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How do firms adjust to rises in the minimum wage? Survey evidence from Central and Eastern Europe

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Abstract

We study the transmission channels for rises in the minimum wage using a unique firm-level dataset from eight Central and Eastern European countries. Representative samples of firms in each country were asked to evaluate the relevance of a wide range of adjustment channels following specific instances of rises in the minimum wage during the recent post-crisis period. The paper adds to the rest of literature by presenting the reactions of firms as a combination of strategies and evaluates the relative importance of those strategies. Our findings suggest that the most popular adjustment channels are cuts in non-labour costs, rises in product prices, and improvements in productivity. Cuts in employment are less popular and occur mostly through reduced hiring rather than direct layoffs. Our study also provides evidence of potential spillover effects that rises in the minimum wage can have on firms without minimum wage workers.

JEL Classifications: D22, E23, J31

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1 Introduction

The debate on the effects of rises in the minimum wage has run for several decades, and the evidence on the impact remains largely disputed. A variety of theoretical models have been developed to describe the possible effects of rises in the minimum wage, such as the competitive model, where there are negative effects on employment as firms substitute lower-skilled with higher-skilled workers; monopsony models, which identify positive effects on employment from the increased use of low-skilled workers; or efficiency wage models, which find efficiency gains as workers make more effort as they have a higher wage. Other transmission channels for adjusting to a rise in the minimum wage include wage spillovers and wage compressions, pass-through into prices, cuts in non-labour costs, improvements in productivity and production capacity, or changes in the quality of human capital and absorption into profits (see Neumark and Wascher (2008) and Belman and Wolfson (2015)).

Only a very small segment of the literature analyses different effects of a rise in the minimum wage simultaneously. Even fewer studies look directly at the answers employers give about their preferred strategies for adjustment. An example of research combining these two aspects is a study of the US restaurant sector by Hirsch et al. (2015), who use a

qualitative survey of restaurant managers about the adjustment channels they use in response to a change in the minimum wage. The survey approach appears again in a paper by Harding and Harding (2004), who study how a rise in the minimum wage affects employment and wages in small- and medium-sized businesses in Australia. A smaller survey is run each year in the US by Small Business Majority, which collects the views of small businesses on possible increases in the minimum wage (see, e.g. Small Business Majority 2015). To the best of our knowledge, there are no studies using European firm-level data focusing on multiple possible adjustment channels, making our study a valuable addition to the literature on minimum wages in Europe.

The unique questionnaire has been prepared within the third wave of the ECB WDN3[1] and asks firms in eight of the participating countries (Bulgaria, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovenia) about their strategies for adjusting following the most recent rises in the minimum wage or recent and envisaged rises in Romania. These countries, which joined the EU in or after 2004, have a higher share of low-wage earners than other European Union members and have seen significant rises in the minimum wage in recent years coupled with a growing ratio of the minimum wage to average earnings, and so they provide an excellent setting for analysis of transmission channels for minimum wage rises.

The WDN3 questionnaire of the CEE8 countries included two questions on minimum wages, one asking about the proportion of employees earning the minimum wage[2] and, the second, asking how firms adjusted following the most recent rise in the minimum wage or recent and envisaged rises for Romania.

We find significant cross-country and sectoral differences in the average share of workers earning the minimum wage. However, there are some similarities in that smaller, domestically owned, non-exporting firms and firms employing a higher proportion of low-skilled blue-collar workers tend to pay the minimum wage to a higher share of their employees.

Our results show that the rise in minimum wages is mostly transmitted into higher prices, cuts in non-labour costs, and improvements in productivity. This result is in line with the findings of Hirsch et al. (2015) for the USA. We also show that cutting employment is not a common reaction to a rise in the minimum wage, and when it happens, it is mostly through reduced hiring rather than direct layoffs. Furthermore, we find evidence of an important spillover effect from rises in the minimum wage to firms with no workers earning the minimum wage. Finally, the analysis of the factors driving the choice of particular adjustment channels takes the possible simultaneous use of the channels into account. For this purpose, we estimate a multivariate probit model consisting of several probit equations that are correlated through their error terms.

The structure of the paper is as follows: we first review the theoretical and empirical literature; then, we explain the survey questions and database harmonisation and provide the main descriptive statistics; next, we discuss our empirical results. The last part concludes.

2 Literature review

2.1 Theoretical models
The literature on the effect of changes in the minimum wage covers four main theoretical approaches—the competitive model, the dynamic monopsony model, the search and

matching model, and the institutional model. These approaches are based on different assumptions about how the labour market functions and the mechanisms for adjusting to binding minimum wages (Schmitt 2013, Wilson 2012) and support the evidence that there are other channels for adjustment to rises in the minimum wage than the employment channel. Different theoretical models feature the pass-through of labour costs to prices, cuts in non-labour costs, wage rises for employees not earning the minimum wage, efficiency improvements, and changes in employment adjustments.

The basic competitive model is a baseline framework in this regard (see Lester 1960, Hirsch et al. 2015, Wilson 2012, Kaufman 2010, Lee and Saez 2012, Schmitt 2013). In perfectly competitive labour markets, setting minimum wages above the market clearing level reduces the demand for labour. This results in lower employment if there is no other possible channel for adjustment. Extending the basic competitive model can introduce further adjustment channels, including cuts in working hours instead of in the number of employees, reduced investment in training and other worker benefits, and lower turnover. Prices can also rise in these models if all the firms experience the same cost increase in response to higher minimum wages. As firms under perfect competition operate at maximum productivity, there is no room left in this framework for any improvement in overall efficiency.

The monopsony model is also often used assessing the impact of minimum wages on firms' decision-making. The static monopsony framework is reviewed by Boal and Ransom (1997); the dynamic monopsony model is discussed in, among others, Manning (2003) and Ashenfelter et al. (2010); see also Kuhn 2004, Lee and Saez 2012, Card and Krueger 1995, and Wilson 2012. Labour market frictions are a key component of dynamic monopsony models. Market power and labour market frictions allow profit-targeting firms in monopsonic markets where there are no binding minimum wages to hire less labour than the socially efficient amount and to set wages below the competitive market rate. The upward-sloping labour supply curve, where employment is an increasing function of wages, determines that both employment and wages in such settings rise in response to the binding minimum wage up to a competitive market level. However, monopsonic market power allows firms to pass at least a part of the increase in their costs on to consumers by raising prices. There are also positive spill-over effects on wages in this model, as monopsonic firms that already pay more than the minimum wage might decide to maintain the differential to the minimum wage in order to attract new employees.

Like the monopsony framework, the search and matching model accounts for labour market imperfections (see Cahuc 2014, Flinn 2006, Rogerson et al. 2005). This model assumes search frictions, as there are both employed and unemployed workers in the labour market, and jobs are either filled or unfilled. Unemployed workers search for job openings, whereas firms, driven by the objective of profit maximisation, search for employees to fill their vacancies. In this framework, like in monopsonic markets, binding minimum wages could, in fact, reduce unemployment under certain conditions. A rise in minimum wages may lead to stronger job search efforts, an improved matching process, and thus a rise in employment and overall efficiency.

The institutional model (see Kaufman 2010, Hirsch et al. 2015, Lester 1960, Hall and Cooper 2012, Schmitt 2013, Wilson 2012) uses concepts from behavioural economics. It assumes that employees are heterogeneous, that labour markets are imperfectly

competitive, integrated, and exposed to an excess labour supply, and that they operate under certain labour market institutions. Firms in the model respond to a rise in the minimum wage by improving their overall efficiency by either reducing organisational inefficiencies or increasing the productivity of employees. In contrast to the competitive model, where there is no room left for productivity improvements, the institutional framework suggests that it is possible under normal circumstances for firms to improve their overall efficiency, even though it appears to be costly as it requires continuous identification of problems and solutions. Furthermore, the pass-through into higher prices appears in this framework to complement the increase in efficiency in offsetting the rise in labour costs. On the demand side, the increase in binding minimum wages is reflected in higher disposable income, which could boost demand for goods and services, spurring growth in firm revenues and then feeding back into demand for additional labour and higher wages, like in the monopsony model.

In total, these theoretical models suggest that firms have a number of strategies for reacting to rises in the minimum wage. Moreover, rises in the minimum wage can result in both increases and decreases in specific cost components.

2.2 Empirical results for the effects of rises in the minimum wage

Estimates of the effects of rises in the minimum wage are based on several different methodological approaches. These approaches can be divided by the extent to which they account for the transmission mechanism of rises in the minimum wage to macroeconomic outcomes (whole economy vs. specific industries, direct vs. indirect effects; see Lemos 2008). General equilibrium models are claimed to account for the whole transmission mechanism, while other methods, such as input-output models, separate Philips curve equation estimations, difference-in-difference estimation, or regression analysis, account only for part of the transmission.

The following overview of the empirical findings focuses mainly on studies of partial equilibria. Empirical findings on the effects of rises in the minimum wage on employment predominate. Although existing studies indicate potential effects in both directions, negative employment effects dominate slightly. Neumark and Washer (2006) and Neumark et al. (2014) review a number of studies on how minimum wages affect employment, mostly in the USA but also in other countries, including some European countries. The authors provide support for the conventional view that minimum wages reduce employment among low-skilled workers and that the low-wage labour market segment can be reasonably well approximated by the neoclassical competitive model. Similar results are obtained by Huang et al. (2014) for China, where the minimum wage is also found to affect employment negatively, particularly in firms with low-wage earners. In contrast, Levin-Waldman and McCarthy (1998) use information from a qualitative survey of small businesses in the USA and find that jobs are not necessarily destroyed, but job creation may be hindered.

For the wage effects, rises in the minimum wage are found to compress the lower tail of the wage distribution and to have some positive spillover effects on wages up to about 20% above the minimum wage level (Neumark and Wascher 2008) or up to the median wage (Manning 2003). A similar effect is found by Hirsch et al. (2015) for the US restaurant sector. Kambayashi et al. (2010) reveal that the increase in the minimum

wage in Japan from the 1990s until the early 2000s in a period of deflation compressed the lower tail of the wage distribution among women. Strong wage compression not only in the lower tail but also in the upper tail of the wage distribution is found during an economic downturn in the German construction sector, indicating a negative wage spillover effect for high-wage earners and increased bargaining power for firms over workers still in employment (Aretz et al. 2012 and 2013; Kraft et al. 2012, Gregory 2014). Wage-setting institutions might play a role in determining the extent of the spillover effect (Rattenhuber 2014). Draca et al. (2011) find that after the minimum wage was introduced in the UK in 1999, wages above the minimum level were raised significantly, while firm profitability declined considerably. Hirsch et al. (2015) find that the profitability growth of firms is particularly likely to be reduced if due to adverse economic conditions the effect cannot be transmitted into higher prices.

Most empirical studies find rises in the minimum wage have no significant effect on training and through that on productivity (e.g. Acemoglu and Pischke 2003; Grossberg and Sicilian 1999; Neumark and Wascher 2001). In contrast, Hirsch et al. (2015) show that a rise in minimum wages creates pressure on managers to increase labour productivity from the workforce by cross-training, multi-tasking, and tighter work schedules.

For the transmission into prices, Card and Krueger (1995), Macdonald and Aaronson (2000), and Hirsch et al. (2015) find that rises in the minimum wage affect inflation significantly, but Katz and Krueger (1992) do not concur. Lemos (2008) compares over 20 studies on the price effects in the USA and concludes that rise in the minimum wage is associated with a stronger increase in food prices and a weaker increase in overall prices. Similarly, Wadsworth (2010) finds that within 4 years of the introduction of the minimum wage in the UK, prices appear to have risen significantly faster in several minimum wage-intensive sectors than in other sectors.

2.3 Empirical studies from Central and Eastern Europe

Empirical findings from Central and Eastern Europe (CEE) show that rises in the minimum wage have a negative effect on employment and hiring, particularly in small enterprises and for younger, unskilled and minimum wage workers, in Hungary (Kertesi and Köllő 2001, Kertesi and Köllő 2004, Halpern et al. 2004), the Czech Republic and Slovakia (Eriksson and Pytlikova 2004, Fialova and Mysikova 2009), Estonia (Hinnosaar and Rõõm 2003), Latvia (Zepa 2006), and Slovenia (Laporšek et al. 2015, Brezigar Masten et al. 2010). Adverse effects on employment are also reported for rises in the minimum wage in Poland, in particular for the workers with the weakest bargaining position, like young workers and temporary workers (Majchrowska and Żółkiewski 2012, Kamińska and Lewandowski 2015).

Evidence of higher consumer prices being caused by a rise in the minimum wage is found in Hungary (Harasztosi and Lindner 2015) and Latvia (Zepa 2006).

A positive wage effect for workers at and above the minimum wage is found for Hungary (Kézdi and Kónya 2012, Harasztosi and Lindner 2015), the Czech Republic and Slovakia (Gottvald et al. 2002; Eriksson and Pytlikova 2004 for the period 1999–2003), Slovenia (Brezigar-Masten et al. 2010 and Laporšek et al. 2015), Latvia (Zepa 2006), and Estonia (Ferraro et al. 2016). Banerjee et al. (2013) find that the rise in the

minimum wage in Slovenia prevented wage cuts being made and thus contributed to downward wage rigidity.

Finally, non-compliance with the minimum wage (the incidence of paying wages below the minimum wage) in Central and Eastern European countries was studied by Goraus and Lewandowski (2016), who found that higher ratios of the minimum wage to the average wage were associated with higher non-compliance, which may significantly weaken the final effects of minimum wage policies in CEE countries.

Following the designated literature and given the specifics of our data (direct firm responses from the WDN3 survey), the analysis in this study is based on a multivariate probit model and is therefore likely to cover only a part of the transmission mechanism, and thus possibly not take account of second-round effects. The adjustment channels considered in the WDN3 survey were chosen to reflect the main theoretical models presented above.

3 Data

The empirical part of the paper uses firm-level data obtained from a survey conducted within the WDN3. The survey was run in 2014 by 25 national central banks[3] using a harmonised questionnaire that covered the period 2010–2013. This paper concentrates specifically on a block of questions about firms' reaction to a rise in the minimum wage, which was included in the questionnaires of the nine countries (Bulgaria, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia). A question about the share of minimum wage earners in 2013 was included in the questionnaires of all nine countries (see Table 7 in the Appendix), and firms in all of them except Slovakia were asked about adjustment strategies they followed after the most recent rise in the minimum wage (see Table 8 in the Appendix).

An advantage of this survey is that firms were asked directly about their chosen course of action following a rise in the minimum wage. This information is not available in administrative datasets. The main caveat of the survey is that questions and answers about adjustment strategies in the minimum wage section of the questionnaire are not perfectly synchronised across countries, which makes a direct comparison of the obtained data and empirical investigation difficult (see Tables 7 and 8 in the Appendix). To proceed with the analysis, we harmonised data by combining answers into binary relevance indicator of each adjustment channel for each firm. These binary relevance indicators are later used in the descriptive and empirical parts of the paper. The observed adjustment channels are layoffs, cuts in hiring, price rises, cuts in non-labour costs, wage rises for employees earning above the minimum wage, and improvements in productivity.

The total sample size of this dataset is 8079 firms. The composition of the sample by countries, sectors, and firm size categories can be seen in Table 1. This sample is designed to be representative across firm-size categories within each country and its sectoral distribution closely follows the distribution of firms in each country.[4,5] The size of the sample, however, varies across countries both in absolute terms and relative to the population of firms in the country, so individual weights have been used to make the sample representative of the population of firms in each country (firm weights)[6] and to account for the number of workers that the firm represents in the population (employment weights).[7] We use weights in the tables showing descriptive results of the survey (see Tables 2 and 4); this way results are representative of the population of employees

Table 1 Number of respondents by countries, sectors, and firm size (conditional on answers being given to the block of questions on the minimum wage)

Countries	BG	EE*	HU	LT	LV	PL*	RO	SI	SK	Total
Sample size	456	498	2031	515	557	899	2029	493	601	8079
Sectors										
Manufacturing	47	134	798	76	100	295	1094	193	185	2922
Electricity, gas, water	–	17	–	–	–	23	–	18	16	74
Construction	21	84	145	60	69	96	216	63	51	805
Trade	205	92	439	169	173	225	291	61	126	1781
Business services	89	157	596	153	203	232	428	150	199	2207
Financial services	–	5	53	57	12	4	–	8	24	163
Public sector services	–	–	–	–	–	9	–	–	–	9
Arts and entertainment	94	1	–	–	–	3	–	–	–	98
Number of employees										
< 20	312	186	235	297	264	307	–	177	155	1933
20–49	94	177	604	98	144	189	173	93	167	1739
50–199	41	108	807	93	118	259	307	144	196	2073
> 199	9	27	385	27	31	144	1549	79	83	2334

Notes: *The sector of operation is missing for 8 firms in the Estonian sample and for 12 in the Polish sample
Sources: WDN3 survey, authors' estimations

and firms. Whereas regressions are performed without applying weights, since controls included in the regressions take into account possible cross-country, sector, and size effects.

4 Descriptive results

4.1 Share of employees earning the minimum wage

There is in general great uncertainty about the actual number of workers employed at the minimum wage, as estimates by various sources may differ significantly. Overall, the WDN estimates are comparable with the official estimates by national statistical offices or ministries for 2013 (see Table 2), though the WDN estimates other than those for Latvia, Estonia, and Poland are a little higher than the national statistics. The most pronounced differences are observed for Hungary, Romania, and Bulgaria. There are several possible explanations for the differences in terms of the share of minimum wage earners in these countries. First, there are differences in terms of the composition of the sample compared to administrative databases in terms of sectors and size. In addition, official statistics often do not account for the shadow economy, while the WDN survey is likely to have captured some employees affected by tax evasion and unaccounted employees (for example, workers paid below the minimum wage are likely to have been included). To minimise the administrative burden of the respondents, they were asked to provide an estimate and not an exact number which also explains part of the difference. For Hungary, the WDN outcome quite close to other estimations, for example those that are based on tax declarations of individuals (30%, see Krekó and Kiss 2007).

The average share of employees earning the minimum wage in our sample varies quite significantly across countries, sectors, and occupations, but only partially across

Table 2 Average share of employees of firms earning the minimum wage (%)

Countries	BG	EE	HU	LT	LV	PL	RO	SI	SK	CEE9
WDN aggregate‡	20.3	4.8	31.5	15.3	15.5	11.8	24.3	8.0	11.8	17.8
National statistics (2013)†	8.6	5.8	17.8	10.5	16.7	13.8	5.0	7.1	7.0	–
Sectors										
Manufacturing	27.8	4.2	34.5	16.2	16.0	10.7	24.0	4.7	10.0	19.0
Electricity, gas, water	–	2.6	–	–	–	1.4	–	2.4	3.7	1.9
Construction	18.4	5.9	28.5	15.3	10.6	18.6	34.7	15.3	10.5	20.5
Trade	18.9	3.5	30.9	16.6	14.6	12.0	22.4	4.6	13.1	17.7
Business services	18.3	5.8	28.6	14.2	19.1	14.4	21.4	15.6	16.8	18.2
Financial services	–	–	23.7	4.5	2.0	–	–	1.1	1.4	7.8
Arts and entertainment	12.5	–	–	–	–	–	–	–	–	12.5
Number of employees										
< 20	23.9	8.8	29.6	29.7	24.7	30.6	–	12.0	14.9	25.4
20–49	25.2	5.7	30.4	17.9	23.1	16.7	36.5	7.9	11.8	23.8
50–199	12.5	3.2	32.7	11.9	13.2	9.3	32.7	8.9	9.6	17.2
> 199	23.8	1.5	32.2	5.0	9.7	5.8	15.2	5.5	10.7	13.1
Workforce type										
LS BC††	23.6	5.4	41.3	21.1	31.9	13.4	43.6	20.4	19.0	23.0
HS BC	16.2	4.6	27.4	14.7	14.1	10.9	24.1	4.8	13.5	17.7
LS WC	25.7	3.1	29.8	11.4	16.5	15.9	24.5	8.2	10.8	17.8
HS WC	13.0	2.5	18.4	12.2	4.7	5.1	7.8	2.3	3.2	8.0
Ownership										
Mainly domestic	20.3	6.0	32.7	18.0	16.2	14.9	30.1	9.2	10.7	20.2
Mainly foreign	55.6*	1.9	26.1	3.8	9.6	3.9	12.9	4.1	14.8	10.7
Exporting status										
Exporting	29.6	4.0	31.6	13.7	13.4	9.3	21.3	–	13.4	16.4
Non-exporting	18.7	6.8	31.4	18.7	19.0	14.8	28.3	–	10.0	19.9

‡WDN aggregate refers to the time before the corresponding rise in the minimum wage rate. See Table 7 in Appendix for the exact reference period
†Source of national statistics on the share earning the minimum wage in 2013: *BG* National statistical institute; *EE* LFS, Statistics Estonia; *SK* Finance Ministry; *LT* Statistics Lithuania (only full-time employees); *LV* LFS, Central Statistical Bureau of Latvia; *HU* LFS, Hungarian Central Statistical Office; *RO* National Institute for Statistics, estimates for October 2012; *SI* Statistical Office of the Republic of Slovenia for the number of all employees and Agency of the Republic of Slovenia for Public Legal Records and Related Services for the number receiving the minimum wage
††High/low-skilled white/blue-collar workers, based on the ISCO-08 classification of the ILO
*This result is driven by one large manufacturing firm with foreign ownership. If it is excluded, the average share is 7.70
Sources: WDN3 survey, authors' estimations, employment adjusted estimates

firm-size groups (see Table 2). There are several points to note from this. First, the WDN survey results show that fewer than 5% of the employees of the average Estonian firm earn the minimum wage, whereas one third of a typical firm's workforce are employed at the minimum wage in Hungary and Romania. Second, the sector with the highest share of minimum wage earners differs across countries, as manufacturing has the largest share in Bulgaria, Lithuania, and Hungary, business services does in Latvia, Slovenia, and Slovakia, while construction has the largest proportion of workers employed at the minimum wage in Estonia, Poland, and Romania. At the opposite end of the spectrum, energy and financial services have the smallest shares of their workers earning the minimum wage. Third, minimum-wage workers are more frequently employed by firms where low-skilled blue-collar workers are a dominant part of the

workforce. Fourth, although the differences across firm-size categories are not very large, small firms with fewer than 50 employees are more likely to pay the minimum wage than larger firms are. In Bulgaria and Hungary, however, the share of workers in large firms earning the minimum wage is more significant, reflecting the higher share of workers on the minimum wage in manufacturing. Finally, minimum wage workers are slightly more frequently employed in domestic and non-exporting firms.

4.2 The adjustment strategies used following rises in the minimum wage

When answering the questions about their strategies for adjusting to rises in the minimum wage, firms evaluated the relevance of several different adjustment channels for a specified moment of minimum wage increase. In most countries, all firms could answer the question, irrespective of whether they actually had any workers on the minimum wage or not. The exception was Slovenia, where only firms with workers employed at the minimum wage answered. The adjustment channels were we had to lay people off, fewer people were hired, we had to increase prices, we had to reduce other costs, we had to increase wages that were above the minimum wage as well, and we raised productivity.[8] By design, the questions in the WDN3 questionnaire on rises in the minimum wage only consider one side of the effects of the channels explored, with the exception of the Bulgarian survey (see Section 3 for details). Specifically, interviewees could not cite any of the positive effects on employment or hiring that are possible under monopsony, matching or institutional model assumptions.

The answer choices were different in different countries (see Table 8 in the Appendix). Most countries offered the choice of 'not relevant', 'of little relevance', 'relevant', and 'very relevant'. The Slovenian questionnaire gave two options, 'relevant' and 'not relevant'. In Bulgaria, as already mentioned, the choices cover both positive and negative effects. Many countries had a binary yes/no choice for the answer to the question about wage spillover from the higher minimum wage to the wages of other workers.

To evaluate how relevant the different adjustment channels were, the answers from the second block were harmonised across countries (see Table 9 in the Appendix) using a binary measure of relevance. The answer 'Relevant' is assigned if the firm answered that the channel is of little relevance, relevant or very relevant, or if the answer 'yes' is given. The answer 'Not relevant' is assigned for all other cases.[9] For Bulgaria, the answer 'Relevant' is assigned for a decrease in the employment or non-labour costs channels if a firm answered that the decrease in the corresponding measure was strong or moderate; similarly, 'Relevant' is assigned for increases in the measures of prices or labour productivity if the firm showed a moderate or strong increase.

The timing and the size of the analysed rises in the minimum wage differ notably across countries (see Table 3). Several countries referred to a specific date when the minimum wage rose, with the Estonian and Latvian questionnaires asking about firms' reaction to the rise in the minimum wage in January 2014, the Slovenian questionnaire referring to the rise in February 2010, and the Lithuania questionnaire to the rise in January 2013. Other countries referred to longer periods of changes in the minimum wage, with the Bulgarian questionnaire covering the period 2010–2013 for example. The Polish questionnaire focused on changes in the minimum wage after 2013, and since the survey was conducted in 2015, its answers reflect how firms reacted to rises

Table 3 Timing and size of rise in the minimum wage, % (period analysed in bold)

Country	2010 Q1–2	2010 Q3–4	2011 Q1–2	2011 Q3–4	2012 Q1–2	2012 Q3–4	2013 Q1–2	2013 Q3–4	2014 Q1–2	2014 Q3–4	2015 Q1–2	2015 Q3–4
BG	–	–	–	–	**13**	**7**	**7**	**–**	10	–	6	6
EE	–	–	–	–	4	–	10	–	**11**	–	10	–
HU	–	–	6	–	**19**	–	5	–	4	–	4	–
LT	–	–	–	–	–	–	**18[‡]**	–	–	–	4	8
LV	–	–	11	–	–	–	–	–	**12**	–	13	–
PL	–	–	5	–	8	–	**7**	–	**5**	–	**4**	–
RO	–	–	12	–	4	–	7	7	**6**	**6**	**8**	**8**
SI	**23**	**–**	2	–	2	–	3	–	1	–	–	–
SK	–	–	3	–	3	–	**3**	–	4	–	8	–

[‡]In Lithuania, there were two rises in the minimum wage between 2012 Q3–4 and 2013 Q1–2, of 6% from 231.7 EUR to 246.18 EUR in July 2012 and of 18% from 246.18 EUR to 289.62 EUR in Jan 2013. In the questionnaire, firms were asked specifically about the 18% increase in the minimum wage
Source: Eurostat, Monthly minimum wages (bi-annual data)

in the minimum wage between 2013 and 2015. No period was specified in the Romanian questionnaire for rises in the minimum wage, and since at the moment of the survey the future path of such rises in 2015 was known to firms, the answers may also reflect the expected change in the minimum wage rather than solely the historical changes before 2013.

The highest single rise in the minimum wage among those analysed was of 23% in Slovenia in 2010, followed by rises of 19% in Hungary in 2012 and of 18% in Lithuania in 2013. The Estonian and Latvian questionnaires focus on relatively small rises of 11% and 12% respectively that occurred more recently in 2014. The Bulgarian, Romanian, and Polish questionnaires refer to extended periods of time with cumulative minimum wage increases of 29% in 2010–2013, 31% in 2014–2015, and 18% in 2013–2015 correspondingly. The correlation between the size of the rise in the minimum wage and the relevance of the adjustment channels is low (0.36). This suggests that cross-country differences in the relevance of the adjustment channels may also rise from differences in institutional characteristics, the sectoral composition of the economies and the economic shocks that were experienced, rather than the extent of minimum wage increases (see Bodnar et al. 2018 for more details).

Overall, more than 90% of all firms in the sample answered that at least one of the six adjustment channels offered was relevant as a response to an increase in the minimum wage (see Table 4). The most frequently chosen channels for adjustment to rises in the minimum wage are increases in productivity, reduction of non-labour costs, and rises in product prices. Cutting employment is relatively less popular, and employment effects are realised mostly through reduced hiring, rather than direct layoffs.

Although around 40% of the firms in the sample do not have any employees on the minimum wage (the share is smaller in Bulgaria and Hungary and larger in Estonia), our results indicate potential spillovers from a rise in minimum wages to these firms (see the lower part of Table 4). More than 80% of firms responded that at least one of the adjustment channels is relevant. The overall importance of the adjustment channels is lower, with the exception of the wage, price and productivity adjustment channels for

Table 4 Share of firms answering that the minimum wage adjustment channel was 'Relevant', in % of the firms in respective sub-group for each country (Relevant + Not Relevant = 100%)

MW rise	BG	EE	HU	LT	LV	PL	RO	SI[‡]	CEE8
Firms with minimum wage employees (before the MW rise)									
We had to lay people off	25.2	9.7	19.2	9.1	22.7	38.5	35.7	7.1	29.6
We could hire fewer people	–	12.2	47.3	28.2	29.5	46.4	54.7	20.7	45.8
We had to raise product prices	35.0	39.2	57.0	36.6	52.5	52.3	67.8	15.0	52.7
We had to reduce non-labour costs	8.1	27.8	56.1	49.7	55.6	66.6	77.9	63.2	59.1
We had to raise the wages of other employees	29.2	32.9	–	30.0	49.9	43.3	29.8	18.8	40.5
We increased productivity	21.5	25.0	59.4	55.7	45.6	68.7	–	–	61.6
Percentage of firms that regard at least one channel as relevant	100.0	66.7	100.0	66.4	70.6	86.6	100.0	100.0	93.2
Number of observations	317	169	1540	264	283	444	1223	493	4650
Firms without minimum wage employees (before the MW rise)									
We had to lay people off	13.9	3.3	11.7	0.0	6.4	7.2	14.2	–	7.8
We could hire fewer people	–	3.2	20.6	3.6	12.0	14.2	29.7	–	14.5
We had to raise product prices	41.3	15.3	30.4	10.8	20.3	21.0	36.0	–	22.9
We had to reduce non-labour costs	5.6	13.6	23.9	13.9	24.0	26.1	45.7	–	23.8
We had to raise the wages of other employees	50.6	10.9	–	22.3	25.8	27.5	12.3	–	27.2
We increased productivity	35.8	12.4	28.5	28.7	26.3	28.1	–	–	28.1
Percentage of firms that regard at least one channel as relevant	100.0	26.3	100.0	39.2	37.1	41.3	100.0	100.0	80.4
Number of observations	211	329	479	248	241	453	815	–	2776

The option 'Relevant' is assigned if the firm answered that the corresponding adjustment channel is of little relevance, relevant or very relevant; when only a yes or no option was available, 'Relevant' refers to the 'yes' answer. 'Total' shows the average share of firms claiming any of the six adjustment channels as 'Relevant'
[‡]Slovenian firms without minimum wage employees were not asked the corresponding question
Sources: WDN3 survey, authors' estimations, firm number adjusted estimates

Bulgaria.[10] Around one quarter of firms without any employees on the minimum wage at the moment the minimum wage was raised view rises in prices and productivity and cuts in non-labour costs as relevant measures.

5 Empirical results

The degree of correlation between the adjustment channels for the minimum wage is high[11] (see Table 10 in the Appendix), suggesting that different adjustment strategies seem to be used jointly. Descriptive evidence suggests that the choice of the preferred adjustment channel depends on firm-specific characteristics, such as the share of workers earning the minimum wage, size, sector, use of collective agreements, and the changes in macroeconomic conditions. In this section, we apply a multivariate probit framework to study the factors that determine the choice of the adjustment channels, controlling for correlation between the channels.

The dependent variable takes the value 1 if the firm answered that the particular adjustment channel is 'Relevant' and 0 otherwise (see Section 3, Tables 8 and 9 in Appendix for details).[12] Explanatory variables include dummy variables for country, sector, size, ownership, and collective bargaining coverage[13] (see Table 11 in the Appendix for the full list of explanatory variables). Firm-specific economic conditions are controlled for by including

ordered variables for changes in the demand for the firm's products and services and changes in external financing conditions. In addition, we control for the presence of minimum wage employees at the firm. Therefore, the average marginal effects of the categorical explanatory variables presented in Tables 5 and 6 refer to discrete changes from the base level.

As not all the adjustment channels were included in the questionnaires of all the countries[14] (see Table 8 in the Appendix and Table 4), we run two versions of the multivariate probit models. The first is for a subset of countries containing Poland, Latvia, Lithuania and Estonia, where all the channels are observed, and the second is for a subset of adjustment channels, consisting of lay-offs, price rises and cuts in non-labour costs, that are observed for all countries.

As expected, estimates from the two versions of the model for all channels and for all countries imply that after the abovementioned characteristics are controlled for, the transmission of rises in the minimum wage is stronger, or more relevant, for firms employing workers at the minimum wage than it is for firms where nobody on the payroll earns the minimum wage. Further, an improvement in demand conditions reduces the probability that the firm will consider cutting employment and non-labour costs or improving productivity. The effect of a change in external financing conditions is weaker but still statistically significant with the short country sample.

Next, in line with the descriptive results shown in Table 2, foreign-owned firms seem to be affected less by rises in the minimum wage and are less likely to find any of the adjustment channels relevant, especially the prices, non-labour costs and productivity channels. Institutional features of the labour market, such as the use of a collective pay agreement, tend to increase the relevance of certain adjustment channels, but only in the full country sample (Table 6). The significance is mainly driven by the strong effect in Hungary and Romania. Binding terms in collective agreements can pose additional restrictions on activity and force firms to compensate for rises in the minimum wage by raising prices and cutting non-labour costs and employment in these countries. However, if all the channels are included in the estimation, and so the sample is restricted to the Baltic countries and Poland (Table 5), the marginal effect of collective agreements becomes statistically insignificant.

Looking into the predicted probabilities for the adjustment channels for firms with different shares of employees at the minimum wage adds additional insights (see Fig. 1). In the subsample of four countries, the predicted probability of the channels being favoured increases with the share of employees earning the minimum wage at the firm and peaks when that share is between 60 and 79% (Fig. 1, left-hand graph). For the full sample of countries (see Fig. 1, right-hand graph), the picture is broadly similar, except that the probability of layoffs being relevant increases monotonically with the share of employees on the minimum wage.

The ranking of the adjustment channels changes slightly with the share of minimum wage employees.[15] The productivity adjustment channel has the highest predicted probability for firms where a small share of employees gets the minimum wage. In the firms with larger shares though, cutting non-labour costs is the most popular channel. The importance of the price rise channel is constantly lower than

Table 5 Multivariate probit model of the relevance of adjustment channels, average marginal effects (all channels; sample restricted to the Baltic countries and Poland)

	(1)	(2)	(3)	(4)	(5)	(6)
	Lay off	Hire less	Increase prices	Cut non-lab. costs	Increase wages	Increase prod.
Presence of MW employees at the firm	0.124***	0.175***	0.241***	0.248***	0.175***	0.222***
	(0.013)	(0.014)	(0.017)	(0.017)	(0.019)	(0.018)
Foreign ownership, dummy	− 0.065***	− 0.091***	− 0.149***	− 0.153***	− 0.133***	− 0.126***
	(0.019)	(0.023)	(0.026)	(0.026)	(0.026)	(0.027)
Presence of collective agreement	0.007	− 0.006	− 0.015	− 0.027	0.002	0.030
	(0.022)	(0.027)	(0.034)	(0.034)	(0.035)	(0.036)
Demand level (base: strong decrease)						
- Moderate decrease	0.008	− 0.005	− 0.007	− 0.033	0.023	− 0.031
	(0.021)	(0.027)	(0.036)	(0.035)	(0.037)	(0.038)
- Unchanged	− 0.038*	− 0.017	0.004	− 0.047	0.008	− 0.044
	(0.022)	(0.028)	(0.037)	(0.036)	(0.039)	(0.039)
- Moderate increase	− 0.043**	− 0.036	− 0.010	− 0.061*	0.010	− 0.046
	(0.021)	(0.027)	(0.035)	(0.035)	(0.037)	(0.038)
- Strong increase	− 0.106***	− 0.054	− 0.016	− 0.082*	0.000	− 0.083*
	(0.033)	(0.039)	(0.046)	(0.047)	(0.049)	(0.049)
Access to external finance (base: strong decrease)						
- Moderate decrease	− 0.005	0.010	0.083*	0.095**	0.039	0.092*
	(0.027)	(0.036)	(0.049)	(0.048)	(0.049)	(0.053)
- Unchanged	− 0.018	− 0.023	− 0.001	− 0.012	− 0.055	0.025
	(0.024)	(0.030)	(0.042)	(0.041)	(0.042)	(0.045)
- Moderate increase	− 0.009	− 0.011	0.009	− 0.003	− 0.036	0.073
	(0.029)	(0.036)	(0.047)	(0.047)	(0.049)	(0.052)
- Strong increase	0.001	0.023	− 0.022	− 0.119	− 0.092	0.010
	(0.046)	(0.054)	(0.077)	(0.077)	(0.078)	(0.085)
Sectoral dummies (base: manufacturing)						
Electricity, gas, water	− 0.022	− 0.079	− 0.211***	− 0.200**	− 0.165*	− 0.221***
	(0.044)	(0.062)	(0.079)	(0.082)	(0.087)	(0.077)
Construction	0.010	0.012	− 0.033	− 0.031	− 0.026	− 0.023
	(0.020)	(0.024)	(0.030)	(0.031)	(0.033)	(0.033)
Trade	− 0.010	− 0.019	− 0.067***	− 0.056**	− 0.043	− 0.116***
	(0.017)	(0.021)	(0.026)	(0.027)	(0.028)	(0.028)
Business services	− 0.021	− 0.038*	− 0.075***	− 0.049*	− 0.038	− 0.102***
	(0.017)	(0.021)	(0.025)	(0.026)	(0.027)	(0.027)
Financial intermediation	0.015	− 0.062	− 0.211***	− 0.055	− 0.125**	− 0.129**
	(0.043)	(0.046)	(0.064)	(0.057)	(0.062)	(0.060)
Arts		− 0.022	− 0.136	− 0.176		0.118
		(0.160)	(0.218)	(0.227)		(0.327)
Firm size dummies (base < 20 employees)						
20–49 employees	− 0.033**	− 0.045**	− 0.043*	− 0.043*	− 0.001	− 0.031
	(0.016)	(0.019)	(0.023)	(0.024)	(0.025)	(0.025)
50–199 employees	− 0.004	− 0.016	− 0.026	− 0.013	− 0.007	− 0.005
	(0.015)	(0.019)	(0.025)	(0.025)	(0.026)	(0.027)

Table 5 Multivariate probit model of the relevance of adjustment channels, average marginal effects (all channels; sample restricted to the Baltic countries and Poland) *(Continued)*

	(1)	(2)	(3)	(4)	(5)	(6)
	Lay off	Hire less	Increase prices	Cut non-lab. costs	Increase wages	Increase prod.
200+ employees	− 0.041*	− 0.066**	− 0.034	− 0.016	0.053	− 0.007
	(0.024)	(0.031)	(0.037)	(0.036)	(0.037)	(0.039)
Country dummies (base: Poland)						
Latvia	− 0.020	− 0.088***	− 0.022	− 0.066**	− 0.049*	− 0.093***
	(0.016)	(0.022)	(0.027)	(0.028)	(0.028)	(0.030)
Lithuania	− 0.113***	− 0.089***	− 0.120***	− 0.123***	− 0.129***	− 0.054**
	(0.018)	(0.019)	(0.024)	(0.023)	(0.026)	(0.025)
Estonia	− 0.078***	− 0.182***	− 0.077***	− 0.177***	− 0.170***	− 0.230***
	(0.018)	(0.022)	(0.026)	(0.026)	(0.026)	(0.028)
Observations	2083	2083	2083	2083	2083	2083

Note: Standard errors in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$
Dependent variable—binary measure of relevance used for all countries (1—Relevant, 0—Not relevant)
For a detailed description of the explanatory variable see Table 11 in the Appendix
Source: WDN3 survey, authors' estimation

the channels for productivity improvement or cuts in non-labour costs. The wage increase channel is used to roughly the same extent whatever share of employees earns the minimum wage, and it has a higher probability than the channel of cuts in employment.

The predicted probabilities for the relevance of adjustment channels for firms with and without employees on the minimum wage show that the most popular channels for adjustment for both groups are cuts in non-labour costs, price rises, and the increases in wages and productivity (Figs. 2 and 3). The channels that affect employment levels through laying off workers and reducing hiring are less popular, which is in line with the descriptive results in Table 2. As would be expected, the average predicted probability of either adjustment channel being found relevant is smaller for firms without employees earning the minimum wage, where it is half as much as at firms paying some employees the minimum wage.

The predicted probabilities for the relevance of the adjustment channels vary significantly by country. At the same time, only some of these cross-country differences are due to the aggregate factors represented by the country dummies. The rest of the differences are explained by sample composition effects related to the distribution of sectors, firm-size categories and other firm-specific characteristics in the sample of each country. Estimates based on the full sample of countries and the three adjustment channels included in the questionnaires of all the countries (Fig. 2) suggest, for example, that Romanian firms are slightly more likely to report each channel as relevant than firms in other countries are. Equally, the probability of Bulgarian firms expressing a preference for lay-offs is above the average, but they are the least likely to consider the non-labour costs channel relevant. Further, Slovenian firms are predicted to be least likely to prefer the price channel and to be less likely than the average to choose the lay-off channel. In contrast, an above average share of Slovenian firms is predicted to favour the non-labour costs

Table 6 Multivariate probit model of the relevance of adjustment channels, average marginal effects (all countries; 3 adjustment channels)

	(1) Lay off	(2) Increase prices	(3) Cut non-lab. costs
Presence of MW employees at the firm	0.137***	0.237***	0.263***
	(0.010)	(0.011)	(0.011)
Foreign ownership	− 0.034***	− 0.077***	− 0.071***
	(0.011)	(0.014)	(0.014)
Presence of collective agreement	0.025**	0.045***	0.057***
	(0.011)	(0.015)	(0.014)
Demand level (base: strong decrease)			
- Moderate decrease	− 0.021	0.028	− 0.014
	(0.015)	(0.022)	(0.021)
- Unchanged	− 0.075***	− 0.033	− 0.114***
	(0.016)	(0.022)	(0.022)
- Moderate increase	− 0.095***	0.004	− 0.088***
	(0.017)	(0.023)	(0.023)
- Strong increase	− 0.172***	− 0.027	− 0.149***
	(0.029)	(0.033)	(0.034)
Access to external finance (base: strong decrease)			
- Moderate decrease	− 0.027	0.066**	0.029
	(0.019)	(0.028)	(0.027)
- Unchanged	− 0.088***	− 0.025	− 0.070***
	(0.018)	(0.026)	(0.025)
- Moderate increase	− 0.065***	0.028	− 0.040
	(0.022)	(0.030)	(0.029)
- Strong increase	0.010	0.002	− 0.038
	(0.038)	(0.050)	(0.051)
Sectoral dummies (base: manufacturing)			
Electricity, gas, water	− 0.080	− 0.240***	− 0.210***
	(0.060)	(0.081)	(0.071)
Construction	0.005	− 0.026	− 0.013
	(0.014)	(0.019)	(0.019)
Trade	− 0.027**	− 0.049***	− 0.010
	(0.012)	(0.015)	(0.015)
Business services	− 0.033***	− 0.054***	− 0.040***
	(0.011)	(0.014)	(0.014)
Financial intermediation	− 0.015	− 0.208***	− 0.055
	(0.038)	(0.047)	(0.041)
Arts	− 0.068*	0.044	− 0.022
	(0.036)	(0.052)	(0.072)
Firm size dummies (base < 20 employees)			
20–49 employees	− 0.000	− 0.030*	− 0.022
	(0.014)	(0.018)	(0.017)
50–199 employees	− 0.005	− 0.043**	− 0.021
	(0.014)	(0.018)	(0.017)
200+ employees	− 0.002	− 0.055***	− 0.019

Table 6 Multivariate probit model of the relevance of adjustment channels, average marginal effects (all countries; 3 adjustment channels) *(Continued)*

	(1) Lay off	(2) Increase prices	(3) Cut non-lab. costs
	(0.016)	(0.021)	(0.020)
Country dummies (base: Poland)			
Latvia	− 0.017	0.010	− 0.050*
	(0.022)	(0.029)	(0.029)
Lithuania	− 0.174***	− 0.151***	− 0.153***
	(0.026)	(0.028)	(0.026)
Estonia	− 0.105***	− 0.100***	− 0.208***
	(0.025)	(0.029)	(0.029)
Hungary	− 0.044***	0.078***	− 0.053***
	(0.015)	(0.020)	(0.020)
Bulgaria	0.066***	− 0.041	− 0.403***
	(0.020)	(0.029)	(0.033)
Slovenia	− 0.185***	− 0.328***	− 0.045
	(0.024)	(0.031)	(0.028)
Romania	0.043**	0.133***	0.102***
	(0.017)	(0.023)	(0.023)
Observations	7011	7011	7011

Note: Standard errors in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. The variable 'Presence of MW employees at the firm' is equal to 1 if the share of minimum wage employees in a firm is greater than 0%, zero otherwise. For detailed variable description see Table 11 in the Appendix
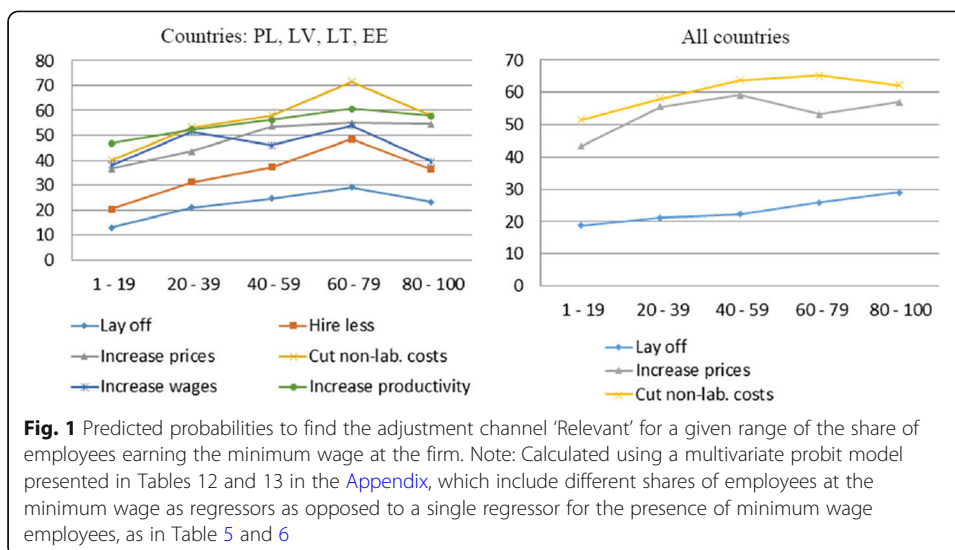Source: WDN3 survey, authors' estimation

channel. Lithuanian and Estonian firms have consistently lower probabilities of considering all three adjustment channels relevant than do firms in other countries.

Figure 3 presents the results for a subsample of the four countries (PL, LV, LT, EE) where the full set of adjustment channels was available. The predicted probability of the adjustment channels being found relevant is consistently higher in Poland than in the Baltic countries. Interestingly, the wage channel has a higher relative importance than the other channels among firms without employees earning the minimum wage. It ranks second after the productivity channel and overtakes the price and non-labour cost channels for predicted relevance.
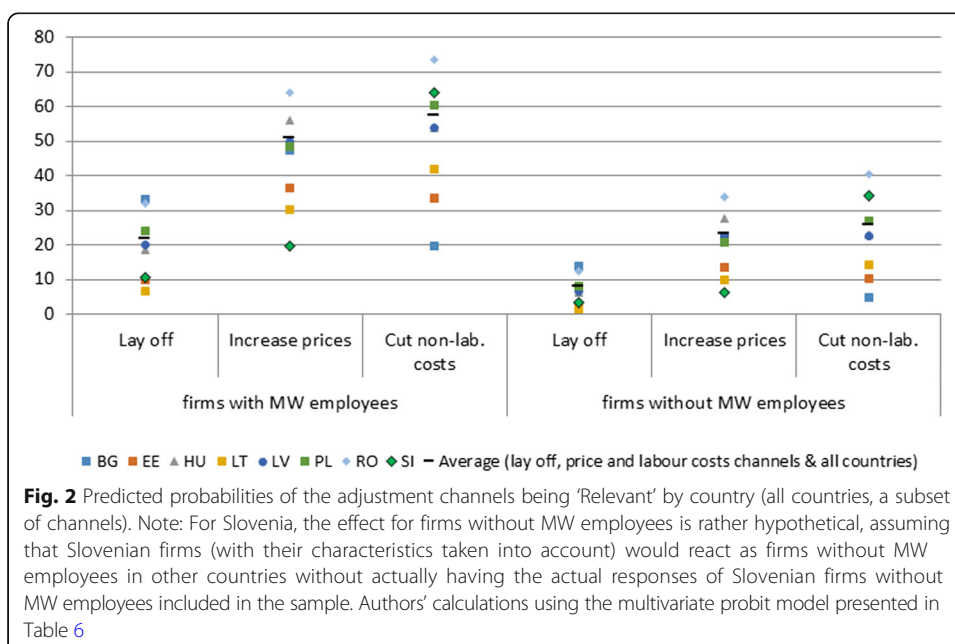
6 Conclusions

This paper uses a unique firm-level cross-country survey dataset on the adjustment channels preferred by firms following a rise in the minimum wage. The data were obtained within the third wave of the WDN survey and come from eight CEE countries, namely Bulgaria, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovenia.
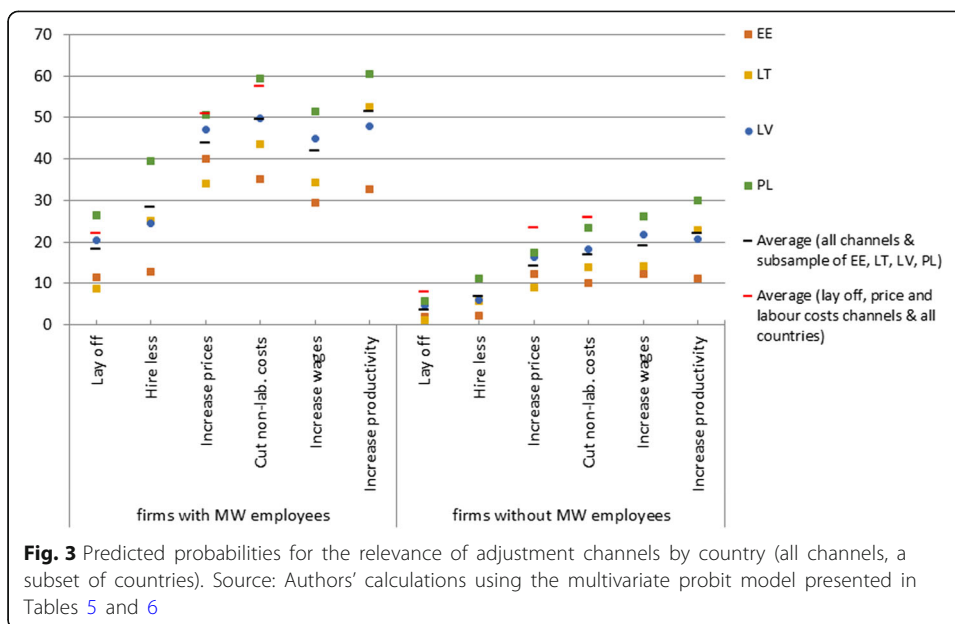
Our paper contributes to the literature on the firm-level impacts of rises in the minimum wage in several ways. First, we provide detailed cross-country informa- tion about the shares of minimum wage workers in the CEE8 and Slovakia, which is rarely available in statistical reports. We show that the average share of

Fig. 1 Predicted probabilities to find the adjustment channel 'Relevant' for a given range of the share of employees earning the minimum wage at the firm. Note: Calculated using a multivariate probit model presented in Tables 12 and 13 in the Appendix, which include different shares of employees at the minimum wage as regressors as opposed to a single regressor for the presence of minimum wage employees, as in Table 5 and 6

workers earning the minimum wage varies significantly across countries, sectors, occupations, ownership, and exporting status, but only partially across firm-size groups.

Second, we look at firms' reaction to rises in the minimum wage as a combination of strategies and report a preference ranking for the adjustment channels in the CEE8. Such information is not available in other studies due to their concentration on a single transmission channel, most frequently layoffs. More than 90% of the subsample of firms which employ workers at the minimum wage responded that at least one of the six adjustment channels proposed was relevant. The most popular adjustment channels are raising product prices, cutting non-labour costs, and improving productivity, which more resembles the theoretical outcome predicted by the institutional model. The

Fig. 2 Predicted probabilities of the adjustment channels being 'Relevant' by country (all countries, a subset of channels). Note: For Slovenia, the effect for firms without MW employees is rather hypothetical, assuming that Slovenian firms (with their characteristics taken into account) would react as firms without MW employees in other countries without actually having the actual responses of Slovenian firms without MW employees included in the sample. Authors' calculations using the multivariate probit model presented in Table 6

Fig. 3 Predicted probabilities for the relevance of adjustment channels by country (all channels, a subset of countries). Source: Authors' calculations using the multivariate probit model presented in Tables 5 and 6

ranking of the channels remains robust to a range of different estimation procedures and variable specifications.

Third, our results indicate important spillovers from a rise in minimum wages to firms employing no minimum wage earners. Almost one quarter of the firms without any employees on their payrolls at the minimum wage reported that an increase in prices, wages or productivity, or a reduction in non-labour costs are relevant reactions to rises in the minimum wage.

Controlling for firm-specific conditions and correlations between the channels, we show that favourable demand conditions and the availability of external financing are associated with lower relevance for the adjustment channels. Foreign-owned firms seem to be affected less by rises in the minimum wage.

Endnotes

[1]In 2014, 25 European national central banks participated in the third wave of the ECB's WDN, conducting a firm-level survey about labour cost adjustment practices, and wage and price setting mechanisms in 2010–2013.

[2]The first question was asked in an additional country, Slovakia, in which case we will refer to CEE9 countries.

[3]Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, France, Greece, Germany, Hungary, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and the UK.

[4]The survey covered non-agricultural private-sector firms with five or more employees (sectors C–N in the NACE 2. rev. classification).

[5]Please note that the WDN aggregate does not necessarily refer to 2013. See Table 7 in the Appendix for the exact reference period.

[6]The calculation of the firm weights sums up to the ratio of the population of firms within each stratum and the realised sample of firms within each stratum in each country.

[7]The calculation of the employment weights can be summarised as the ratio of population employment by stratum and the realised sample of firms within each stratum in each country.

[8]For the list of adjustment channels offered in each country's questionnaire and for the slight differences in wording, see Table 8 in the Appendix.

[9]As a robustness check we use a different measure of relevance, i.e. when 'Relevant' does not include the answer option 'of little relevance'. The results of the robustness check are presented in the Empirical results in Section 5 of the paper.

[10]One possible explanation for the stronger spillover effects of minimum wage increases on the wages of employees earning above the minimum wage in Bulgaria may be that the minimum wage system is linked to the practice of determining minimum social security thresholds by economic activity and occupation in that country. The stronger wage spillover effect may therefore indirectly lead to a stronger relevance of other adjustment channels in companies without employees on the minimum wage in Bulgaria. It should also be remembered for Bulgaria that the question about adjustment to the minimum wage rise was related to the strategies of companies over a longer period of time, 2010–2013, and not only to the most recent change as in other countries. The reference of the question to a longer period of time makes it more likely that second round spillover effects related to the wage distribution will also materialise at firms without any workers earning the minimum wage.

[11]With the exception of Bulgaria, where the specific questionnaire design allowed for both positive and negative effects of the rise in the minimum wage in all adjustment channels.

[12]We performed a robustness check using a different specification of the relevance indicator, when only answer options 'relevant' and 'very relevant' were included. The main conclusion of this exercise is that the ranking of the adjustment channels remains the same. The effects (both marginal effects and fitted probabilities) are somewhat smaller, which is in line with a lower share of ones in the binary indicator of relevance.

[13]In order to control for potential endogeneity between an increase in the minimum wage share and the presence of a firm-level collective bargaining agreement, we tried two different versions of the variable—presence of any collective agreement and presence of an outside-firm collective agreement. The effect of change in the variable is very small, which was expected due to the relatively low level of collective agreement coverage in the CEE9 countries. Therefore, we keep the broader version of the variable in our estimations.

[14]All countries asked about the relevance of three adjustment channels—lay-offs of workers, price rises, and cuts in non-labour costs, while only four countries—Latvia, Lithuania, Estonia, and Poland—asked about all six of the adjustment channels in the questionnaire.

[15]The structure of firms in different groups by the share of minimum wage employees is not the same. This affects the predicted probability of the adjustment channel being used in each group. Therefore, differences in probabilities between groups should be treated with caution.

Appendix

Table 7 Country specific questions: share of employees earning the minimum wage

Country	Question	Measurement	Period
BG	What was the percentage of employees receiving the minimum wage and secured at the minimum insurance threshold in your company at the end of 2013?		
	% of employees receiving the minimum wage	%	At the end of 2013
	% of secured at the minimum insurance threshold	%	At the end of 2013
EE	What was the percentage of employees receiving the minimum wage in your company before the increase in the minimum wage on 1 January 2014 and what was the percentage after?	%	Before 01/01/2014
		%	After 01/01/2014
HU	What was the percentage of employees receiving the minimum wage in your company before the increase in the minimum wage (Jan 2012) and what was the percentage after?		
	% of employees receiving the minimum wage before the change in the minimum wage	%	Before 01/01/2012
	% of employees receiving the minimum wage after the change in the minimum wage	%	After 01/01/2012
LT	What was the percentage of employees receiving the minimum wage in your company before the increase in the minimum wage in January 2013 and what was the percentage after?	%	Before 01/01/2013
		%	After 01/01/2013
LV	What was the percentage of employees receiving the minimum wage in your company before the increase in the minimum wage on 1 January 2014 and what was the percentage after?	%	Before 01/01/2014
		%	After 01/01/2014
PL	What was the percentage of employees receiving the minimum wage and secured at the minimum insurance threshold in your company at the end of 2013?	%	At the end of 2013
RO	What was the percentage of your employees earning the minimum wage in 2013?	%	In 2013
SI	What percentage of the employees received minimum wage:		
	Before the adoption of the new minimum wage legislation	%	Before 23/02/2010
	After the adoption of the new minimum wage legislation	%	After 23/02/2010
SK	What was the percentage of your employees earning the minimum wage in 2013?	%	In 2013

Source: WDN3 survey

Table 8 Country-specific questionnaires: adjustment channels and answer options

Country	Adjustment channel	Country specific formulation of adjustment channel or question used to derive relevance of adjustment channel	Answer type
LV, LT, HU	Number of employees	We had to lay people off	1
EE, RO, PL			2
SI			3
BG		Number of employees	4
LV, LT, HU	Hiring	We were able to hire fewer people	1
RO, PL			2
SI			3
EE		We could not replace empty positions	2
		We were not able to open new job positions	
BG		n.a.	
LV, LT, HU	Prices	We had to increase product prices	1
EE, RO, PL			2
SI			3
BG		Price of main product/service	4
LV, LT, HU	Non-labour costs	We had to reduce non-labour costs	1
EE, RO, PL			2
RO		We had to reduce other costs	2
SI			3
BG		Non-labour costs	4
LV, LT, HU, PL	Productivity	We increased productivity	1
EE		We had to seek to improve the quality and scope of products through process innovation	2
		We had to seek to increase productivity through organisational innovation	2
		We had to seek to increase productivity through process innovation	2
BG		Labour productivity	4
RO, SI		n.a.	
EE, PL	Hours	We had to reduce working hours	2
LV, LT, HU, RO, SI, SK, BG		n.a.	
LV	Wages above the minimum wage	We had to increase the wages of employees earning above the minimum wage level	1
PL		We had to increase the wages of employees earning above the minimum wage level in order to keep the wage relations in the firm	2
EE		Did the increase in the minimum wage on 1 January 2014 make it necessary to raise wages or any other type of compensation for those employees in your company?	5
		Please indicate the percentage of employees whose wages or other type of compensation increased in response to the rise in the minimum wage (including those who earned minimum wages and who earned higher wages before 1 January 2014)	%
RO		In the event of a rise in the minimum wage, do you raise the wages of your employees earning more than the minimum wage?	5
		Please specify the percentage of employees affected	%

Table 8 Country-specific questionnaires: adjustment channels and answer options *(Continued)*

Country	Adjustment channel	Country specific formulation of adjustment channel or question used to derive relevance of adjustment channel	Answer type
LT		Did the increase in the minimum wage on 1 January 2013 make it necessary to raise wages or any other type of compensation for those employees in your company who earned more than the minimum wage (who earn more than 1000Lt)?	5
		Please indicate the percentage of employees whose wages or other type of compensation increased in response to the rise in the minimum wage (including those who earned minimum wages and who earned higher wages before 1 January 2013	%
SI		We also had to increase wages above the minimum wage	3
BG		Base wages of above minimum wage earners	4
		Flexible wage components (bonuses, benefits etc.)	4

Notes: answer types
(1) 1 = Not relevant, 2 = Of little relevance, 3 = Relevant, 4 = Very relevant, 5 = Do not know
(2) 1 = Not relevant, 2 = Of little relevance, 3 = Relevant, 4 = Very relevant
(3) 1 = Relevant, 0 = Not relevant
(4) 1 = Strong decrease, 2 = Moderate decrease, 3 = Unchanged, 4 = Moderate increase, 5 = Strong increase
(5) 1 = Yes, 0 = No
Source: WDN3 survey

Table 9 Scheme of answer harmonisation for adjustment channel questions

Answer type	Relevant (1)		Not relevant (–)
1 & 2	2, 3, 4		1
3	1		0
4	BG: Number of employees	< 3	≥ 3
	BG: Non-labour costs		
	BG: Prices	> 3	≤ 3
	BG: Labour productivity		
5	1		2

Note: answer types
(1) 1 = Not relevant, 2 = Of little relevance, 3 = Relevant, 4 = Very relevant, 5 = Do not know
(2) 1 = Not relevant, 2 = Of little relevance, 3 = Relevant, 4 = Very relevant
(3) 1 = Relevant, 0 = Not relevant
(4) 1 = Strong decrease, 2 = Moderate decrease, 3 = Unchanged, 4 = Moderate increase, 5 = Strong increase
(5) 1 = Yes, 0 = No
Source: WDN3 survey

Table 10 Tetrachoric correlations between minimum wage adjustment channels

Latvia

(obs=474)

	A	B	C	D	E	F
A	1					
B	0.944	1				
C	0.874	0.895	1			
D	0.894	0.885	0.941	1		
E	0.831	0.858	0.876	0.894	1	
F	0.797	0.834	0.852	0.859	0.896	1

Estonia

(obs=500)

	A	B	C	D	E	F
A	1					
B	0.972	1				
C	0.801	1	1			
D	0.833	0.919	0.945	1		
E	0.215	0.417	0.61	0.556	1	
F	0.78	0.867	0.886	0.916	0.486	1

Lithuania

(obs=489)

	A	B	C	D	E	F
A	1					
B	0.795	1				
C	0.49	0.71	1			
D	0.617	0.73	0.657	1		
E	0.203	0.095	0.341	0.34	1	
F	0.68	0.7	0.626	0.794	0.448	1

Hungary

(obs=1955)

	A	B	C	D	F
A	1				
B	0.762	1			
C	0.518	0.719	1		
D	0.606	0.777	0.691	1	
F	0.572	0.707	0.782	0.754	1

Romania

(obs=2030)

	A	B	C	D	E
A	1				
B	0.91	1			
C	0.802	0.81	1		
D	0.795	0.85	0.912	1	
E	0.107	0.165	0.252	0.326	1

Bulgaria

(obs=528)

	A	C	D	E	F
A	1				
C	0.013	1			
D	0.291	-0.49	1		
E	-0.2	0.638	-0.56	1	
F	-0.27	0.669	-0.37	0.722	1

Slovenia

(obs=493)

	A	B	C	D	E
A	1				
B	0.947	1			
C	0.869	0.892	1		
D	0.869	0.871	0.946	1	
E	0.795	0.833	0.857	0.873	1

Poland

(obs=879)

	A	B	C	D	E	F
A	1					
B	0.917	1				
C	0.613	0.729	1			
D	0.797	0.845	0.874	1		
E	0.551	0.624	0.645	0.765	1	
F	0.765	0.837	0.819	0.926	0.744	1

Notes: Binary measure of relevance used for all countries (1—Relevant, 0—Not relevant). Slovenian sample does not include firms without minimum wage employees

A—We had to lay people off

B—We were able to hire fewer people

C—We had to increase product prices

D—We had to reduce non-labour costs

E—We had to increase the wages of other employees

F—We increased productivity

Sources: WDN3 survey, authors' estimations

Table 11 Explanatory variable definition

Name	Description	Values
Sector	Sector breakdown constructed from NACE sectors	1 'Manufacturing'
		2 'Electricity, gas, water'
		3 'Construction'
		4 'Trade'
		5 'Business services'
		6 'Financial intermediation'
		8 'Arts'
Size	Agreed size distribution	1 '5–19' 2 '20–49'
		3 '50–199' 4 '200+'
Ownership	Ownership status	= 0 'Mainly domestic'
		= 1 'Mainly foreign'
Demand	Change in level of demand for main products/ services in 2010–2013	1 = Strong decrease
		2 = Moderate decrease
		3 = Unchanged
		4 = Moderate increase
		5 = Strong increase
Access to external finance	Change in level of access to external finance in 2010–2013	1 = Strong decrease
		2 = Moderate decrease
		3 = Unchanged
		4 = Moderate increase
		5 = Strong increase
Collective agreement	Collective pay agreement outside or inside firm	= 1 if there is such agreement, = 0 otherwise
Share of minimum wage employees	Share of employees receiving the minimum wage in total number of employees before the increase in the minimum wage	= 1 if share of employees earning minimum wage is bigger than 0%;
		= 0 otherwise

Sources: WDN3 survey

Table 12 Multivariate probit of adjustment channel relevance, average marginal effects (all channels; sample restricted to Baltic countries and Poland)

	(1) Lay off	(2) Hiring	(3) Increase prices	(4) Reduce non-lab costs	(5) Increase wages	(6) Increase prod.
Share of MW employees at the firm, dummies (base: no MW employees)						
1–19%	0.093***	0.133***	0.188***	0.184***	0.153***	0.200***
	(0.016)	(0.018)	(0.021)	(0.022)	(0.023)	(0.023)
20–39%	0.145***	0.196***	0.244***	0.275***	0.257***	0.238***
	(0.021)	(0.025)	(0.033)	(0.034)	(0.037)	(0.038)
40–59%	0.158***	0.220***	0.301***	0.308***	0.196***	0.260***
	(0.023)	(0.029)	(0.038)	(0.038)	(0.042)	(0.043)
60–79%	0.164***	0.267***	0.302***	0.394***	0.247***	0.276***
	(0.024)	(0.027)	(0.039)	(0.039)	(0.043)	(0.042)
80–100%	0.146***	0.199***	0.313***	0.294***	0.137***	0.249***
	(0.019)	(0.023)	(0.029)	(0.029)	(0.035)	(0.032)
Foreign ownership	− 0.061***	− 0.086***	− 0.144***	− 0.150***	− 0.136***	− 0.125***
	(0.019)	(0.023)	(0.026)	(0.026)	(0.026)	(0.027)
Presence of collective agreement	0.010	− 0.002	− 0.015	− 0.021	0.006	0.027
	(0.022)	(0.027)	(0.033)	(0.033)	(0.034)	(0.035)
Demand level (base: strong decrease)						
- Moderate decrease	0.006	− 0.002	− 0.009	− 0.030	0.027	− 0.029
	(0.020)	(0.027)	(0.036)	(0.035)	(0.037)	(0.038)
- Unchanged	− 0.039*	− 0.013	0.003	− 0.047	0.012	− 0.041
	(0.022)	(0.028)	(0.037)	(0.036)	(0.039)	(0.039)
- Moderate increase	− 0.042**	− 0.029	− 0.010	− 0.057*	0.014	− 0.043
	(0.021)	(0.027)	(0.035)	(0.034)	(0.037)	(0.038)
- Strong increase	− 0.104***	− 0.048	− 0.015	− 0.075	0.004	− 0.080
	(0.032)	(0.038)	(0.046)	(0.047)	(0.049)	(0.049)
Access to external finance (base: strong decrease)						
- Moderate decrease	− 0.006	0.009	0.083*	0.096**	0.039	0.089*
	(0.026)	(0.035)	(0.048)	(0.047)	(0.049)	(0.053)
- Unchanged	− 0.014	− 0.016	0.006	− 0.001	− 0.051	0.026
	(0.023)	(0.030)	(0.041)	(0.041)	(0.042)	(0.045)
- Moderate increase	− 0.005	− 0.005	0.019	0.010	− 0.032	0.076
	(0.028)	(0.035)	(0.047)	(0.047)	(0.049)	(0.052)
- Strong increase	0.004	0.023	− 0.018	− 0.118	− 0.089	0.013
	(0.044)	(0.052)	(0.076)	(0.073)	(0.078)	(0.084)
Sectoral dummies (base: manufacturing)						
Electricity, gas, water	− 0.018	− 0.072	− 0.201***	− 0.191**	− 0.166*	− 0.214***
	(0.045)	(0.063)	(0.078)	(0.077)	(0.085)	(0.074)
Construction	0.014	0.016	− 0.025	− 0.023	− 0.026	− 0.019
	(0.019)	(0.023)	(0.030)	(0.031)	(0.033)	(0.033)
Trade	− 0.006	− 0.013	− 0.060**	− 0.050*	− 0.043	− 0.111***
	(0.017)	(0.021)	(0.025)	(0.027)	(0.028)	(0.028)
Business services	− 0.019	− 0.035*	− 0.069***	− 0.045*	− 0.040	− 0.099***
	(0.017)	(0.020)	(0.025)	(0.025)	(0.027)	(0.027)

Table 12 Multivariate probit of adjustment channel relevance, average marginal effects (all channels; sample restricted to Baltic countries and Poland) *(Continued)*

	(1) Lay off	(2) Hiring	(3) Increase prices	(4) Reduce non-lab costs	(5) Increase wages	(6) Increase prod.
Financial intermediation	0.022	− 0.048	− 0.189***	− 0.037	− 0.134**	− 0.120**
	(0.042)	(0.046)	(0.065)	(0.055)	(0.063)	(0.060)
Arts		− 0.026	− 0.163	− 0.185		0.106
		(0.152)	(0.211)	(0.217)		(0.327)
Firm size dummies (base < 20 employees)						
20–49 employees	− 0.026*	− 0.038**	− 0.027	− 0.028	− 0.001	− 0.025
	(0.016)	(0.019)	(0.023)	(0.024)	(0.025)	(0.025)
50–199 employees	0.011	0.003	0.004	0.017	− 0.003	0.008
	(0.016)	(0.019)	(0.025)	(0.025)	(0.027)	(0.027)
200+ employees	− 0.020	− 0.039	0.008	0.025	0.063*	0.016
	(0.025)	(0.031)	(0.037)	(0.036)	(0.038)	(0.039)
Country dummies (base: Poland)						
Latvia	− 0.020	− 0.088***	− 0.019	− 0.068**	− 0.055*	− 0.093***
	(0.016)	(0.021)	(0.027)	(0.028)	(0.028)	(0.030)
Lithuania	− 0.116***	− 0.092***	− 0.123***	− 0.127***	− 0.130***	− 0.058**
	(0.018)	(0.019)	(0.024)	(0.023)	(0.026)	(0.025)
Estonia	− 0.069***	− 0.169***	− 0.064**	− 0.164***	− 0.170***	− 0.227***
	(0.018)	(0.022)	(0.026)	(0.026)	(0.027)	(0.028)
Observations	2083	2083	2083	2083	2083	2083

Note: Standard errors in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$
Dependent variable—binary measure of relevance used for all countries (1—Relevant, 0—Not relevant). For detailed description of the explanatory variables see Table 11 in the Appendix. The model is used for the calculation of the predicted probabilities in Fig. 1
Sources: WDN3 survey, authors' estimations

Table 13 Multivariate probit model of the relevance of adjustment channels, average marginal effects

Variables	(1)	(2)	(3)
	Lay off	Increase prices	Reduce non-lab costs
Share of MW employees at the firm, dummies (base: no MW employees)			
1–19%	0.110***	0.182***	0.198***
	(0.012)	(0.014)	(0.014)
20–39%	0.142***	0.269***	0.289***
	(0.014)	(0.017)	(0.017)
40–59%	0.137***	0.286***	0.338***
	(0.016)	(0.020)	(0.020)
60–79%	0.169***	0.246***	0.342***
	(0.016)	(0.020)	(0.021)
80–100%	0.181***	0.284***	0.300***
	(0.014)	(0.018)	(0.018)
Foreign ownership	− 0.031***	− 0.076***	− 0.069***
	(0.011)	(0.014)	(0.014)
Presence of collective agreement	0.026**	0.045***	0.058***
	(0.011)	(0.015)	(0.014)
Demand level (base: strong decrease)			
- Moderate decrease	− 0.021	0.027	− 0.014
	(0.015)	(0.022)	(0.021)
- Unchanged	− 0.074***	− 0.033	− 0.116***
	(0.016)	(0.022)	(0.022)
- Moderate increase	− 0.095***	0.002	− 0.090***
	(0.016)	(0.023)	(0.022)
- Strong increase	− 0.170***	− 0.030	− 0.151***
	(0.029)	(0.033)	(0.034)
Access to external finance (base: strong decrease)			
- Moderate decrease	− 0.032*	0.059**	0.022
	(0.019)	(0.028)	(0.027)
- Unchanged	− 0.090***	− 0.026	− 0.071***
	(0.018)	(0.026)	(0.025)
- Moderate increase	− 0.066***	0.026	− 0.041
	(0.022)	(0.030)	(0.029)
- Strong increase	0.008	− 0.003	− 0.047
	(0.037)	(0.050)	(0.051)
Sectoral dummies (base: manufacturing)			
Electricity, gas, water	− 0.073	− 0.233***	− 0.198***
	(0.060)	(0.080)	(0.067)
Construction	0.008	− 0.023	− 0.009
	(0.014)	(0.019)	(0.019)
Trade	− 0.024**	− 0.045***	− 0.004
	(0.012)	(0.015)	(0.015)
Business services	− 0.031***	− 0.052***	− 0.037***
	(0.011)	(0.014)	(0.014)

Table 13 Multivariate probit model of the relevance of adjustment channels, average marginal effects *(Continued)*

Variables	(1)	(2)	(3)
	Lay off	Increase prices	Reduce non-lab costs
Financial intermediation	− 0.009	− 0.197***	− 0.045
	(0.038)	(0.048)	(0.041)
Arts	− 0.061*	0.050	− 0.014
	(0.036)	(0.052)	(0.073)
Firm size dummies (base < 20 employees)			
20–49 employees	0.009	− 0.016	− 0.005
	(0.014)	(0.018)	(0.017)
50–199 employees	0.007	− 0.024	0.001
	(0.014)	(0.018)	(0.018)
200+ employees	0.018	− 0.025	0.014
	(0.016)	(0.021)	(0.021)
Country dummies (base: Poland)			
Latvia	− 0.016	0.011	− 0.050*
	(0.022)	(0.029)	(0.028)
Lithuania	− 0.177***	− 0.155***	− 0.155***
	(0.026)	(0.027)	(0.026)
Estonia	− 0.097***	− 0.093***	− 0.197***
	(0.025)	(0.029)	(0.029)
Hungary	− 0.055***	0.053**	− 0.087***
	(0.015)	(0.021)	(0.020)
Bulgaria	0.064***	− 0.046	− 0.411***
	(0.020)	(0.029)	(0.033)
Slovenia	− 0.182***	− 0.319***	− 0.036
	(0.024)	(0.031)	(0.027)
Romania	0.032*	0.121***	0.087***
	(0.017)	(0.023)	(0.022)
Observations	7010	7010	7010

Note: Standard errors in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Dependent variable—binary measure of relevance used for all countries (1—Relevant, 0—Not relevant). For detailed variable description see Table 11 in the Appendix
The model is used for the calculation of the predicted probabilities in Fig. 1. Sources: WDN3 survey, authors' estimations

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