes profits π with respect to the variety price. The optimization problem reads

$$\max_p \pi = Ap^{-(\sigma-1)} - c(w, t, F, \phi, Ap^{-\sigma}),$$

where we substituted q by the demand function. The first-order condition leads to

$$B_4 \equiv p - \frac{\sigma}{\sigma - 1} mc(w, t, \phi, Ap^{-\sigma}) = 0, \tag{9}$$

which determines the profit-maximizing price $p = p(w, t, \phi, \sigma, A)$. The second-order condition is fulfilled at the maximum. Given the price, we can compute the profit-maximizing output and hence the (unconditional) demand for both inputs.

For later use, we calculate how the profit-maximizing output, $q = Ap(w, t, \phi, \sigma, A)^{-\sigma}$, responds to demand shocks, modelled by changes in the demand shifter A. Differentiating implies

$$\frac{dq}{dA} = p^{-\sigma}(1 - \sigma\psi), \tag{10}$$

with $\psi \geq 0$ denoting the price elasticity of demand shocks. Suppose that the demand shock is positive, i.e., A increases. Then, output is influenced by two countervailing effects. On the one hand, output increases because of the positive demand shock. On the other hand, however, firms raise their prices which, c.p., reduces output. This price adjustment prevails if the initial output hike leads to higher marginal costs. It can be measured by the elasticity ψ. Naturally, the price will not be changed if marginal costs are constant, i.e., $mc_q = 0 \Leftrightarrow \psi = 0$. Using (10), we can formulate the following condition:

$$\frac{dq}{dA} > 0 \Leftrightarrow \psi < 1/\sigma. \tag{11}$$

Following the literature, in particular trade studies in the spirit of Krugman (1980), we assume that (11) holds, i.e., the price adjustment (measured by ψ) is sufficiently low, compared to the initial impact on product demand.

4.3 The Employment-to-Outsourcing Ratio

We use our model to investigate how firms respond to (product demand induced) output variations. In particular, we analyze the impact on the employment-to-outsourcing ratio, m/h.[19]

To that end, we first look at the conditional input demand separately. Using Cramer's

[19] In our theoretical analysis, we abstain from investigating the impact on the labor costs to outsourcing costs ratio, $wh/(tm)$. As we have assumed w and t to be exogenously given, a change in output will not affect input prices by construction. If we had modelled input supply functions as well, input prices would – under common assumptions – respond in the same direction as input quantities. As such, our simplifying assumption of perfectly elastic input supply functions does not qualitatively alter the results.

rule, we obtain

$$\frac{dh}{dq} = \underbrace{\frac{\lambda}{|H|}}_{<0} \underbrace{(f_h f_{mm} - f_m f_{mh})}_{<0} > 0, \tag{12}$$

$$\frac{dm}{dq} = \underbrace{\frac{\lambda}{|H|}}_{<0} \underbrace{(f_m f_{hh} - f_h f_{mh})}_{<0} > 0. \tag{13}$$

This shows that an increase (a decline) in output raises (reduces) input demand.

Second, we differentiate the employment-to-outsourcing ratio with respect to q, taking (12) and (13) into account. This leads to

$$\frac{d(h/m)}{dq} = \frac{1}{m^2}\left(\underbrace{\frac{dh}{dq}}_{>0} m - \underbrace{\frac{dm}{dq}}_{>0} h\right), \tag{14}$$

$$\frac{d(h/m)}{dq} < 0 \Leftrightarrow \frac{m}{h} < \frac{dm/dq}{dh/dq} = \frac{f_m f_{hh} - f_h f_{mh}}{f_h f_{mm} - f_m f_{hm}}. \tag{15}$$

Defining the elasticity between the two inputs as $\eta \equiv dm/dh \times h/m$, we can re-write condition (15) as

$$\frac{d(h/m)}{dq} < 0 \Leftrightarrow \eta > 1. \tag{16}$$

To get an intuition, suppose that output declines due to a reduction in product demand. This implies that the use of both input factors will be reduced. If $\eta > 1$ holds, outsourcing will respond more elastically than employment. Therefore, the decline in outsourcing will be more pronounced than the reduction in employment and the employment-to-outsourcing ratio will increase. In such a case, outsourcing mitigates the negative effect on labor demand because the output shock is less severe for employment than in a world where both input factors were reduced proportionally. If, in contrast, output rises, the reverse argumentation holds, i.e., the positive employment effects are less pronounced as long as the employment-to-outsourcing ratio declines. This can be summarized as:

Lemma 1.

Outsourcing mitigates employment effects of output variations if $\eta > 1$ holds.

The question is, however, under which technological circumstances outsourcing reacts more elastically than employment. This can be clarified by using (15). Suppose that $m > h$ holds and assume that output decreases. Then, as showed above, outsourcing will only mitigate the negative employment effects if $\eta > 1$. This situation is more likely to occur the higher, c.p., the marginal product of outsourcing, f_m, is, given that the cross derivation, f_{hm}, is relatively small (compared to the level of f_{hh}). Alternatively, the marginal product of employment, f_h, should be relatively small. The larger the marginal product of outsourcing relative to the marginal product of labor, the more likely it is that firms predominantly adjust outsourcing (instead of labor) in response to product demand shocks. If, in contrast $m < h$ holds, the opposite explanation can be made.

Note that a conventional Cobb-Douglas production function, e.g., $q = \phi h^{\alpha} m^{\beta}$, $0 < \alpha, \beta \leq 1$, implies $\eta = 1$. Here, employment and outsourcing react proportionally and there is no mitigation of negative employment effects. This is also true in case of a CES production technology. In contrast, $q = \phi(h^{\alpha} + m^{\beta})$, $0 < \alpha, \beta < 1$, for example, leads to $\eta > 1 \Leftrightarrow \beta > \alpha$. Here, outsourcing adjusts more elastically than employment as long as the marginal product of outsourcing exceeds the marginal product of employment.

4.4 Application: Trade Shocks

Any exogenous variation that causes a change in output will affect input demand in absolute and relative terms as analyzed above. As an application, we consider a trade shock in the following.

Suppose that the industry is exposed to import competition and assume that this competition becomes more severe, for instance due to trade liberalization. Such a trade shock will reduce the domestic demand, i.e., A declines, which in turn reduces output q [see (11)].[20] The decline in output reduces both employment and outsourcing, but if $\eta > 1$ holds, the decrease in outsourcing will be larger than the decrease in employment, implying that outsourcing mitigates the negative consequences of trade shocks on employment.

As a result, we can explain our empirical finding by considering the properties of

[20] Trade liberalization will surly also effect the price of outsourcing, t. We do not analyze this channel in our model since we are interested in the effects of different degrees of competition and hence on demand shifts. Moreover, the empirical investigation has shown that input price variations do not affect our main result, i.e., outsourcing mitigates employment effects of trade shocks.

the production technology only. As shown above, a higher (marginal) productivity of outsourcing (relative to the one of employment) can, e.g., explain that outsourcing reacts more elastically than employment. Hence, firms re-structure their use of inputs, and this outcome is persistent also in the long-run due to the longevity nature of production technologies. Different adjustment costs of inputs play no role in our model.

Next, we consider an exporting industry and assume that trade liberalization increases the export opportunities of firms. Formally, the demand shifter A rises, which implies that demand and hence output q increase. Consequently, input demand increases as well. If $\eta > 1$ holds, however, the increase in outsourcing will be stronger than the increase in employment, such that outsourcing again mitigates the (now positive) employment effects of trade shocks. Empirically, we have – at least partially – obtained the same result and our theory suggests, as before, that the technology itself is the main driver for the change in the employment-to-outsourcing ratio.

Proposition 1 summarizes our findings.

Proposition 1.
Employment effects of trade shocks are mitigated by outsourcing changes if $\eta > 1$*, i.e., if* (15) *or, equivalently,* (16) *hold. Then, an increase in import competition (export opportunities) implies a rise (reduction) of the employment-to-outsourcing ratio and the mitigation is caused by the pattern of the used technology.*

4.5 Empirical Test

As a last step, we empirically test the validity of Proposition 1, i.e., we clarify whether our data supports the theoretical explanation that the technology is (at least partially) responsible for our main result. In doing so, we estimate specific forms of the production function and test whether the results match condition (15) (and hence (16)). We rely on translog production functions as a flexible functional form that can approximate various alternative production technologies (see Christensen et al., 1973).

The translog production function in general has the form

$$lnY = lnA + \sum_{i=1}^{n} \beta_i \ln X_i + \sum_{i=1}^{n} \sum_{i'=1}^{n} \beta_{ii'} \ln X_i \ln X_{i'}, \tag{17}$$

where $i = 1, ..., n$ is an index for the production factors X, and Y denotes output. We start with (1) a simple version of this equation that consists only of labor h and outsourcing m, and the interaction of the two as production factors. We subsequently extend the model by including (2) time t as a control, (3) interactions of time with all production factors, and finally (4) a full model including squared terms for all variables.

We then use the results of these regressions to compute the following statistic by inserting the estimated production function into condition (15) (see Appendix A.3 for more details). To simplify the exposition, we define

$$c \equiv \frac{m}{h} - \frac{f_m f_{hh} - f_h f_{mh}}{f_h f_{mm} - f_m f_{hm}}. \tag{18}$$

Note that c varies across industries and years due to the functional form of the production technology. Condition (15) is then fulfilled if $c < 0$ holds. We further require that $|H| = \lambda(f_{hh} f_m^2 + f_{mm} f_h^2 - 2 f_{mh} f_m f_h) < 0$, (12) and (13) hold. We compute c, $|H|$ and the relevant parts of (12) and (13) for all industry-year combinations.

Table 8 provides the results and shows that condition (15) is met for all specifications. We analogously show that $|H| < 0$, (12) and (13) hold in Appendix Table A.19. Consequently, outsourcing mitigates employment effects of trade shocks due to the pattern of the used technology – our theoretical framework can explain why outsourcing mitigates employment responses to trade shocks not only in the short run, but specifically in the long run due to the nature of the underlying production technology.

5 Conclusion

In this paper, we shed light on the role of outsourcing for the labor market effects of trade shocks. Using data at the 4-digit industry level in Germany, we find that outsourcing declines more strongly than employment in industries that are exposed to import-

Table 8: Testing the Mechanism

	(1)	(2)	(3)	(4)
controls				
m, h, $m \times h$	X	X	X	X
t		X	X	X
$t \times m$, $t \times h$			X	X
m^2, h^2, t^2				X
results for statistic c				
mean	-13.77	-13.02	-18.33	-9.84
95th pct.	-5.16	-4.86	-6.63	-3.18

competition. Vice versa, we see that the increase in outsourcing exceeds the rise of labor demand in industries with higher export opportunities. This highlights our main result: outsourcing mitigates the employment effects of trade shocks. While this result is not surprising in the short run due to larger adjustment costs for labor than for outsourcing, we find that these effects persist in the long run. In our theoretical analysis, we have established that a key driver for the long-run adjustment is the used technology itself.

While we focus on trade shocks in our empirical analysis as a source of exogenous variation in output, our model holds for more general shocks to product demand. Moreover, our theory also shows that the change in the employment-to-outsourcing ratio only holds under specific conditions, which might not be met for a different set of inputs. For example, we would not expect similar results for the ratio of skilled-vs-unskilled labor, because the factor shares and first derivatives are more similar between skill groups than they are between labor and other inputs.[21]

Our model provides the properties of production technologies under which outsourcing mitigates employment effects of trade shocks, while the underlying reasons for the shape of the production function are beyond the scope of this paper. For example, reallocation might take place between firms with different employment-to-outsourcing ratios, while we only study industry-level aggregates.[22] While we show that our mechanisms are at work for the case that we study, other mechanisms might be simultaneously at work. For example, trade liberalization potentially has reduced outsourcing costs by the availability of cheaper intermediates for German firms in Eastern Europe and China.

[21]We cannot test this in our data set because of the lack of skill-specific employment and wage information.

[22]We cannot further study these potential mechanisms because of the lack of adequate data.

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A Appendix

A.1 Additional Results for Section 3.2

Table A.1: Effects of Trade on Number of Firms

Log Firm Count	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.361*	0.0818**	0.110***	0.418
	(1.66)	(2.45)	(3.19)	(1.56)
Import E.	-0.172**	-0.0428***	-0.0484***	-0.160**
	(-2.16)	(-3.67)	(-4.26)	(-2.00)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.2: Effects of Trade on Employment – Fewer Clusters

Log Employment	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.138***	0.349*	0.307**	0.664***
	(2.87)	(1.75)	(2.12)	(2.95)
Import E.	-0.0694*	-0.130*	-0.209***	-0.372***
	(-1.96)	(-1.69)	(-2.86)	(-2.70)
N	4379	1438	619	207
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.3: Effects of Trade on Employment – Unweighted

Log Employment	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.131***	0.148***	0.129***	0.473***
	(2.81)	(6.66)	(4.70)	(2.95)
Import E.	-0.0542	-0.0583***	-0.103***	-0.250***
	(-1.43)	(-5.79)	(-10.51)	(-9.37)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.4: Effects of Trade on Employment – Alternative IV

Log Employment	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.0418	-0.189	0.0280	0.431*
	(0.09)	(-0.88)	(0.36)	(1.91)
Import E.	-0.224***	-0.0118	-0.107***	-0.267***
	(-3.33)	(-0.34)	(-7.70)	(-4.35)
N	3911	1258	536	158
F excl. Instr.				
Export E.	1.79	2.38	2.41	6.64
Import E.	8.02	5.94	8.48	13.95
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.5: Effects of Net Trade on Employment by Trading Partner

Log Employment	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Eastern Europe	0.410*	0.237	0.0897	0.483**
	(1.83)	(1.15)	(0.84)	(2.08)
China	0.229***	0.0304*	0.103***	0.220***
	(4.09)	(1.86)	(6.84)	(7.19)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.6: Effects of Trade on Labor Costs

Log Labor Costs	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.557***	0.395***	0.376***	0.594***
	(3.81)	(6.54)	(5.11)	(3.44)
Import E.	-0.150***	-0.0333*	-0.0786***	-0.170***
	(-3.88)	(-1.91)	(-4.03)	(-4.77)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.7: Effects of Trade on Wages

Log Wages	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.201***	0.240***	0.246**	0.124**
	(2.83)	(2.93)	(2.41)	(2.02)
Import E.	0.0969***	0.0270	0.0250	0.0803***
	(4.04)	(1.31)	(1.18)	(4.49)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

Table A.8: Effects of Trade on Sales

Log Sales	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.706***	0.414***	0.373***	0.669***
	(3.45)	(2.81)	(2.83)	(2.95)
Import E.	-0.212***	-0.0534**	-0.0994***	-0.186***
	(-3.37)	(-2.28)	(-4.62)	(-3.70)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

Table A.9: Effects of Trade on Real Intermediate Use

Real Intermediates	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.920***	0.483***	0.395***	0.823***
	(4.12)	(9.39)	(5.55)	(3.27)
Import E.	-0.275***	-0.0800***	-0.124***	-0.248***
	(-5.08)	(-3.97)	(-5.16)	(-4.47)
N	3997	1313	563	191
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

Table A.10: Effects of Trade on Outsourcing

Log Employment	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.239***	0.104*	-0.0699	0.122**
	(4.83)	(1.86)	(-1.56)	(2.37)
Import E.	-0.127***	-0.0486***	-0.0622***	-0.0861***
	(-4.84)	(-3.19)	(-3.68)	(-7.60)
GVA	0.919***	0.661***	0.805***	0.953***
	(35.88)	(10.44)	(20.33)	(33.35)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

A.2 Additional Results for Section 3.3

Table A.11: Effects of Trade on the Labor-to-Outsourcing Ratio – Fewer Clusters

Labor Costs/Outsourcing	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	-0.0617***	-0.00128	0.0501	-0.0977
	(-2.71)	(-0.04)	(1.37)	(-1.21)
Import E.	0.0252***	0.0318***	0.0339***	0.0383
	(5.33)	(5.01)	(5.46)	(1.26)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

Table A.12: Effects of Trade on the Labor-to-Outsourcing Ratio – Alternative IV

Labor Costs/Outsourcing	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	-0.0399	0.0998	-0.0274	-0.00653
	(-1.41)	(0.57)	(-0.41)	(-0.17)
Import E.	0.0283***	0.0157	0.0437***	0.0207
	(6.56)	(0.47)	(4.73)	(1.02)
N	3911	1258	536	158
θ_t,θ_p	X	X	X	X
ν_i	X			

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

Table A.13: Dynamic Effects of Trade on the Employment-to-Outsourcing Ratio (1)

Labor Costs/Outsourcing	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
Lag (years)	0	1	2	3	4
Export E.	-0.0617**	-0.0655**	-0.0638**	-0.0628**	-0.0572*
	(-2.36)	(-2.49)	(-2.50)	(-2.30)	(-1.95)
Import E.	0.0252***	0.0320***	0.0352***	0.0372***	0.0374***
	(3.75)	(3.95)	(3.74)	(3.26)	(2.79)
N	4056	3854	3657	3464	3276
θ_t	X	X	X	X	X
ν_i	X	X	X	X	X

Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$

Table A.14: Dynamic Effects of Trade on the Employment-to-Outsourcing Ratio (2)

Labor Costs/Outsourcing	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
Lag (years)	0	1	2	3	4
Export E.	-0.0617**	0.00721	-0.0470	-0.0552	-0.0387
	(-2.36)	(0.12)	(-0.86)	(-1.20)	(-1.13)
Import E.	0.0252***	-0.0159	-0.00168	0.0108	0.0194**
	(3.75)	(-0.95)	(-0.13)	(1.14)	(2.48)
Export E. (lag)		-0.0850	-0.0204	-0.00413	-0.0139
		(-1.17)	(-0.32)	(-0.09)	(-0.49)
Import E. (lag)		0.0510**	0.0390**	0.0272**	0.0201*
		(2.13)	(2.12)	(1.98)	(1.80)
N	4056	3854	3657	3464	3276
θ_t	X	X	X	X	X
ν_i	X	X	X	X	X

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.15: Effects of Trade on the Labor-to-Outsourcing Ratio – by Type

Labor Costs/Outsourcing	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
	intermediates			
Export E.	0.197***	-0.0201	-0.0852*	0.0855
	(2.67)	(-0.48)	(-1.93)	(0.95)
Import E.	-0.108***	-0.0349***	-0.0380***	-0.0385
	(-6.63)	(-4.34)	(-5.08)	(-1.04)
	contract work			
Export E.	0.141**	0.141***	0.179***	0.138***
	(2.45)	(5.05)	(3.02)	(2.78)
Import E.	0.0367	-0.000435	0.00173	0.00278
	(1.35)	(-0.03)	(0.08)	(0.20)
	agency work			
Export E.	0.207**	0.0266	0.0175	0.119
	(2.28)	(0.46)	(0.38)	(1.64)
Import E.	-0.0504***	-0.0204**	-0.0184*	-0.0437***
	(-2.66)	(-2.48)	(-1.83)	(-3.05)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.16: Conditional Effects of Trade on the Labor-to-Outsourcing Ratio

Labor Costs/Outsourcing	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	-0.0622**	-0.0245	0.0255	-0.110*
	(-2.18)	(-0.55)	(0.64)	(-1.75)
Import E.	0.0253***	0.0333**	0.0364***	0.0410
	(3.54)	(2.17)	(3.00)	(1.26)
GVA	0.00235	0.0461	0.0410	0.0208
	(0.18)	(0.99)	(0.76)	(0.38)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.17: Effects of Trade on Employment Conditional on Outsourcing

Log Employment	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	0.405***	0.149*	0.123**	0.501***
	(2.79)	(1.79)	(2.28)	(2.60)
Import E.	-0.266***	-0.0624***	-0.109***	-0.260***
	(-4.50)	(-3.77)	(-8.91)	(-7.39)
outsourcing-Labor-Ratio	-0.221	-0.131	-0.172	-0.272
	(-1.43)	(-1.25)	(-1.08)	(-0.68)
N	4056	1330	572	192
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

Table A.18: Effects of Trade on Outsourcing per Employment using Real Intermediates Prices

Outsourcing/Employment	FE-IV yearly	2SLS 3-year	2SLS 6-year	2SLS long
Export E.	-0.558***	-0.336***	-0.267***	-0.351***
	(-4.06)	(-7.18)	(-3.93)	(-3.03)
Import E.	0.0300	0.0226	0.0219	-0.00210
	(0.91)	(1.19)	(1.24)	(-0.06)
N	3997	1313	563	191
θ_t,θ_p	X	X	X	X
ν_i	X			

*Notes: weighted by 1995 emp. shares; s.e. clustered at 4-digit industries; t-values in parantheses; *** $p < .01$, ** $p < .05$, * $p < .1$*

A.3 Additional Results and Details for Section 4.5

In the most complex version, the translog production technology is

$$
\begin{aligned}
lnY = &\beta_0 + \beta_m \ln m + \beta_h \ln h + \beta_{mh} \ln m \ln h + \beta_{m^2} (\ln m)^2 + \beta_{h^2} (\ln h)^2 \\
&+ \beta_t \ln t + \beta_{t^2} (\ln t)^2 + \beta_{mt} \ln m \ln t + \beta_{ht} \ln h \ln t.
\end{aligned}
\tag{19}
$$

We compute the first, second, and cross-derivatives of this equation:

$$
\begin{aligned}
f_m = &\frac{\partial \ln Y}{\partial \ln m} \frac{Y}{m} = \frac{Y}{m} \left(\beta_m + \beta_{mh} \ln h + \beta_{m^2} \ln m + \beta_{mt} \ln t \right), \\
f_h = &\frac{\partial \ln Y}{\partial \ln h} \frac{Y}{h} = \frac{Y}{h} \left(\beta_h + \beta_{mh} \ln m + \beta_{h^2} \ln h + \beta_{ht} \ln t \right), \\
f_{mm} \approx &\frac{Y}{m^2} \beta_{m^2}, \\
f_{hh} \approx &\frac{Y}{h^2} \beta_{h^2}, \\
f_{mh} \approx &\frac{Y}{mh} \beta_{mh}, \\
f_{hm} \approx &\frac{Y}{hm} \beta_{mh}.
\end{aligned}
$$

We use these to compute the statistic for each industry and year:

$$
c = \frac{m}{h} - \frac{f_m f_{hh} - f_h f_{mh}}{f_h f_{mm} - f_m f_{hm}}.
$$

We further compute the statistic $|H| = \lambda (f_{hh} f_m^2 + f_{mm} f_h^2 - 2 f_{mh} f_m f_h) < 0$ in the same way, where we can assume positive prices $\lambda > 0$. The derivatives (12) and (13) further imply $f_h f_{mm} - f_m f_{mh} < 0$ and $f_m f_{hh} - f_h f_{mh} < 0$, which we test in an analogous way.

We proceed analogously for the less complex versions of the production technology.

Table A.19: Testing the Mechanism (Additional Results)

	(1)	(2)	(3)	(4)
		controls		
m, h, $m \times h$	X	X	X	X
t		X	X	X
$t \times m$, $t \times h$			X	X
m^2, h^2, t^2				X
		results for statistic $f_h f_{mm} - f_m f_{mh}$		
mean	-4.43×10^{-9}	-4.74×10^{-9}	-3.42×10^{-9}	-3.75×10^{-8}
95th pct.	-4.07×10^{-11}	-4.35×10^{-11}	-3.31×10^{-11}	-4.19×10^{-10}
		results for statistic $f_m f_{hh} - f_h f_{mh}$		
mean	-4.55×10^{-8}	-4.65×10^{-8}	-4.54×10^{-8}	-3.25×10^{-7}
95th pct.	-8.10×10^{-8}	-8.30×10^{-10}	-7.97×10^{-10}	-6.09×10^{-9}
		results for statistic $\|H\|$		
mean	-1.08×10^{-8}	-1.15×10^{-8}	-8.72×10^{-9}	-1.23×10^{-7}
95th pct.	-9.39×10^{-9}	-9.95×10^{-11}	-7.66×10^{-11}	-1.35×10^{-8}