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WAGE DYNAMICS NETWORK

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ASYMMETRY IN THE SPEED OF ADJUSTMENT

by Tairi Rõõm
and Aurelijus Dabušinskas

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In 2011 all ECB publications feature a motif taken from the €100 banknote.

NOTE: This Working Paper should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the authors and do not necessarily reflect those of the ECB.

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Wage Dynamics Network

This paper contains research conducted within the Wage Dynamics Network (WDN). The WDN is a research network consisting of economists from the European Central Bank (ECB) and the national central banks (NCBs) of the EU countries. The WDN aims at studying in depth the features and sources of wage and labour cost dynamics and their implications for monetary policy. The specific objectives of the network are: i) identifying the sources and features of wage and labour cost dynamics that are most relevant for monetary policy and ii) clarifying the relationship between wages, labour costs and prices both at the firm and macro-economic level.

The WDN is chaired by Frank Smets (ECB). Giuseppe Bertola (Università di Torino) and Julián Messina (World Bank and University of Girona) act as external consultants and Ana Lamo (ECB) as Secretary.

The refereeing process of this paper has been co-ordinated by a team composed of Gabriel Fagan (ECB, chairperson), Philip Vermeulen (ECB), Giuseppe Bertola, Julián Messina, Jan Babecký (CNB), Hervé Le Bihan (Banque de France) and Thomas Mathä (Banque centrale du Luxembourg).

The paper is released in order to make the results of WDN research generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the author's own and do not necessarily reflect those of the ESCB.

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Abstract

The time series of various economic variables often exhibit asymmetry: decreases in the values tend to be sharp and fast, whereas increases usually occur slowly and gradually. We detect signs of an analogous asymmetry in firms' wage setting behaviour on the basis of managerial surveys, with employers tending to react faster to negative than to positive shocks in the same variables. As well as describing the presence of asymmetry in the speed of wage adjustment, we investigate which companies are more likely to demonstrate it in their behaviour. For this purpose, we apply the Heckman selection model and develop a methodology that improves identification by exploiting heteroscedasticity in the selection equation. The estimation results imply that companies operating in a more competitive environment have a higher propensity to react asymmetrically. We also find that businesses relying on labour-intensive production technology are more likely to react faster to negative shocks. Both of these findings support the hypothesis that this behaviour results from companies' attempts to protect profit margins.

JEL Code: J30, J31, J33

Keywords: wage dynamics, asymmetry, wage setting, survey

Non-technical summary

There is a substantial body of literature on asymmetries in the dynamics of prices. One of its key findings is that the pass-through of cost increases to prices is both stronger and faster than that of cost decreases. Another general tendency is that, conditional on price adjustment, the opposite pattern prevails in the speed of price responses to demand shocks. We demonstrate that similar asymmetries are characteristic of wages as well: at the level of the firm, the speed and incidence of wage adjustments depend on the type and direction of shocks. Our evidence on the asymmetric incidence of wage changes conforms to downward nominal wage rigidity, but the findings on asymmetries in the speed of wage adjustment are novel. The main focus of the current paper is on analysing the possible reasons for the latter type of asymmetry, i.e. the tendency of firms to react to economic shocks with asymmetric speed.

Micro-level data from three surveys of private sector company managers in Estonia enable us to examine wage responses to shocks in six variables: positive and negative changes in sales turnover, output price, labour productivity, competitors' wage level, inflation and unemployment. We find that the speed of wage adjustment is asymmetric in the case of the first four shocks. Conditional on wage adjustment, wages are changed more promptly to decreases than to increases in turnover, output price and productivity, whereas they are adjusted sooner after increases than decreases in competitors' wages. Thus, in the former three cases, the pattern of speed asymmetry is similar to what is known as the positive asymmetry in the literature on asymmetric price transmission: adjustment of wages is faster when shocks squeeze profit margins and slower when they stretch them. The most natural explanation for this asymmetry is that it results from firms' desire to protect profit margins.

However, the same logic does not rationalize the more rapid adjustment of wages to increases than decreases in competitors' wages; ceteris paribus, such behaviour would seem to harm rather than enhance profitability. In this case, our alternative hypothesis is that the asymmetry arises from the payment of efficiency wages. To maintain the wage premium, firms may be willing to adjust wages promptly when competitors' wages rise but delay adjustment when competitors' pay declines.

We investigate how the asymmetries in the speed of wage responses relate to a number of firm-specific characteristics using standard probit and, to address potential selection bias, probit with selection (Heckman probit). Also, to aid identification of the latter model in the absence of sound exclusion restrictions, we develop an extension of the model with heteroscedastic selection. For this purpose, we use an insight from the paper by Klein and Vella

(2009), who show that it is possible to exploit heteroscedasticity in the binary selection equation to identify the structural model without exclusion restrictions. They discuss this method in the framework of a treatment model, whereas we apply their idea in the context of the Heckman probit model. By and large, our estimation results show that selection does not pose a major problem, and our main findings hold regardless of whether we model selection explicitly or not.

For turnover, output price and productivity shocks, our estimation results imply that the speed asymmetry in wage adjustment is positively associated with product market competition and the labour intensity of production technology. Both of these findings support the hypothesis that this particular asymmetry results from firms' attempts to protect profit margins.

For shocks to competitors' wages, we hypothesised that asymmetric wage adjustments result from the payment of efficiency wages. Consequently, we anticipated that the incidence of this asymmetry would co-vary with firm size, capital intensity, the share of skilled labour and piece-rate remuneration — available firm-level characteristics that could be expected to correlate with firms' propensity to pay efficiency wages. Of these, however, the only covariate we found to be significantly related to the asymmetry — negatively, as expected — was the dummy variable for piece-rate remuneration. Hence, although our estimation results do not make the efficiency wage-based explanation look implausible, we conclude that the underlying reasons for this asymmetry remain largely unclear.

1. Introduction

The time series of various economic variables, such as output, employment, etc., often exhibit asymmetry: decreases in the aggregate values tend to be sharp and fast, whereas increases usually occur slowly and gradually. Using the well-known quote by Keynes (1936: 314): "(…) the substitution of a downward for an upward tendency often takes place suddenly and violently, whereas there is, as a rule, no such sharp turning-point when an upward is substituted for a downward tendency".

In this paper, we describe a similar asymmetry in the behaviour of wages, using micro-data. Our analysis draws on three surveys of Estonian company managers that we carried out at two-year intervals in 2005–2009. We detect asymmetric behaviour in the response of wages to four types of shocks: changes in sales turnover, output price, labour productivity, and competitors' wage level. A substantial share of employers react faster to a decrease than they do to an increase in the first three of these variables. An opposite pattern is detected in response to changes in competitors' wages. This implies that companies react faster to negative than to positive shocks. In this context, the nature of the shock is determined from a company's viewpoint: it is considered negative if it could reduce the profit margin and vice versa.

For the first three of the variables, the asymmetric nature of the response is explainable by profit maximization: it is optimal from a company's point of view to delay wage increases as long as possible and to implement wage cuts promptly, ceteris paribus. This type of asymmetric wage setting has a positive impact on profits, as long as the gains exceed the potential costs stemming from the adverse impact of such behaviour on workers' effort. An asymmetric reaction is more likely in the presence of informational asymmetries where workers know less than the company does about the nature and the magnitude of the shocks. It can also be expected that the tendency to react asymmetrically is positively related to the employer's bargaining power in wage negotiations.

No similar profitability-based rationale can be used to explain the asymmetry in response to changes in the wage levels of competitors. In this case, companies react faster to increases than to falls in competitor wages, which could have an adverse effect on the profit margin. We hypothesize that this pattern in wage setting may be the result of paying efficiency wages. Emloyers that follow a remuneration policy of setting their workers' wages above the industry average also have an incentive to delay wage cuts and to increase wages promptly in response to changes in the external wage level.

The accuracy of the profit-margin-based explanations can be assessed by investigating which companies are more likely to react faster to negative than to positive economic shocks. Our regression results indicate that the propensity to react asymmetrically is higher for firms, which operate in a highly competitive environment and/or use labour-intensive production technologies. These findings support the rationale that companies use this wage setting strategy because it has a positive effect on profit margins. First, competition increases the pressure on companies to use every possible means to increase the margins, including asymmetric reaction. Second, the more labour-intensive the production technology is, i.e. the higher the share of labour costs in total costs are, the stronger is the positive impact on profits that firms can achieve by delaying wage increases as long as possible and cutting wages as promptly as possible in response to shocks.

In this respect, it is notable that the estimated effects for product market competition and production technology are significant only in those cases where the presence of asymmetry can be explained by the profit-margin-based rationale, i.e. in the case of shocks to sales turnover, labour productivity and product prices. Neither of these variables is significantly related to the tendency to react asymmetrically in response to shocks in competitors' wages.

The regression analysis also allows us to investigate the hypothesis that the asymmetric reaction to competitors' wages stems from a policy of paying efficiency wages. Although we have no direct way of measuring the extent of efficiency wage payments, we can analyse this possible link indirectly by assessing the relationship between wage setting asymmetry and the company characteristics which are associated with the likelihood of that company paying efficiency wages. For this purpose, we look at four variables: firm size, occupational structure, labour-intensity of production technology and use of piece-rate remuneration.

There is substantial evidence that wages are higher in larger and/or more capital-intensive companies. This positive relationship is first and foremost caused by higher labour productivity in such firms. However, it may also result from a higher tendency to pay efficiency wages. Theoretical models predict that larger companies are more likely to use the strategy of paying efficiency wages for two main reasons. First, monitoring the effort of workers is more costly (Oi, 1983) and second, search and training costs are higher than in small firms (Barron et al., 1987). Companies which use more capital-intensive technology may opt to pay efficiency wages since worker effort is more valuable there (Layard et al., 2005). As argued in Babecký et al. (2010), high-skilled workers are more likely to receive efficiency wages because of similar considerations: their effort is more difficult to monitor and more valuable to a given firm in terms of value added, and replacing them is more costly.

An additional firm characteristic which may be associated with efficiency wages is remuneration on a piece-rate basis. One of the reasons why efficiency wages are paid is that monitoring the effort of workers is costly. Since evaluation of labour productivity is nearly costless when employees are remunerated on a piece-rate basis, we can expect that this type of remuneration is associated with a lower tendency to pay efficiency wages.

For the above-given reasons, we expected to find a positive relationship between firm size, capital intensity, and/or the share of high-skilled workers on the one hand and the asymmetric reaction speed to shocks in competitors' wage level on the other. In addition, we anticipated that the indicator for piece-rate remuneration should be negatively associated with this variable. Our regression analysis, however, supported only one of these implications: the estimated effect for the dummy of piece-rate remuneration was indeed negative, but the marginal effects for the other variables were insignificant. Thus, we were not able to provide strong evidence supporting the hypothesis that asymmetric reaction to competitors' wage level is driven by the payment of efficiency wages, which leaves open the question of what the reasons for this pattern are.[1]

In addition to the asymmetries in reaction speed, we detected another type of asymmetry in wage setting: companies are more likely to increase wages in response to a shock than to cut them. This finding corresponds with numerous previous empirical studies that demonstrate the existence of downward rigidity in nominal wages.[2] Since this type of asymmetry in wage setting has been extensively covered by the existing literature, we focus on the asymmetric reaction speed, a topic which to our knowledge has not been analysed before.

The current paper is structured as follows. In Section 2, we present an overview of the related literature describing analogous asymmetries in the dynamics of prices. Section 3 analyses various characteristics of the Estonian labour market which could be associated with the tendency of wages to react asymmetrically. Section 4 describes the data used in the current analysis. Section 5 gives a detailed overview of the asymmetries detected and the dis-

[1] An alternative explanation for the asymmetry described above could be non-rational behaviour, which may be related to loss aversion. An asymmetric pattern in wage setting may simply stem from a general tendency of economic agents to react to negative news more promptly than to positive news. Indeed, there is ample evidence of asymmetric time series dynamics of the same kind for various other variables. (An overview of the related literature for prices is presented in the next section.) However, we are not aware of the use of this explanation in the existing literature, and it is not possible to test its validity in the context of the current study.

[2] E.g. Campbell and Kamlani, 1997; Bewley, 1999; Dickens et al., 2007, Biscourp et al., 2005.

tributions of lagged responses to various shocks. In Section 6 we investigate which companies are more prone to react with asymmetric speed. For this purpose, we employ probit and Heckman probit models, and also a modified version of the latter for which we develop a methodology for identifying the Heckman structural model from heteroscedasticity in the selection equation. Section 7 concludes.

2. Overview of the related literature: asymmetric reaction speed in price setting

Although the asymmetric reaction speed of wages has not been described before, there is an abundant parallel literature which analyses a similar phenomenon in the movements of prices. Studies assessing price transmission describe asymmetric lagged responses to two types of shock. First, prices tend to respond faster to increases than to falls in costs. Overviews of the research analysing this type of asymmetry are given by Peltzman (2000) and Meyer and von Cramon-Taubadel (2005) among others.[3] Second, prices tend to respond faster to falls than to increases in demand, as shown in an article by Fabiani et al (2006) which draws on data from nine EU countries and, like the current analysis, is based on managerial surveys.[4]

There is an obvious analogy in the nature of asymmetries in the reaction speeds of prices and wages. An increase in cost and a fall in demand are negative shocks from a company's perspective. Consequently, it appears that companies react faster to negative than to positive shocks in price setting, as they do in the wage setting process.

The most common explanation for the first type of asymmetry in pricing behaviour, (i.e. the tendency to react faster to input price increases than falls by changing output prices) is that, when possible, firms try to delay actions which result in a squeeze of their profit margins, whereas they react promptly if a price change stretches the margin. To be able to do this, companies need to exhibit market power, and this type of asymmetric reaction speed is often described in the context of monopolistic or oligopolistic behaviour. For example, such asymmetries in the price transmission process are often observed in the middle levels of the marketing chain for agricultural products and in gasoline markets (Meyer and von Cramon-Taubadel, 2005). In both types of

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[3] Most of the analysis in this strand of literature is dedicated to assessing the impact of changes in input prices on output prices.

[4] Blinder et al. (1998) analysed the asymmetric reaction speed of prices in response to demand and cost shocks on the basis of a US managerial survey and came to the conclusion that the asymmetry is neither significant in a statistical sense nor very large economically. Their results may be influenced by a relatively small sample size.

markets, it is argued, the asymmetric behaviour reflects the oligopolistic power of market participants who set the retail prices. However, the evidence that market concentration is positively associated with this type of asymmetry is inconclusive (Peltzman, 2000).

It is more difficult to put forward a similar argument for the second type of asymmetry in pricing behaviour (i.e. the tendency to react faster to a fall in demand). The impact of a price reduction on a company's revenues depends on the elasticity of demand – it has a positive effect only when demand is elastic (i.e. elasticity exceeds one). We can conjecture from this that the second type of asymmetry in pricing behaviour is more likely to be found in competitive markets, where the elasticity of demand is high (it is infinitely elastic in the case of perfect competition). As far as we know, this hypothesis has not been tested in the existing literature.

3. Characteristics of the Estonian labour market that are associated with asymmetric reaction

The survey results indicate that Estonian businesses react to economic shocks by changing wages with asymmetric speed. To our knowledge, there are no previous studies that detect this pattern either in Estonia or in other countries. The tendency to react asymmetrically to shocks may be influenced by the institutional framework of the labour markets and norms for wage setting, which can differ substantially across countries. In this section we describe some institutional characteristics of the Estonian labour market and features of wage-setting behaviour that can be associated with asymmetric behaviour.

It can be assumed that the more flexible the wage setting regime is, the more likely it is that companies will react to economic shocks with asymmetric speed. An institutional characteristic which is likely to be influential in this respect is collective bargaining coverage. Bargaining at the individual level would increase the ability of the company to choose the reaction speed in response to shocks, whereas collectively bargained wage contracts would lower this ability for two main reasons. First, collectively bargained contracts fix wages for a specific (usually pre-defined) time period, which is less likely to be the case for individual bargaining. Second, collective bargaining is usually associated with greater rigidity in wage setting, a finding which is confirmed by several studies (e.g. Holden and Fulfsberg, 2008; Babecký et al., 2010). The level at which collective wage bargaining takes place is also relevant. The more decentralised the bargaining structure, the larger the possibility that companies can react to company-specific shocks by changing wages, which also means that the likelihood of there being an asymmetric reaction speed is higher.

In the European context, the level of collective bargaining in the Estonian labour market is very low. Since the current study covers only private sector businesses, we compare collective bargaining coverage and the incidence of union contracts negotiated at different levels for this part of the economy only. Table 1 presents this information for 15 EU member states. This evidence shows that Estonia has the lowest collective bargaining coverage among the countries sampled, with only 8.7 percent of workers covered by collective agreements. The incidence of bargaining contracts agreed outside the company is especially low, with only 3.4 percent of private sector businesses covered by higher-level agreements. For the reasons outlined above, the institutional framework of wage setting in Estonia makes it more probable that asymmetries can be observed in wage setting. It is less likely that such patterns would be detected in highly unionised EU countries, whereas they are more likely to be present in countries like the USA where the level of collective bargaining coverage is similar to that of Estonia.

Another institutional characteristic that affects wage rigidity is the strictness of employment protection legislation (EPL). According to recent theoretical and empirical work, strict EPL increases downward wage rigidity. Holden (2004) has developed a theoretical model, which shows that when strict EPL is combined with strong negotiating power of labour unions, the likelihood that companies would cut nominal wages is significantly lowered. Holden reasons that EPL increases wage rigidity because collectively negotiated wage agreements mean that wage cuts need the mutual consent of employers and employees. Such cuts are harder to make if strong EPL means that the threat of redundancies is more difficult for the company to implement. There is also empirical evidence that supports Holden's theoretical work. The analysis by Babetsky et al. (2010) implies that strict EPL is associated with stronger downward rigidity in nominal wages and this effect is more substantial in companies where a larger share of the workforce consists of permanent workers. In this context, it is worth noting that in most of the countries that the study of Babestky et al. covers, wage reductions require the consent of both parties and several of the countries are very highly unionised.

Table 1: Collective bargaining coverage, incidence of union contracts and strictness of employment protection legislation in 15 EU Member States

Country	Employees covered (%)	Companies with union agreements (any level, %)	Companies with firm-level agreements (%)	Companies with higher level agreements (%)	EPL index
Austria	94.6	97.8	23.3	96.2	2.15
Belgium	89.3	99.4	35.3	97.9	2.50
Czech Republic	50.2	54.0	51.4	17.5	2.02
Estonia	8.7	12.1	10.4	3.4	2.33
France	67.1	99.9	58.7	98.8	3.07
Greece	91.0	93.4	20.8	85.9	2.89
Hungary	18.4	19.0	19.0	0	2.90
Ireland	42.2	72.4	31.3	68.3	1.65
Italy	97.0	99.6	42.9	99.6	1.32
Lithuania	15.6	24.2	23.7	0.8	2.44
Netherlands	67.6	75.5	30.1	45.4	2.81
Poland	19.3	22.9	21.4	4.7	2.27
Portugal	55.5	62.1	9.9	58.9	2.22
Slovenia	N/A	100.0	25.7	74.3	3.49
Spain	96.8	100.0	16.9	83.1	2.63
Total	67.8	76.4	33.0	65.5	2.50
Euro area	84.5	94.2	35.6	87.3	2.63
Non-euro area	24.1	27.7	26.3	6	2.15

Notes: Figures are employment-weighted and re-scaled to exclude non-responses. The data refer to private sector businesses and are based on the WDN wage and price setting surveys that were carried out in 2007 or 2008. The reference year is 2006.

Source: Babecký et al (2010).

As argued above, strict EPL imposes stronger downward wage rigidity. This in turn means that asymmetries in the speed of wage adjustment are less likely to be observed in countries with strict EPL, since firms need to be able to change wages in both directions in order for an observer to detect asymmetric behaviour.

The last column of Table 1 gives an overview of the strictness of employment protection legislation on the basis of an EPL index. EPL indices for EU-15 member states are based on OECD (2004) and analogous indices for the new member states are based on Tonin (2005), which replicates the OECD methodology. The EPL index can range from 0 to 6, with higher scores representing stricter regulation. The figures presented in Table 1 show that the strictness of employment protection in Estonia was close to the EU average. This implies that, unlike in collective bargaining coverage, there is no sharp contrast in EPL between Estonia and the EU-15 member states. However, EPL tends to be stricter in the EU than in other industrial countries. Thus, in comparison with e.g. the USA (where the value of the EPL index was 0.65), EPL is relatively strict in Estonia.

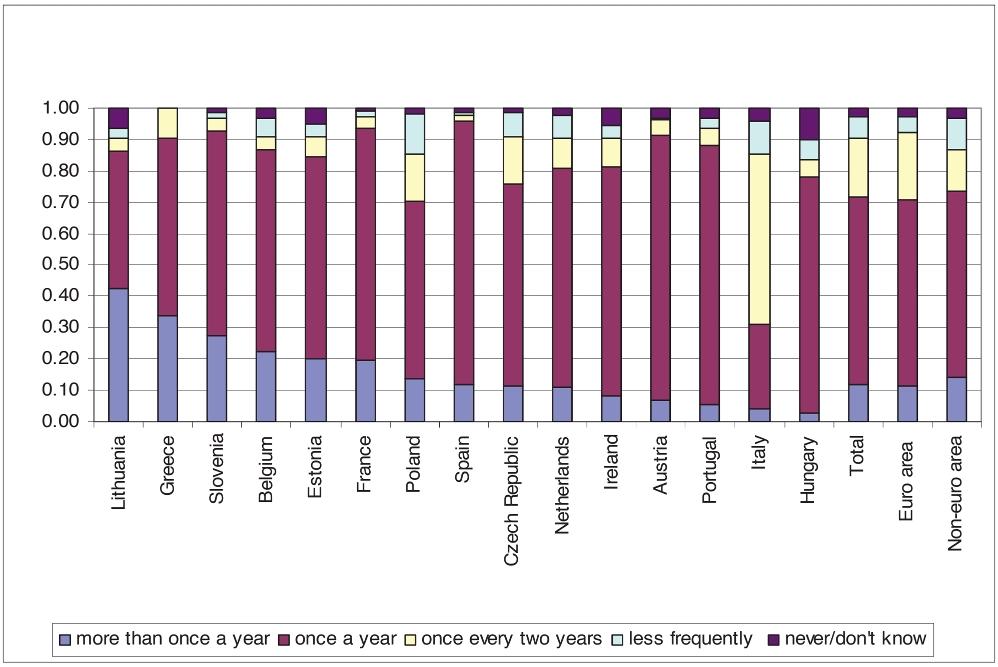

Figure 1: Frequency of base wage changes

Notes: The figure presents the share of companies who change wages at the given frequency. Figures are employment-weighted and re-scaled to exclude non-responses. The data is based on the 2007/2008 WDN survey.

Source: Druant et al. (2009).

An aspect of wage setting which might also be relevant in this context is the duration of wage contracts. It can be presumed that speed-related asymmetries are more likely to be detected if the frequency of wage changes is high. This positive relationship is explainable by purely statistical reasons: asymmetric behaviour is more likely to be observed for companies that change wages more often. Figure 1 gives an overview of the wage change frequency in 15 EU member states. The countries are ordered by the share of companies that change wages more often than once a year (i.e. with the highest frequency). As can be seen from Figure 1, frequency distributions are quite similar across countries. With a few exceptions (Lithuania and Italy), the mode frequency is once a year. The frequency of wage changes in Estonia is not very different from the sample average.

Another feature that might affect the propensity to react asymmetrically to economic shocks is related to the timing of wage changes. Broadly speaking, companies fall into two categories: they either apply time-dependent or state-dependent wage changing rules. It is plausible to assume that firms which follow state-dependent rules are more likely to have asymmetric wage setting, as even if the likelihood of being hit by different types of economic shock varies seasonally to some extent, we can expect that most of the shocks will still occur sporadically. In this respect, it is relevant that 58% of Estonian companies apply state-dependent wage changing rules. As can be seen from Figure 2, this share is relatively high in comparison to the other EU countries covered by the WDN survey.

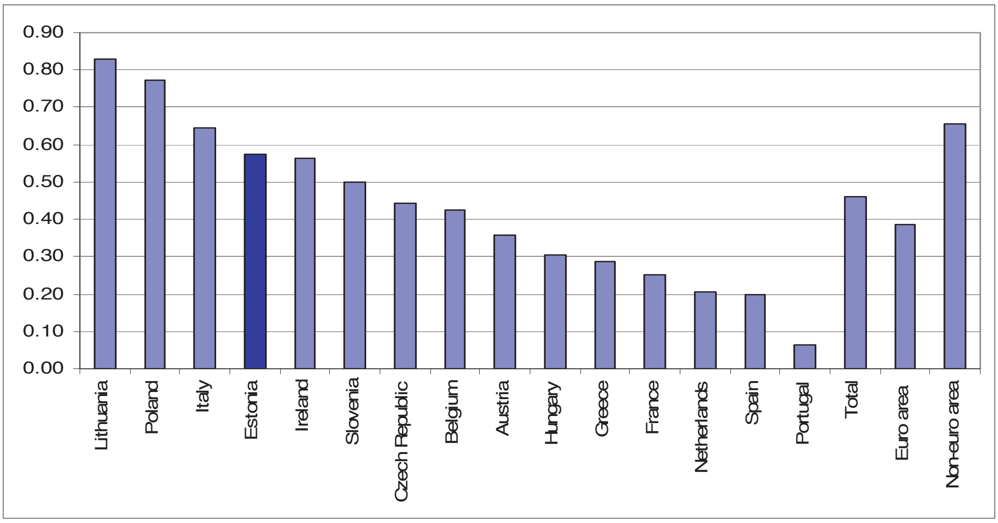

Figure 2: Prevalence of state-dependent wage setting rules

Notes: The graph presents the share of firms who rely on state-dependent wage setting. Figures are employment-weighted and re-scaled to exclude non-responses. The data is based on the 2007/2008 WDN survey.

Source: Druant et al. (2009).

Yet another aspect of wage setting which may affect asymmetric behaviour is the payment of bonuses. The related survey questions ask how fast firms adjust the total wage bill (i.e. the base wage plus bonus). Since it is easier to adjust flexible wage components than base wages, it can be assumed that companies paying performance-related bonuses are more likely to react to shocks by changing wages. As asymmetric reaction can only be detected if firms are reacting to shocks, we are more likely to observe asymmetric reaction in countries where a large share of companies pay bonuses. We should note that in this context we are only discussing the link between the possibility of observing an asymmetric reaction and the use of flexible pay components. The direct link between the payment of bonuses and an asymmetric reaction speed is more likely to be negative than positive, at least for shocks such as productivity and turnover shocks. This is discussed further in the sixth section.

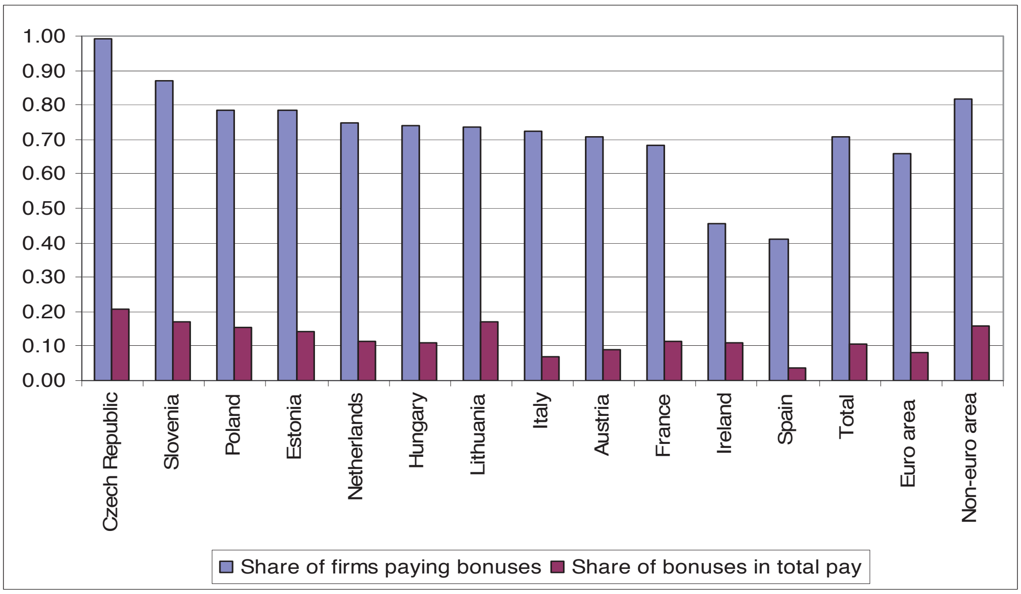

Figure 3: Payment of performance-related bonuses

Notes: Countries are ordered on the basis of the proportion of companies that pay bonuses. Figures are employment-weighted and re-scaled to exclude non-responses.

Source: WDN Survey 2007/2008.

Figure 3 gives an overview of the share of firms paying bonuses and the proportion of bonuses in the total wage bill in 12 EU countries. Countries are ordered by the first variable. The share of companies that use flexible pay components is 78% in Estonia, which is above the sample average.

The prevalence of piece-rate remuneration is associated with the detection of wage setting asymmetries for reasons that are similar to the payment of bonuses. Firms that remunerate on a piece-rate basis are more likely to adjust wages (i.e. the total wage bill) in response to changes in the economic environment, in particular to changes in labour productivity and sales turnover. Thus the likelihood of observing an asymmetric reaction is higher in countries where a large share of firms remunerate on a piece-rate basis.[5] Figure 4 depicts the distributions of companies applying different remuneration meth-

[5] As discussed in Section 6, piece-rate remuneration is negatively related with asymmetric reaction speed to shocks in competitors' wages.

ods across 10 EU member states. The incidence of piece-rate remuneration is quite high in Estonia: 26% of companies remunerate employees in the main occupational group on a piece-rate basis, which is the second highest share after Lithuania among the countries presented in Figure 4.

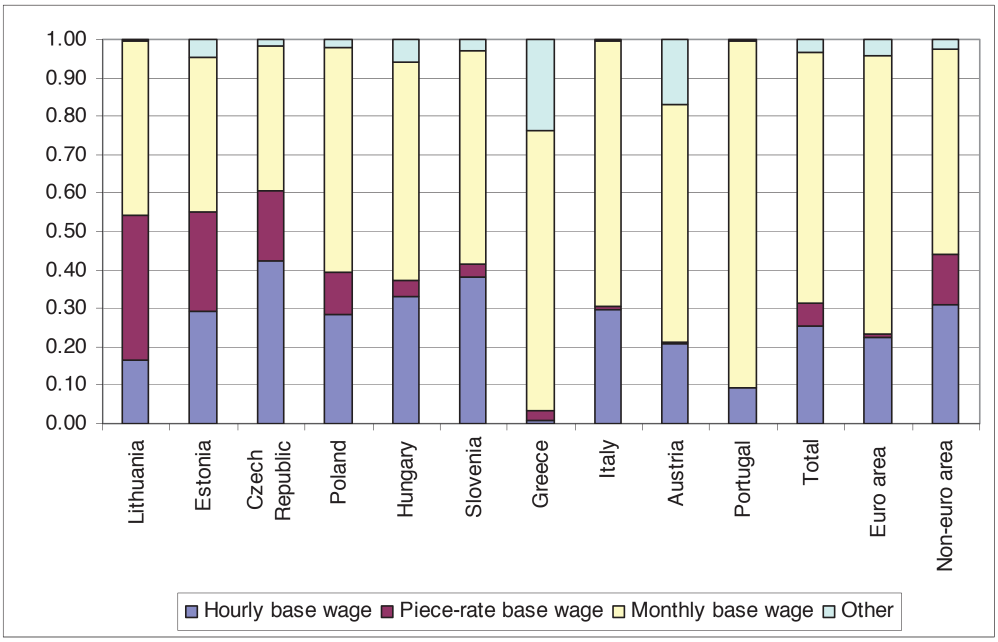

Figure 4: Remuneration methods

Notes: The figure presents the percentage of companies who use each remuneration method for their main (most numerous) occupational group. Countries are ordered by the proportion of companies which remunerate on a piece-rate basis. Figures are employment-weighted and re-scaled to exclude non-responses.

Source: WDN Survey 2007/2008.

4. Data description

Our analysis is based on three surveys of Estonian company managers, which were conducted at two-year intervals in 2005–2009. The first of the three managerial surveys was designed by a team of researchers at the Bank of Estonia that included the authors of the current study. An overview of this survey, including a copy of its questionnaire, is provided by Rõõm and Uusküla (2009). The next two surveys were carried out in the framework of the Wage Dynamics Network (WDN), a research network set up by the European System of Central Banks for the purpose of conducting research into wage setting and labour cost dynamics, and their implications for monetary policy. The WDN surveys were implemented by the national central banks that participated in the network. The first WDN survey covered 16 European Union countries[6] and, depending on the country, was carried out either in the second half of 2007 or in the first quarter of 2008. Its aim was to collect internationally comparable data on the wage and price setting practices of companies, information that was not generally available from other sources. The second WDN survey was conducted in summer 2009 in 11 EU member states.[7] The purpose of the later survey was to analyse the wage setting behaviour of companies in the context of the financial and economic crisis that started in the autumn of 2008.

The harmonised questionnaires of both WDN surveys contained core sets of questions, which were used in all the countries.[8] In addition some countries, including Estonia, extended the surveys in several directions. The block of questions on the speed of reaction to economic shocks in wage setting, which is the focus of the current study, was only covered by the surveys conducted in Estonia.

The three Estonian surveys were carried out in August–September 2005, September–October 2007 and May–June 2009. Most of the survey questions asked about wage setting practices either with reference to the previous economic year, which is typically the previous calendar year, or in more general terms. The Bank of Estonia commissioned all of these surveys from an external company (EMOR), which conducted the 2005 survey by telephone and carried out the 2007 and 2009 surveys over the internet.

The target population of companies for all three surveys was defined using the Estonian business registry, excluding companies employing less than five people. To ensure better coverage, sampling was stratified along three dimensions of sector, size and location, though not in exactly the same way in each survey. The stratification of the 2005 survey was based on three economic sectors, primary, secondary and tertiary, and three firm size groups (5–9, 10–49, and 50 or more employees). The 2007 and 2009 surveys, however, were stratified across three somewhat different sector groups[9] and size

[6] Austria, Belgium, the Czech Republic, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Lithuania, Poland, Portugal, Slovenia and Spain.

[7] Austria, Belgium, the Czech Republic, Cyprus, Estonia, France, Italy, the Netherlands, Luxembourg, Poland and Spain.

[8] For a more detailed description of the WDN survey see Druant et al. (2009).

[9] The three sector groups were as follows: i) manufacturing, electricity, gas and water supply, and construction (NACE codes D, E, F, respectively); ii) trade and restaurants, codes G, H; iii) transport, storage and communications, financial intermediation, and real estate, renting and other business activities, codes I, J, K. This coding and classification of sectors refers to EMTAK 2003, a NACE-compatible classification system that Statistics Estonia (SE) used before 2008. Even though SE has switched to an updated system (EMTAK, 2008) since then, we continue referring to the older classification, because the business registry database used for sampling in our surveys was based on EMTAK 2003.

categories.[10] When looking at company location, all three sampling schemes differentiated between Tallinn and the rest of Estonia. In total, the sample scheme involved 18 strata in 2005 and 2007, and 24 strata in 2009.

The 2005 survey, which was based on telephone interviews with executive managers, achieved a relatively high response rate of 60 percent. The final sample for this survey consisted of 250 observations (firms). The realised samples for the 2007 and 2009 surveys, which asked the managers to fill in internet-based questionnaires, covered 439 and 567 companies. The response rates for these surveys were much lower at 25 and 30 percent, respectively. The likely reason for the considerably higher response rate in the first survey was the difference in the survey methods (telephone vs. internet).

To see how the basic structure of our survey samples compares to that of the target population, we examine the distributions of companies across several economic sectors and firm size categories in our data and the business registry. In particular, we distinguish between four types of economic activity (manufacturing, construction, trade, and market services)[11] and four firm size groups (5–19, 20–49, 50–99, and 100 or more employees) and compare the corresponding distributions of companies and employment in each of our three survey samples, in a pooled data set and in the target population of companies.[12] The comparison leads to three main insights. First, our survey samples over-represent manufacturing and under-represent trade and market services (though this pattern holds only for the distribution of companies, not of employment). Second, as a result of the stratified sampling described above, the mismatch between the survey samples and the population is much larger for size groups than sectors: there is considerable under-sampling of small companies (5–19 employees) and over-sampling of medium-sized and large companies (50–99, and 100 and more employees). Finally, there are clear structural similarities between each of our three survey samples. That is encouraging, because in the empirical part of the paper we regard the three data sets as comparable and even pool them.

In light of the structural differences noted above between the target population and our survey samples, we constructed employment-based weights that can be used to adjust sample statistics in accordance with the distribution of employment in the population of companies. More specifically, we post-stratified the pooled data using the sectors and firm size categories shown in

[10] The size categories were 5–19, 20–49, 50–99, and 100 and more employees. In the 2007 sampling design, the two smallest categories (5–19 and 20–49) were not distinguished.

[11] Market services combine hotels and restaurants (H), transport, storage and communications (I), and real estate, renting and other business activities (K).

[12] The details of this comparison are shown in Appendix 1.

Appendix 1[13] and then computed the weights as the amount of employment that companies in a given stratum need to represent, on average, in order to account for the total employment of that particular stratum in the whole population of companies.[14] By construction, the structure of the sample weights thus obtained exactly matches the population distribution of employment across the sectors and firm size groups implied by the chosen stratification (see column 5 of Panel D in Appendix 1).

We apply the weights to adjust all of the descriptive statistics discussed in Section 5 but not the econometric models estimated in Section 6. We estimate the latter without weights and instead include sets of dummy variables to control for potential sector and size effects. The main reason why we prefer this approach is that it allows us to shift emphasis from the incidence of asymmetric behaviour to the potential mechanisms or factors driving it. Insights about the degree to which various asymmetries in wage setting are more or less widespread or economically relevant, because they concern a more or less substantial share of employment, can be gained from a variety of descriptive statistics discussed in Section 5.

From the methodological point of view, survey data analysis offers a number of advantages, as well as certain limitations and potential risks. An obvious benefit of collecting the data from managerial surveys is that it permits analysis of the causal effect, meaning there is no need to worry about problems arising from the potential endogeneity of the dependent variable. A drawback of the reliance on this type of data is that the estimated effects may be biased. There are two potential sources of bias associated with the conduct of surveys like ours. One is attributable to measurement error, as the assessments by the company managers of the potential response lag to shocks may not completely correspond with their actual behaviour. There is no way for us to address this problem in the context of the current survey. However, we can draw associations from the empirical literature on similar subjects, including asymmetric reaction speed in price setting. The findings about prices that use managerial surveys like the one we conducted (e.g. Fabiani et al., 2006) agree with the evidence from data on the actual dynamics of prices (Peltzman, 2000; Meyer and von Cramon-Taubadel, 2005). A second related subject is the evidence from another type of asymmetry in the dynamics of wages, in the tendency of firms to react more to shocks that induce wage increases (i.e. downward nominal wage rigidity). In this case, the assessments from managerial surveys (e.g. Babecký et al., 2010) are also strongly correlated with the

[13] We also discriminated between two locations, Tallinn and the rest of the country, so the total number of strata was 32.

[14] Therefore, the weights are strata-specific, and their sum within a stratum is equal to the total employment of that stratum in the target population; the sum of weights across all sample firms is equal to the total employment in the population.

estimates based on actual wage changes (e.g. Dickens, et al., 2007). Thus, we have good reason to believe that what we detect from the managerial surveys on the asymmetric reaction speed for wages is not a phantom phenomenon.

Another potential bias associated with managerial surveys, or indeed surveys of any kind, comes from low response rates. For our study, the bias caused by this type of sample censoring can arise when some unobserved characteristics of companies (or firm managers) are linked to the propensity for an asymmetric reaction speed. While the linkages between the response rate and selection bias are obvious for issues where differences in company behaviour are directly related to management quality, it is difficult to propose good reasons why this might be the case for the present study, although we should reiterate that this possibility cannot be ruled out

5. Asymmetries in wage setting

Our wage setting surveys inquired about six types of shock: sales turnover, output price, labour productivity, competitors' wage level, inflation, and unemployment.[15] Company managers were asked whether changes in each of these variables have an effect on wages and if so, how quickly these changes affect wages, including bonuses. Appendix 2 gives an overview of the related survey questions. For each of the variables, we asked separately how long the response lag is for an increase in a particular variable and for a decrease in it. Managers' answers indicated that the reaction to shocks is asymmetric. We detected two types of asymmetry, one related to the reaction speed and the other to the propensity to react to a given shock.

5.1. First asymmetry: companies react faster to negative shocks

Table 2 shows the proportions of companies that react to a negative economic shock faster than, at the same speed as, or slower than they do to a positive shock. The nature of the shock (positive vs. negative) is determined from the company's point of view: shocks that could have an adverse effect on the profit margin are considered negative shocks and vice versa. Following this logic, increases in sales turnover, product price or labour productivity are defined as positive shocks, whereas an increase in competitors' wage level is classified as a negative shock.

[15] The first survey, which was carried out in 2005, covered only three variables: sales turnover, output price, and labour productivity.

An increase in unemployment is considered a positive shock for a particular company, since it is associated with lower wage pressure and better availability of workers. However, it is not clear how company managers interpreted this question in the survey context, as an increase in unemployment has a negative connotation from the macroeconomic perspective and thus they could also perceive it as a negative shock.

For the last type of shock, changes in inflation, it is not possible to associate the direction of a shock with a positive or negative effect. From a particular company's point of view an increase in inflation can have a neutral, negative or positive effect, depending on how the prices of the company's output and input factors change.

As the figures presented in Table 2 indicate, a substantial share of companies react with a longer time lag to a positive shock than to a negative shock for the four variables which we consider: sales turnover, output price, labour productivity and competitors' wage level. For each of these four shocks, this share is significantly larger than the proportion of firms that are subject to the opposite asymmetry (i.e. react slower to a negative shock) and the corresponding t-statistics are highly significant. The difference in reaction speed to increases and decreases is insignificant for unemployment and inflation.

Table 2: Share of companies reacting faster, similarly or slower to a negative shock

	Faster reaction	Similar reaction	Slower reaction	t-value	Observations
Sales turnover	0.215	0.758	0.027	12.1	809
Product price	0.158	0.813	0.028	8.4	679
Labour productivity	0.126	0.817	0.057	5.1	920
Wages of competitors	0.105	0.870	0.024	5.8	604
Inflation	0.029	0.950	0.021	–0.8	541
Unemployment	0.047	0.901	0.052	0.3	530

Notes: We define as a negative shock a decrease in sales turnover, product price, labour productivity and the unemployment rate and an increase in competitors' wage level. Figures are employment-weighted.
** We do not associate the direction of change with the nature of the shock in the case of inflation. The figures presented show the proportion of companies who react faster, similarly or slower to an increase in this variable.*

The figures presented in Table 2 imply that the asymmetry is most pronounced in response to turnover shocks: 22 percent of companies react faster to a fall in turnover than they do to an increase, whereas only 3 percent of companies react in the opposite manner. Comparing these proportions across separate surveys shows that the asymmetries were most pronounced in 2009 and least so in 2005 (see Appendix 4). Such variation may reflect the fact that the surveys were conducted at different phases of the business cycle, but it could also stem from a change in the survey method. The earliest survey was conducted by telephone, whereas the two later ones were carried out over the internet with company managers filling in electronic questionnaires.

The two earlier surveys were carried out in an upward phase of the business cycle while the 2009 survey was conducted during an economic downturn (see Appendix 3 for an overview of the main economic indicators for Estonia). This may also influence the findings, inasmuch as the reaction of companies to negative news may be sharper in the recession, a tendency which is reflected in stronger asymmetry. In this context, it is noteworthy that the asymmetry is more pronounced in 2009 for sales turnover and labour productivity. It is less pronounced for competitors' wage, which fits with the earlier assertion that adverse conditions enhanced the asymmetry, since the situation in the labour market improved from a company point of view during 2009. The earlier years (especially the last years of the boom, i.e. 2007 and 2008) were characterised by a very tight labour market, whereas 2009 was characterised by considerable labour market easing.

5.2. Second asymmetry: companies react more likely to shocks that lead to wage increases

Table 3 depicts the proportion of firms that react to a given shock by changing wages. The figures presented in the Table imply that the reaction is more likely in response to an increase than to a decrease in a given variable. This asymmetry is highly significant for all the variables that we specified, except unemployment, indicating that wages are more rigid downward than upward - a finding that corresponds with numerous previous empirical studies which demonstrate the existence of downward rigidity in nominal wages (e.g. Bewley, 1999; Dickens et al., 2007).

We also assessed the reaction probability for each survey separately (see Appendix 5). The asymmetry described above is significant for all variables except unemployment in the samples based on the two earlier surveys. Interestingly, the asymmetry is much less pronounced in the 2009 survey, and for some variables it is even reversed. Companies react more to falls than to rises in sales turnover and product price whereas the difference in reaction probabilities is insignificant for labour productivity. Inflation and the wage levels of competitors are the only variables for which the asymmetry that was present in the earlier surveys still exists, i.e. the likelihood of reaction is still larger in response to a shock that would lead to an increase in wages.

Table 3: Share of companies reacting by changing wages in response to a particular shock

Shock	React to increase	React to decrease	t-statistic	Observations
Sales turnover	0.739	0.687	2.9	1214
Product price	0.614	0.577	1.9	1195
Labour productivity	0.855	0.794	3.9	1183
Competitors' wage	0.817	0.669	7.3	913
Inflation	0.741	0.595	6.7	895
Unemployment	0.649	0.635	0.6	895

Note: Figures are employment-weighted

The data on response patterns in the 2009 survey correspond with alternative evidence stemming from the same survey which shows that downward nominal wage rigidity considerably eased in Estonia during the economic downturn in 2009. By May or June 2009, about 44% of companies had lowered nominal wages since the beginning of the crisis (Messina and Rõõm, 2009). This implies that when downward wage rigidity is not a strongly binding constraint, then the asymmetries in response probabilities follow a pattern which is analogous to that of asymmetric reaction speed. For both types of asymmetry, companies react more sharply in response to negative news. Firms are more likely to react to a fall in turnover or product price, both of which are negative events from a company's point of view. They are more likely to react to increases in competitors' wages or in the inflation rate, which are also negative events.

We described the analogy between prices and wages in asymmetric reaction speed in Section 2. It is noteworthy that the dynamics of prices and wages become even more similar when downward nominal wage rigidity is less pronounced. The asymmetries in price setting are described in Fabiani et al. (2006). According to their study, companies are more likely to react to negative shocks by changing prices and the reaction is faster than it is for positive shocks to the same variables.[16] We observe the same types of asymmetries in the dynamics of wages in Estonian companies in 2009.

[16] They analyse companies' reaction to cost and demand shocks.

5.3. Reaction speed to shocks

Figure 5 shows the distribution of the reaction speed. For all types of shock the modal reaction speed is one year or more. This corresponds with the general wage setting frequency, which has a mode of one wage change per year (see Figure 1).[17] The reaction of companies is fastest to changes in labour productivity with 24 percent reacting to a productivity increase and 27 percent to a decrease within one month. Firms also react relatively fast to changes in sales turnover and product prices, whereas the average time lag in reaction to changes in competitors' wages, unemployment and inflation is much longer. The response is slowest in the aftermath of changes in inflation, with only 2 percent changing wages within one month, while 74 percent react to a rise in the inflation rate and 70 percent to a fall with a lag of one year or more. The pattern of reaction does not differ substantially across surveys conducted in different years (see Appendix 6).

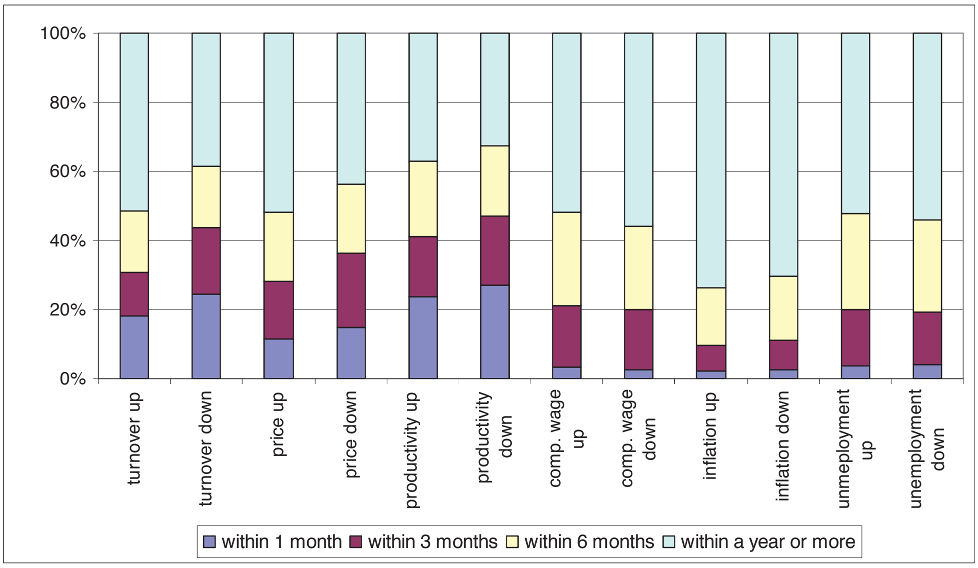

Figure 5: Proportion of businesses that react to different shocks within a given time period

Note: Figures are employment-weighted.

[17] Wage setting frequency refers to base wages, whereas reaction speed to shocks refers to the total wage bill of base wage plus bonus. It can be expected that the dynamics of the total wage are less staggered than the dynamics of the base wage.

6. Asymmetric reaction speed: regression analysis

The following regression estimations focus on analysing the first type of asymmetry described in the previous section, the tendency of companies to react faster to negative than to positive shocks. These assessments are performed for the variables for which the asymmetry was detected: sales turnover, output price, labour productivity and competitors' wage level. The purpose of the analysis is to relate the likelihood of an asymmetric reaction to a number of company-specific characteristics, such as firm size, occupational structure, etc. In addition, we analyse the effects of product market competition and collective wage bargaining. Appendix 7 gives an overview of the unconditional means of the regression variables, differentiating between companies that react asymmetrically to shocks in a particular variable, and the rest of the sample.

We start by estimating probit regression equations, where the dependent variable is a binary variable indicating an asymmetric reaction speed to shocks. Thereafter we estimate the same relationship using the Heckman probit model. We employ the Heckman methodology since asymmetric reaction can only be observed if a company reacts to positive and negative shocks in a particular variable and some regression covariates may be related both to the propensity to react and to the likelihood of the reaction being asymmetric. This method enables us to correct the possible selection bias that may arise from non-random data censoring. The selection equation estimates the propensity of a given variable to react to shocks, both positive and negative. The structural equation estimates the propensity for a given variable to react asymmetrically by reacting faster to negative than to positive shocks.

The validity of the results of the Heckman selection model depends on two assumptions. First, the correct estimation of the model relies on the assumption that the regression residuals are jointly normally distributed. Second, model identification requires the selection equation to have a source of variation which is not related to the structural equation.

One possible way of identifying the model is to use exclusion restrictions, i.e. a variable or a set of variables which enter the selection equation but are not included in the structural equation. This involves the assumptions that these variables only affect the probability of selection and that they are not related to the outcomes of the structural equation. It is often difficult to find variables which satisfy these assumptions. The model that we use in the current paper faces the same problem, i.e. it is hard to find variables which are related to the propensity to react to shocks, but do not affect the likelihood of the reaction speed being asymmetric.

When exclusion restrictions are not available then the model can be identified on the basis of the assumption of the joint normality of regression residuals. However, this may result in poor identification and high multicollinearity in the structural equation, since normal probability function is nearly linear for a large range of values and exhibits non-linearities only in the tails (see e.g. Moffitt, 1999).

To overcome the problems related to model identification, we use an insight from the paper by Klein and Vella (2009), who show that it is possible to exploit heteroscedasticity in the binary selection equation to identify the structural model without exclusion restrictions. They discuss this method in the framework of a treatment model, while we apply their idea in the context of the Heckman probit. We describe the details of our estimation methodology in the following subsection.

6.1. Estimation methodology

To reiterate, our dependent variables are binary indicators of asymmetry in the speed of wage adjustment that we define as follows. Let $i = 1,2,..n$ index firms, and $s \in \{t, p, a, w\}$ indicate the type of shock: turnover, product price, productivity or competitor wage, respectively. For $s \in \{t, p, a\}$, we set the binary outcome variable Y_{1is} equal to 1 if wage adjustment is faster when a shock lowers the affected economic variable, i.e. when turnover, product price or productivity declines, and 0 otherwise. In contrast, for the shock to competitor wages ($s = w$), Y_{1is} equals 1 if the firm's own wages are adjusted more promptly when competitor wages rise than when they fall; Y_{1is} is 0 otherwise.

As noted above, we first assume that the asymmetric response of firms to shocks can be described by a standard probit model:

$$Y_{1is} = [X_{1i}\beta_s + \varepsilon_{is} > 0], \qquad (1)$$

where $[\cdot]$ is the indicator function; X_{1i} is a row vector of observed exogenous variables; β_s is a vector of unknown true parameters; and ε_{is} is the unobserved component, distributed independently of X_{1i} according to standard normal. Under these assumptions, parameters β_s can be estimated by MLE.

Note however, that for a given type of shock s, the outcome Y_{1is} is observed only for those firms that react to the shock in both directions; that is,

Y_{1is} has missing values if wages are adjusted in response only to positive or to negative realisations of the shock, or if wages are not adjusted at all. This suggests that a more appropriate characterisation of the data generating process might be probit with selection:

$$Y_{1is} = [X_{1i}\beta_s + \varepsilon_{is} > 0] \text{ and if } Y_{2is} = 1, \tag{2}$$

$$Y_{2is} = [X_{2i}\delta_s + v_{is} > 0], \tag{3}$$

where Y_{2is} is a dummy variable showing whether outcome Y_{1is} is observed or not. According to equation (3), Y_{2is} is determined by an indicator function that depends on a set of observed exogenous variables X_{2i} and an unobserved component v_{is}, which is independent of X_{2i}. Under the assumption that $(\varepsilon_{is}, v_{is})$ has zero mean and unit variance bivariate normal distribution $\Phi(0,0,1,1,\rho_s)$, parameters $(\beta_s, \delta_s, \rho_s)$ can be simultaneously and efficiently estimated by MLE.[18] Importantly, selection is irrelevant for the estimation of equation (2) if the unobserved factors are uncorrelated ($\rho_s = 0$). In this case, β_s can be estimated by probit disregarding the selection equation (3).

The probit model with sample selection (2)–(3), also known as the Heckman probit, is well identified if there is at least one factor determining selection but not outcome, that is, if X_{2i} contains at least one variable that is not in X_{1i}. Otherwise, the set-up owes identification solely to the nonlinearities in the probit models (Wooldridge, 2002).

Coming up with sound exclusion restrictions, with defensible identification based on observables, is often difficult, and it seems to also be problematic in the case at hand. Firstly, any of the available variables, such as competition intensity or pay structure that we suggest might be related to the asymmetric speed of wage response may also be regarded as a potential explanatory variable for how likely it is that wages will be adjusted upwards and downwards, or, indeed, whether they will be adjusted in response to the shocks under consideration at all, the issue of selection. And conversely, it is very difficult to see why any of the variables that are observed and contain information about the propensity to change wages in response to shocks would be void of explanatory power for the asymmetric reaction speed in wage adjustment.

On the other hand, it is not so obvious a priori that ε_{is} and v_{is} are correlated, and thus that selection actually matters for the estimation of equation

[18] In Stata, model (2)–(3) can be estimated by heckprob.

(2). Consider, for example, the unobserved component in selection equation (3). By construction, v_{is} is larger for firms that are more likely to respond to shocks by adjusting wages, upward or downward. There may be many different factors behind this term, but it seems reasonable to expect that particularly relevant are the magnitude of shocks that different respondents had in mind when answering the survey questions, and considerations of downward wage rigidity. Thus, everything else being the same, relatively large v_{is}'s should be associated with those respondents who thought about large rather than small shocks and/or those companies for which downward wage rigidity is relatively unimportant. To be more precise about the latter, we might even consider various theoretical explanations for wage rigidity and the suggested socio-economic mechanisms that are said to cause it, and assume that large v_{is}'s correspond to firms that lack the characteristics associated with wage rigidity. Yet even such a more structured view of v_{is} does not imply that v_{is} and ε_{is} should be related in some particular way. Theoretical explanations of wage rigidity are silent about whether or why there could be asymmetry in the speed of wage adjustments, depending on the type of shock and its direction. And typically we would not think that the magnitude of shocks should matter in this regard either.

In short, judging from the questionnaire design and the way our survey data on wage adjustment to shocks were collected, it seems natural to consider our empirical analysis in the framework of a probit model with selection (2)–(3). The issue of whether or not selection is relevant for the estimation is an empirical one; we do not have strong grounds to expect that selection actually matters. Nor do we have a set of sound exclusion restrictions to ensure that the model with selection is structurally identified. In our empirical analysis, therefore, we will rely upon a "technical identification" that is based on the intrinsic non-linearities of the probits in (2)–(3).

In empirical applications, however, estimation without exclusion restrictions may be problematic, because most of the non-linearity for identification arises in the tails of the normal distribution underlying the model (2)–(3). To address this problem, we follow the idea proposed by Klein and Vella (2009), albeit in a different setting, that identification without exclusion restrictions can be aided by exploiting heteroscedasticity in the selection equation, equation (3) in our case. The crux of their insight is that, once the probit selection equation is normalised to account for heteroscedasticity in its random term, the resulting normalised regressors are usually linearly independent of the original explanatory variables; Klein and Vella (2009) show that this property can be exploited in identification.

We note, however, that in the context of our analysis, the idea of a possibly heteroscedastic unobserved component in equation (3) is appealing not only because such heteroscedasticity might help with model identification. There are other good reasons for suspecting heteroscedasticity in this part of the model as well. Our sample, for instance, includes data from three different surveys which may differ in the amount of intrinsic uncertainty contained in their answers. A similar argument may also be brought up about firms from different economic sectors. And of course, there can be other, subtler reasons causing a heteroscedastic unobserved component as well.

Our empirical strategy for making use of the idea of Klein and Vella (2009) is as follows. First, we forgo the previous assumption that v_{is} has constant variance and assume instead that its variance is a function of the explanatory variables in equation (3). More precisely, we assume that $\sigma_{is}^2 = \{\exp(X_{3i}\gamma_s)\}^2$, where σ_{is}^2 is the variance of v_{is} and $X_{3i}\gamma_s$ is a linear index of exogenous regressors. The latter may include all elements of X_{2i} except for the constant. As a result, the selection equation (3) becomes:

$$Y_{2is} = [X_{2i}\delta_s + v_{is} > 0] = \left[\frac{X_{2i}\delta_s}{\exp(X_{3i}\gamma_s)} + \frac{v_{is}}{\exp(X_{3i}\gamma_s)} > 0 \right] = [\tilde{X}_{2is}\delta_s + \tilde{v}_{is} > 0], \quad (3')$$

where $\tilde{X}_{2is} = \frac{X_{2i}}{\exp(X_{3i}\gamma_s)}$ and $\tilde{v}_{is} = \frac{v_{is}}{\exp(X_{3i}\gamma_s)}$. Ignoring, for a moment, that ε_{is} and $\tilde{v}_{is}$ may be correlated, equation (3') represents a heteroscedastic probit model which can be estimated by MLE.[19] However, once we combine equation (3') with the outcome equation (2) and allow for correlation between ε_{is} and $\tilde{v}_{is}$, the model becomes non-standard. To estimate it, we adopt the two-step procedure considered by Van de Ven and Praag (1981).

Following Heckman (1979), Van de Ven and Praag (1981) show that ignoring selection in (2)–(3) and estimating (2) as a standard probit model amounts to an omitted variable specification error. To correct for it, equation (2) needs to be amended by an extra regressor, the inverse Mills ratio:

$$Y_{1is} = [X_{1i}\beta_s + \rho\lambda_{is} + \tilde{\varepsilon}_{is} > 0], \quad (4)$$

where $\lambda_{is} = \frac{\varphi(A_{is})}{\Phi(-A_{is})}$, $A_{is} = -\tilde{X}_{2is}\delta_s$ and $E(\tilde{\varepsilon}_{is} \mid Y_{2is} = 1) = 0$.[20] The random term in (4) is heteroscedastic, however, since $E(\tilde{\varepsilon}_{is}^2 \mid Y_{2is} = 1) = \tau_{is}^2 = 1 + \rho^2\lambda_{is}(A_{is} - \lambda_{is})$. After normalising equation (4) with respect to τ_{is}, we obtain the final specification, which resembles a standard probit:

$$Y_{1is} = \left[\frac{X_{1i}}{\tau_{is}}\beta_s + \rho\frac{\lambda_{is}}{\tau_{is}} + \tilde{\tilde{\varepsilon}}_{is} > 0 \right], \quad (4')$$

[19] In Stata, this model can be estimated by hetprob.

[20] $\varphi(\cdot)$ is standard normal density.

where $\tilde{\tilde{\varepsilon}}_{is} = \dfrac{\tilde{\varepsilon}_{is}}{\tau_{is}}$ now has unit variance.

If $\dfrac{X_{1i}}{\tau_{is}}$ and $\dfrac{\lambda_{is}}{\tau_{is}}$ were known, model (4') could be estimated by standard probit. However, as λ_{is} and τ_{is} are not readily available, we follow Van de Ven and Praag (1981) and estimate (4') in several steps. First, we estimate the heteroscedastic probit model (3') by MLE and obtain estimates for the inverse Mills ratio $\hat{\lambda}_{is}\left(\hat{A}_{is}\right)$. Next, we use them as regressors in equation (4), which we estimate by OLS. That is, we apply a linear probability model to obtain a consistent estimate $\hat{\rho}$, which enables us to compute $\hat{\tau}_{is}$. Finally, we use the latter to calculate $\dfrac{X_{1i}}{\hat{\tau}_{is}}$ and $\dfrac{\hat{\lambda}_{is}}{\hat{\tau}_{is}}$, and estimate (4') by probit.

The main difference between the estimation procedure just described and that considered by Van de Ven and Praag (1981) concerns the first step, namely the specification and estimation of model (3'). Van de Ven and Praag assumed that v_{is} was homoscedastic and estimated the resulting model by probit. In contrast, we allow for the possibility that v_{is} is heteroscedastic and estimate model (3') as a heteroscedastic probit. As explained above, we make this deviation from the original estimation procedure to make use of Klein and Vella's (2009) insight that, in the presence of heteroscedasticity, the normalisation inherent in (3') introduces additional non-linearities that may aid identification.

When exclusion restrictions are absent, meaning $X_{1i} = X_{2i}$, a usual problem with the original two-step estimator is that $\lambda_{is} = \dfrac{\varphi(X_{2i}\delta_s)}{\Phi(X_{2i}\delta_s)}$ is near-linear over a wide range of its argument, $X_{2i}\delta_s$, and that tends to make λ_{is} strongly collinear with $X_{1i}\beta_s$. Klein and Vella (2009) note, however, that non-linear transformations like $\tilde{X}_{2is} = \dfrac{X_{2i}}{\exp(X_{3i}\gamma_s)}$ in (3'), typically make X_{2i} and $\tilde{X}_{2is}$ linearly independent. If so, the same heteroscedasticity-related normalisation should enhance identification of the probit with selection set-up by reducing the problem with collinearity between $\lambda_{is} = \dfrac{\varphi(\tilde{X}_{2i}\delta_s)}{\Phi(\tilde{X}_{2i}\delta_s)}$ and $X_{1i}\beta_s$.

6.2. Estimation results: separate regressions for each type of shocks

We estimate separate regressions on each variable, i.e. on the asymmetric reaction speed to shocks in sales turnover, product price, labour productivity and competitors' wage level. The regression results are presented in Appendix 8, Tables A8.1.–A8.4. Estimates of the probit regression are shown in the first column, followed by the estimates of the two types of selection model, the unadjusted Heckman probit and the heteroscedasticity-adjusted Heckman probit regressions (the latter are referred to as modified Heckman regressions in Appendix 8). The unadjusted Heckman probit regressions are estimated without exclusion restrictions, so the identification is based solely on functional form assumptions.

We use two tests to assess the correlation between the residuals of the selection and structural equations. For the unadjusted Heckman probit regressions we use the Wald test (the related Chi-square statistics are reported at the end of the second column in Tables A8.1.–A8.4.). For the heteroscedasticity-adjusted Heckman probit regressions we use the t-test to assess the significance of the "rho", i.e. the term that corrects for the selection bias in the two-step estimation (reported at the end of the third column in Tables A8.1.–A8.4.). In all the regression specifications that we estimate, the estimated coefficients for the "rho" are not significantly different from zero. The Chi-square statistics for the Wald test for the unadjusted Heckman probit regressions are also mostly in the range where the null hypothesis of no correlation between the unobserved factors is not rejected (it is rejected only in one regression out of four). Consequently, the statistical tests do not support the existence of the selection effects. Furthermore, a comparison of the estimates from the probit and selection models shows that the estimated marginal effects are quite similar across the different methods. This implies that selection does not cause significant biases and that we can mostly trust the probit estimations.

We also use the likelihood-ratio test of the existence of heteroscedasticity in the selection equation to validate the use of the heteroscedasticity-adjusted Heckman probit model, since the identification in this case is based on the assumption that the residuals are heteroscedastic. The test is based on a Chi-square statistic, the estimated values for which are presented at the end of the last column in Tables A8.1.–A8.4. The test results strongly suggest the presence of heteroscedasticity in all estimated regressions.

The estimated results exhibit strong similarities among the first three sets of regression estimates, where the dependent variables are constructed using shocks in sales turnover, product price, and labour productivity. The results are different, however, for asymmetry associated with a shock to competitors' wages. This is an expected result since, as we discussed in the introduction, the underlying cause of the asymmetric reaction speed is different for the last variable. For the first three variables listed, the asymmetric nature of the response has a positive impact on profits because it is profitable from a company's point of view to delay wage increases as long as possible and to implement wage cuts promptly, ceteris paribus. No similar profitability-based rationale can be used to explain the asymmetry in response to changes in competitors' wage level. Faced with shocks to this variable, companies react faster to increases than to decreases, which could potentially have an adverse effect on the profit margin. Rather than stemming from the reason suggested above, this pattern in wage setting may arise because of the tendency to pay efficiency wages.

6.2.1. Asymmetric reaction to shocks in turnover, price and productivity

We begin by describing the regression results on the three first variables. Our estimations indicate that the propensity for asymmetric reaction is positively related with product market competition.[21] The estimated effects are significantly positive for the dummy of severe competition across all regression specifications. As we discussed before, companies may react to shocks asymmetrically since it allows them to stretch the margins. Thus, a possible explanation for this finding is that competition increases the pressure on companies to use all possible means of increasing the profit margins, including the tendency to react asymmetrically.

The propensity for asymmetric reaction is affected by production technology. The estimated marginal effects for the set of dummy variables measuring the share of labour costs in total costs are positive, and increasing with the level of this variable for two of the three shocks, sales turnover and product price. This implies that companies which employ more labour-intensive technologies have a higher tendency to react asymmetrically. A likely explanation for this relationship is also that asymmetric reaction speed enhances a company's profit margins. The higher the share of labour costs in total costs, the stronger the positive effect on profits that firms can achieve by delaying wage increases as long as possible and implementing wage cuts as promptly as possible in response to shocks.

[21] The measure of competition is based on company managers' perception.

The regressions also include fixed effects for the separate surveys, which control for the differences in the macroeconomic environment and the survey method. The estimated effects indicate that the asymmetric reaction was more pronounced in 2009 than in 2007 or in 2005, which shows that companies are more prone to react asymmetrically in a recession. The difference between the 2005 and 2009 surveys can also stem from the way the surveys were conducted, as the 2005 survey was carried out by telephone interviews whereas the 2009 survey was based on internet questionnaires.

There are other significant results in the regressions but they are not present for all three variables and in general not as robust as the results described above. Therefore we discuss the additional significant estimates only selectively.

We find that firm size, which is measured in terms of employment, is negatively related to the propensity for asymmetric reaction in the case of shocks to labour productivity. An explanation for this finding could be that in small companies wage changes are more likely to take place on an ad hoc basis, whereas in large companies it is more probable that wage setting is based on formally defined procedures, and this lessens the possibility of asymmetric reaction. We do not have a good explanation, though, why it is significant only in regressions on productivity shocks.

We also investigate the relationship between collective bargaining and asymmetric behaviour. For the reasons outlined in the third section, this relationship should be negative. Collectively bargained wage contracts would lower a company's ability to choose the reaction speed in response to shocks for two main reasons. First, collectively bargained contracts fix wages for a specific, usually pre-defined, time period, which is less likely to be the case with individual bargaining. Second, collective bargaining is usually associated with greater rigidity in wage setting. The estimated relationship is mostly not significantly different from zero, and it is negative only in the Heckman probit regression where the dependent variable is a sales turnover shock. (In the case of this particular regression the Chi-square statistic is significantly different from zero.) The insignificance of this result may be caused by the small number of observations, as only around 7% of the sampled companies have collective agreements.

The estimated relationship between state-dependent (as opposed to time-dependent) wage setting rules and asymmetric behaviour is insignificant, which is an unexpected result. We expected that the use of state-dependent wage setting would be positively related with the tendency to react asymmetrically, since it gives companies more flexibility in choosing the reaction speed.

The regression results indicate that the share of bonuses in total pay is insignificantly related to the tendency to react asymmetrically to shocks in turnover and prices, whereas the estimated marginal effect is negative for labour productivity shocks. A possible explanation for this result is that the changes in bonuses paid are usually directly related to productivity changes — the relationship between productivity and the level of bonus payments is usually explicitly formulated in the wage contract. Consequently, companies who pay bonuses have to treat increases and decreases in productivity symmetrically, i.e. they cannot alter the timing of the payment of bonuses more in response to positive than to negative shocks in this variable.

6.2.2. Asymmetric reaction to shocks in competitors' wages

As discussed earlier, a possible reason for an asymmetric reaction in the case of shocks to competitors' wages is that companies are paying efficiency wages. This would cause them to react slowly to decreases and promptly to increases in the external wage level. The validity of this hypothesis can be assessed indirectly in the regression context by looking at the relationship between some firm characteristics and the tendency to react asymmetrically to this type of shock. Research on this topic has shown that the payment of efficiency wages is more likely in companies which are larger, use more capital-intensive production technology and/or hire high-skilled workers. An additional firm characteristic, which may be associated with the payment of efficiency wages, is remuneration on a piece-rate basis. One of the reasons why efficiency wages are paid is that monitoring workers' effort is costly. Since the evaluation of labour productivity is costless when employees are remunerated on a piece-rate basis, we can expect this type of remuneration to be associated with a lower tendency to pay efficiency wages.

The regression estimates are presented in Table A8.4 in Appendix 8. Only one of the company characteristics proposed here are significantly related with the propensity to react asymmetrically — the dummy variable of piece-rate remuneration has a significantly negative coefficient. This supports our hypothesis that an asymmetric reaction to a competitors' wage shock is caused by the payment of efficiency wages, but the support is not very robust.

Since we are not able to find much evidence in favour of the hypothesis that the asymmetric reaction speed to changes in competitors' wages is caused by the payment of efficiency wages, it leaves open the question of what is causing the asymmetric behaviour in response to shocks in this variable. It is possible that the insignificance of the results described above is caused by insufficient sample size. The variable measuring the speed of response to shocks in competitors' wages is not available in the first of the three surveys and the asymmetry is less pronounced than for other variables, i.e. a smaller proportion of companies react asymmetrically in response to shocks to competitors' wages. Consequently, the number of companies for which the dummy dependent variable in these regressions is equal to one is relatively small — in the range of 50 observations (see Table A7.4 in Appendix 7 for details of sample size). Most of the estimated marginal effects are insignificant for this variable, with only a few exceptions.

One of the exceptions was described above — the estimated effect is significantly negative for the piece-rate remuneration dummy. The second exception is the estimate for the fixed effect of the 2007 survey, which is significantly positive for all estimated model specifications. This indicates that firms were more likely to react asymmetrically in response to changes in competitors' wages in 2007, when the labour market was tight. As we discussed in Section 5, it shows that adverse labour market conditions enhance the asymmetry.

6.2.3. Estimated effects for selection equations

The estimations for the selection equations of the unadjusted and heteroscedasticity-adjusted Heckman probit models are presented in the two last columns of Tables A8.1.–A8.4. in Appendix 8. The selection equation estimates the propensity of companies to react to shocks, both increases and decreases, in a given variable by changing wages. Since we have no compelling reasons to expect that these results should differ between estimations for the competitors' wage shock and the other three shocks (in contrast to the structural equations) we discuss the estimation results for all four variables simultaneously.

The regression results imply that the propensity to react to shocks is positively related with the frequency of wage changes, which is an expected result.[22] The estimated marginal effects for the set of dummy variables measuring wage change frequency are significantly positive and increase monotonically with the level of frequency in most of the estimated selection equations.

[22] The measures of frequency apply to changes in base wages, whereas the propensity to change wages in response to shocks applies to the total wage bill. Even so, the two variables should be positively related, since not all companies apply flexible payment methods.

Our estimations indicate that the likelihood of reaction is positively related with the share of bonuses in total pay and with use of the piece-rate remuneration method. The estimated effects are significant for three variables out of the four, for shocks in sales turnover, output price and labour productivity. These estimation results confirm our expectations. As indicated by numerous previous studies on this topic, fixed base wages tend to be rigid (e.g. Babecký et al., 2010). Therefore the use of flexible payment methods, such as the payment of bonuses or remuneration on a piece-rate basis, makes it more likely that companies can react to economic shocks by altering wages.

In addition to these findings, the regression results imply that manufacturing sector businesses are less likely to react to shocks by altering wages than companies operating in other sectors. The capital intensity of production technology also matters, as more labour-intensive companies are more likely to react to shocks.[23] Across the years, the reaction was most likely to be observed in 2009 and least likely in 2005.

The estimated effects for firm size are not uniform. We find that size is positively related with the propensity to react in response to productivity and competitors' wage shocks, whereas the estimated relationship is negative for price shocks.

6.3. Estimation results: combined variable of asymmetric reaction

Next, we estimate regressions where the dependent variable indicating asymmetric reaction speed is created using the combined reaction to three different types of shock (i.e. shocks to sales turnover, labour productivity, and output price). The regression estimates are presented in Appendix 9. It is a dummy which equals one if a company reacts asymmetrically to a shock in at least one of these variables. We opted to construct the combined measure of asymmetric reaction using three rather than four variables, since the reasons behind the asymmetric behaviour are different for the fourth variable (shocks to competitors' wages).

The main advantage of using a combined measure, rather than estimating separate regressions for each type of shock, is that it enlarges the sample used in the estimations. The implications of these regressions are similar to those already described, but the significance of the estimated effects is stronger. In particular, this applies to our measure of competition. We obtain significant estimates for marginal effects for the dummy variables of strong and severe

[23] The estimated effects for the related dummy variables are significant for three variables only, they are not significant for competitors' wage shocks.

competition in all regression specifications, whereas they were significant only for the severe competition dummy in the regressions for separate shocks. The estimated marginal effects increase with the level of competition.

The regression estimates imply that firm size is negatively related with the tendency to react asymmetrically. With separate regressions for each shock, this relationship was only present for one variable out of the three, the productivity shock. We also find that companies in the construction sector are more likely to react asymmetrically than manufacturing companies and piece-rate remuneration is associated with a higher tendency to react asymmetrically.

7. Conclusions

There is a substantial body of literature on asymmetries in the dynamics of prices. One of its key findings is that the pass-through of cost increases to prices is both stronger and faster than that of cost decreases. Another general tendency is that, conditional on price adjustment, the opposite pattern prevails in the speed of price responses to demand shocks. We demonstrate that similar asymmetries are characteristic of wages as well: at the level of the firm, the speed and incidence of wage adjustments depend on the type and direction of shocks. Our evidence on the asymmetric incidence of wage changes conforms to downward nominal wage rigidity, but the findings on asymmetries in the speed of wage adjustment are novel.

We find that the speed of wage adjustment is asymmetric: firms react faster to negative than to positive shocks. The main focus of our analysis is on detecting the possible reasons for this behaviour. For this purpose, we employ the probit and Heckman probit models. The standard Heckman selection model can be identified using exclusion restrictions, i.e. a variable or a set of variables which enter the selection equation but are not included in the structural equation. When exclusion restrictions are not available the model can be identified using the assumption of the joint normality of regression residuals. However, this may result in poor identification and high multicollinearity in the structural equation, since normal cumulative probability function is nearly linear for a large range of values and exhibits nonlinearities only in the tails.

The set of variables that are available to us does not contain good candidates for exclusion restrictions. Thus, we take a different path and exploit heteroscedasticity in the binary selection equation for identification of the structural model. The derivation of this methodology, which we labelled the modified Heckman probit model, is discussed in detail in Section 6.

The estimation results of the three alternative models — the probit, standard and modified Heckman probit models — imply that selection does not pose a major problem in the empirical estimation, and our main findings hold regardless of whether we model selection explicitly or not.

For turnover, output price and productivity shocks, our estimation results imply that the speed asymmetry in wage adjustment is positively associated with product market competition and the labour intensity of production technology. Both of these findings support the hypothesis that this particular asymmetry results from firms' attempts to protect profit margins.

For shocks to competitors' wages, we hypothesised that asymmetric wage adjustments result from the payment of efficiency wages. Consequently, we anticipated that the incidence of this asymmetry would co-vary with firm size, capital intensity, the share of skilled labour and piece-rate remuneration — available firm-level characteristics that could be expected to correlate with firms' propensity to pay efficiency wages. Of these, however, the only covariate we found to be related to the asymmetry — negatively, as expected — was the dummy variable for piece-rate remuneration. Hence, although our estimation results do not make the efficiency wage-based explanation look implausible, their indirect support for this hypothesis is insufficient. We conclude that the underlying reasons for this asymmetry remain largely unclear.

Our results offer a more refined picture of nominal wage rigidity at the microeconomic level. Thanks to the advantages provided by survey data, we have been able to focus on issues that are otherwise difficult to pin down such as the connection between the nature and direction of a disturbance causing a wage change and the time lag until the change is implemented. It is unlikely that the speed asymmetry thus uncovered is due to information lags, in the sense that the direction of a shock means it systematically takes more or less time for a firm to learn about its nature — whether the shock is permanent or temporary, how large the shock is, and so forth. Rather, some firms actively use the implementation lags as choice variables when adjusting to shocks. This behaviour is intrinsically state-dependent and the underlying differences in the implementation lags are certainly non-trivial: given how the speed of wage adjustment is measured by our survey (see Appendix 2), the reaction speeds differ by at least a factor of two. It would be interesting to see if the speed asymmetry in wage setting could also be detected using matched employee-employer panel datasets.

It is also natural to ask what economic significance the speed asymmetry in wage adjustment might have at the macroeconomic level. In the context of DSGE models, similar questions concerning downward nominal wage rigidity (DNWR) have recently been investigated by Kim and Ruge-Murcia (2009a, 2009b) and Fahr and Smets (2010). To extend the framework for conducting analogous analysis to speed asymmetry however, it would be necessary to model wage rigidity in a more refined manner than has been done in the existing studies. First, the models should make a meaningful distinction between the incidence and the speed of wage adjustment, both of which would in addition have to permit asymmetries — DNWR and the speed asymmetry, respectively. Currently, the two most commonly used mechanisms for modelling nominal frictions, those proposed by Rotemberg (1982) and Calvo (1983), make no such distinction as both rely on a single model parameter to characterise wage setting. The linex function that Kim and Ruge-Murcia (2009a, 2009b) and Fahr and Smets (2010) use to account for DNWR generalises Rotemberg's mechanism by introducing an additional parameter that controls the degree of asymmetry in wage adjustment costs. To allow for the speed asymmetry in addition to DNWR, however, it would be necessary to modify the underlying micro-foundations of wage setting in more fundamental ways.

The second insight from the current study that could be useful for macro modelling is that the nature of speed asymmetry in wage adjustment depends on the type of shock. For some disturbances, the direction in which this asymmetry affects wage flexibility coincides with that of DNWR, but for other shocks, the two work in opposite directions. This also suggests that, in comparison to the modelling of DNWR with the help of the linex function, accounting for the speed asymmetry would require more substantial modifications in the micro mechanism of wage setting.

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Appendix 1: Stratification and sample structure

	Sample			Population[1]	
	Number of firms	Number of firms, percent	Actual employment, percent	Number of firms, percent	Employment, population, percent
	(1)	(2)	(3)	(4)	(5)
A: 2005 Survey					
Sector:[2]					
Manufacturing	89	35.6	46.6	24.5	40.2
Construction	33	13.2	10.5	14.9	10.9
Trade	52	20.8	9.6	27.5	20.0
Market serv.	76	30.4	33.4	33.0	28.9
Total	250	100.0	100.0	100.0	100.0
Size:					
5–19	107	42.8	6.9	72.9	24.8
20–49	52	20.8	9.9	17.5	19.9
50–99	51	20.4	22.0	8.1	28.3
100 and more	40	16.0	61.2	1.4	27.0
Total	250	100.0	100.0	100.0	100.0
B: 2007 Survey					
Sector:					
Manufacturing	177	40.7	44.5	24.5	40.2
Construction	60	13.8	7.3	14.9	10.9
Trade	80	18.4	15.1	27.5	20.0
Market serv.	118	27.1	33.2	33.0	28.9
Total[3]	435	100.0	100.0	100.0	100.0
Size:					
5–19	114	26.2	2.9	72.9	24.8
20–49	110	25.3	8.2	17.5	19.9
50–99	97	22.3	16.2	8.1	28.3
100 and more	114	26.2	72.8	1.4	27.0
Total[3]	435	100.0	100.0	100.0	100.0
C: 2009 Survey					
Sector:					
Manufacturing	184	32.5	38.5	24.5	40.2
Construction	87	15.3	9.3	14.9	10.9
Trade	116	20.5	21.1	27.5	20.0
Market serv.	180	31.7	31.2	33.0	28.9
Total	567	100.0	100.0	100.0	100.0
Size:					
5–19	176	31.0	4.6	72.9	24.8
20–49	150	26.5	11.4	17.5	19.9
50–99	120	21.2	19.7	8.1	28.3
100 and more	121	21.3	64.3	1.4	27.0
Total	567	100.0	100.0	100.0	100.0
D: Pooled data					
Sector:					
Manufacturing	450	35.9	42.3	24.5	40.2
Construction	180	14.4	8.6	14.9	10.9
Trade	248	19.8	16.8	27.5	20.0

	Sample			Population[1]	
	Number of firms	Number of firms, percent	Actual employment, percent	Number of firms, percent	Employment, population, percent
	(1)	(2)	(3)	(4)	(5)
Market serv.	374	29.9	32.3	33.0	28.9
Total	1252	100.0	100.0	100.0	100.0
Size:					
5–19	397	31.7	4.2	72.9	24.8
20–49	312	24.9	9.8	17.5	19.9
50–99	268	21.4	18.6	8.1	14.3
100 and more	275	22.0	67.4	1.4	41.0
Total	1252	100.0	100.0	100.0	100.0

Notes:

(1) Information on the target population is based on the Estonian business registry for 2005.

(2) Thirteen companies that were attributed to the primary sector in the original data file are now included in manufacturing.

(3) The total number of observations is 435 rather than 439, because there are four companies in the 2007 survey for which information on either sector (1 company) or employment (3 companies) is not available

Appendix 2: Description of the survey question on reaction speed to shocks

Reaction speed to shocks

How quickly do the changes listed below influence the wage payments (including paid bonuses) of the employees in the main occupational group (as defined in question 2.1)?

Please choose one option for each line

	Within 1 month	*Within 3 months*	*Within 6 months*	*Within a year or more*	*These changes do not influence wages*	*Don't know*
Increase in turnover	□	□	□	□	□	□
Decrease in turnover	□	□	□	□	□	□
Increase in the price of your main product/service	□	□	□	□	□	□
Decrease in the price of your main product/service	□	□	□	□	□	□
Improvement in employee work efficiency	□	□	□	□	□	□
Decrease in employee work efficiency	□	□	□	□	□	□
Increase in competitors' wages	□	□	□	□	□	□
Decrease in competitors' wages	□	□	□	□	□	□
Increase in inflation	□	□	□	□	□	□
Decrease in inflation	□	□	□	□	□	□
Increase in unemployment	□	□	□	□	□	□
Decrease in unemployment	□	□	□	□	□	□

Definition of the main occupational group

2.1.A – How were your firm's employees distributed across the following occupational groups at the end of the last economic year?	
Low skilled blue collar/Production	____%
High skilled blue collar/Technical	____%
Low skilled white collar/Clerical	____%
High skilled white collar/Professional	____%
Other (please specify) ____	____%
TOTAL (= 100%)	100 %
ONE GROUP HAS THE LARGEST SHARE OF WORKERS: ***According to your answer, the main (i.e. the most numerous) occupational group in your firm is …*** **→ GO TO QUESTION 2.2** **TWO (OR MORE) GROUPS HAVE EQUAL SHARES OF WORKERS:** **2.1.B – What is the main occupational group in your firm?** ***Please choose only one option***	
Low skilled blue collar/Production	□
High skilled blue collar/Technical	□
Low skilled white collar/Clerical	□
High skilled white collar/Professional	□
Other (please specify) ____	□

Definition of the main product or service

"If your firm produces (or sells) more than one single good or service, the answers must refer to the 'main product or service', defined as the one that generated the highest fraction of your firm's revenue in the last economic year."

Source: firm level data from the Amadeus database, Estonian Commercial Register and Latvian Commercial Register.

Appendix 3: Main economic indicators of the Estonian economy, 1997–2009

	1997	1998	1999	2000	2001	2002	2003	2004	**2005**	2006	**2007**	2008	**2009**
Real GDP growth (%)	11.7	6.7	–0.3	10.0	7.5	7.9	7.6	7.2	**9.4**	10.0	**7.2**	–3.6	**–14.1**
HICP growth (%)	9.3	8.8	3.1	3.9	5.6	3.6	1.4	3.0	**4.1**	4.4	**6.7**	10.6	**0.2**
GDP deflator growth (%)	10.3	5.2	6.8	4.5	5.3	3.3	4.2	3.6	**5.5**	7.6	**10.2**	6.7	**–0.6**
Current account (% of GDP)	–11.1	–8.6	–4.3	–5.4	–5.2	–10.6	–11.3	–11.3	**–10.0**	–16.9	**–17.8**	–9.4	**3.9**
Unemployment rate (%)	9.6	9.8	12.2	13.6	12.6	10.3	10.0	9.7	**7.9**	5.9	**4.7**	5.5	**13.8**
Employment growth (%)	0.0	–1.7	–4.5	–1.2	0.9	1.4	1.5	0.2	**2.0**	6.4	**1.4**	0.2	**–9.2**
GDP growth per full-time employee (%)	0.0	0.0	1.6	9.5	7.8	9.3	6.3	7.4	**9.4**	5.6	**7.1**	–4.6	**–13.6**
Real wage growth (%)	8.9	7.1	3.5	6.5	6.4	7.9	7.4	5.7	**7.5**	10.4	**12.0**	4.3	**–4.5**
Average gross wage growth (%)	19.6	14.8	7.8	10.4	13.0	10.9	9.7	7.8	**11.4**	16.2	**20.4**	13.8	**–5.0**
Nominal credit growth (%)	69.6	40.7	2.5	22.4	25.4	27.2	26.9	33.0	**50.4**	51.6	**30.2**	7.3	**–6.4**
Fiscal budget balance (% of GDP)	2.2	–0.7	–3.5	–0.2	–0.1	0.3	1.7	1.6	**1.6**	2.3	**2.6**	–2.8	**–2.7**

Source: Bank of Estonia.

Appendix 4: Asymmetric reaction speed to shocks

Share of businesses that react to a negative shock faster, slower or with the same time lag as to a positive shock

2005 survey

Shock	Faster reaction	Similar reaction	Slower reaction	t-value	Obser-vations
Sales turnover	0.071	0.903	0.025	1.7	120
Product price	0.034	0.930	0.035	0.0	70
Labour productivity	0.029	0.941	0.030	0.0	127

2007 survey

Shock	Faster reaction	Similar reaction	Slower reaction	t-value	Obser-vations
Sales turnover	0.162	0.801	0.037	4.9	267
Product price	0.167	0.806	0.028	5.4	248
Labour productivity	0.096	0.844	0.059	1.8	354
Competitors' wage	0.138	0.852	0.010	5.9	277
Inflation*	0.029	0.951	0.021	0.6	247
Unemployment	0.055	0.874	0.071	–0.7	237

2009 survey

Shock	Faster reaction	Similar reaction	Slower reaction	t-value	Obser-vations
Sales turnover	0.288	0.691	0.021	11.6	422
Product price	0.174	0.799	0.028	6.7	361
Labour productivity	0.176	0.761	0.063	5.3	439
Competitors' wage	0.078	0.886	0.037	2.3	327
Inflation*	0.029	0.950	0.021	0.6	294
Unemployment	0.040	0.924	0.036	0.3	293

Notes: Negative shocks are a decrease in sales turnover, product price, labour productivity and unemployment; and an increase in the wage levels of competitors. Figures are employment-weighted

** We do not associate the direction of change with the nature of the shock in the case of inflation. The figures presented here show the proportion of firms who react faster, similarly or slower to an increase in this variable.*

Appendix 5: Asymmetric reaction probability to shocks

Share of businesses that react to an increase/decrease in a given variable

2005 survey

Shock	React to increase	React to decrease	t-statistic	Observations
Sales turnover	0.646	0.470	4.0	250
Product price	0.329	0.263	1.6	250
Labour productivity	0.635	0.494	3.2	250

2007 survey

Shock	React to increase	React to decrease	t-statistic	Observations
Sales turnover	0.703	0.615	2.8	435
Product price	0.658	0.549	3.3	435
Labour productivity	0.893	0.817	3.2	435
Competitors' wage	0.886	0.633	9.1	435
Inflation	0.770	0.551	7.0	435
Unemployment	0.639	0.593	1.4	435

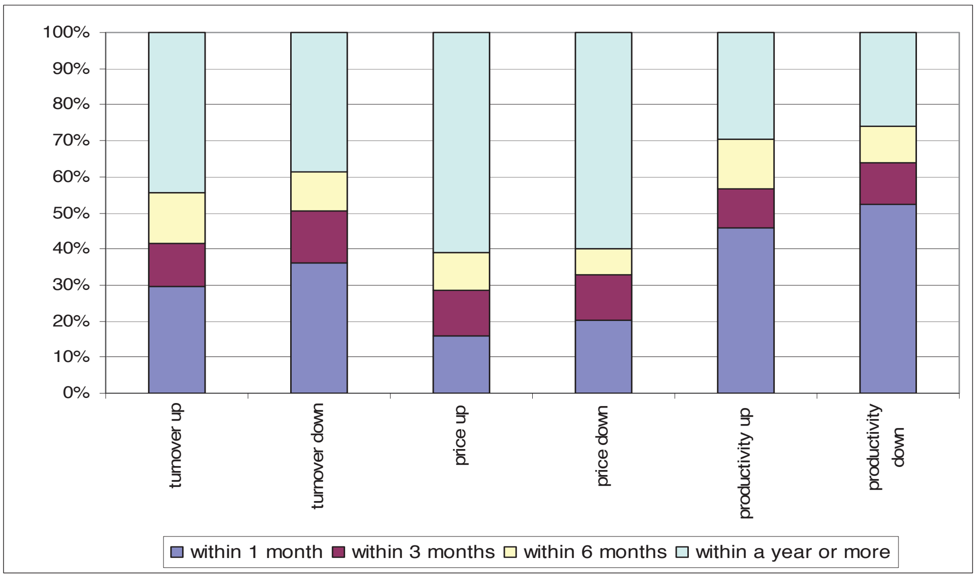
2009 survey

Shock	React to increase	React to decrease	t-statistic	Observations
Sales turnover	0.812	0.846	–1.5	529
Product price	0.709	0.748	–1.4	510
Labour productivity	0.923	0.916	0.4	498
Competitors' wage	0.752	0.704	1.7	478
Inflation	0.714	0.637	2.5	460
Unemployment	0.659	0.677	–0.6	460

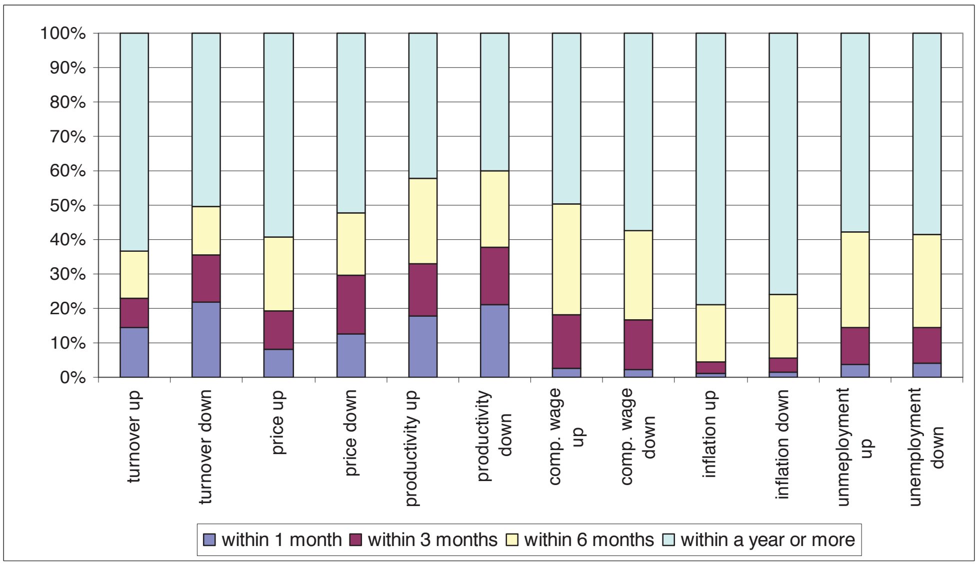
Notes: Figures are employment-weighted.

Appendix 6: Distribution of reaction speed

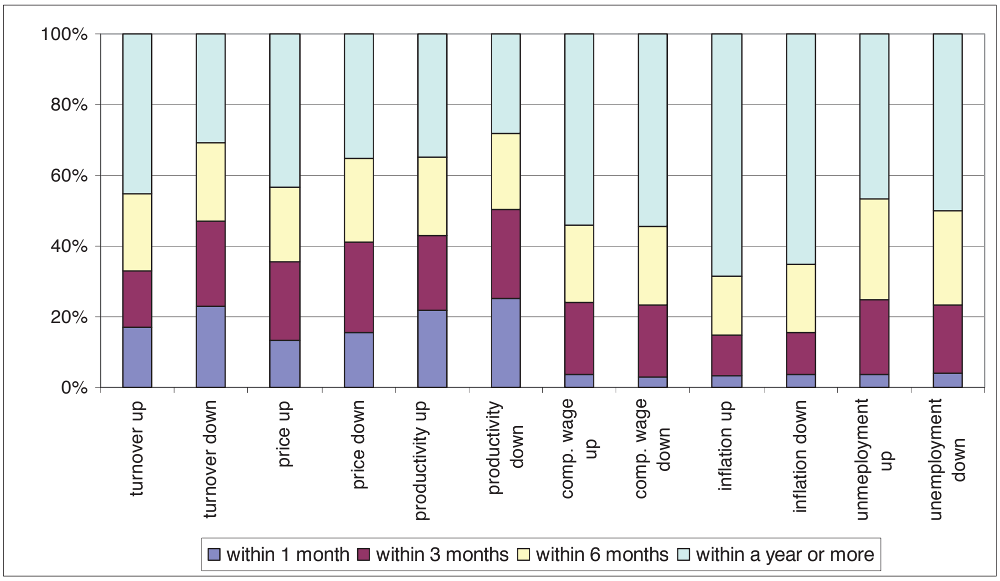
2005 survey



2007 survey



2009 survey



Notes: The 2005 survey included the related questions for three variables: sales turnover, product price and labour productivity. The two following surveys also included questions for competitors' wages, inflation and unemployment. Figures are employment-weighted.

Appendix 7: Differences in unconditional sample means: firms that react asymmetrically vs. other companies

A7.1: Sales turnover shock

Variable	Mean (asym. reaction)	Mean (other)	Observa-tions (asym. reaction)	Observa-tions (other)	t-stat.	Observa-tions
Main occupational group						
Low-skilled blue collar	0.253	0.240	182	629	0.351	811
High-skilled blue collar	0.555	0.563	182	629	–0.188	811
Low-skilled white collar	0.066	0.100	182	629	–1.404	811
High-skilled white collar	0.126	0.097	182	629	1.146	811
Sector						
Manufacturing, etc	0.302	0.315	182	628	–0.335	810
Construction	0.203	0.132	182	628	2.384	810
Trade	0.154	0.240	182	628	–2.486	810
Services	0.341	0.312	182	628	0.727	810
Level of competition						
No/marginal competition	0.063	0.114	176	603	–1.999	779
Average competition	0.455	0.534	176	603	–1.857	779
Severe competition	0.483	0.352	176	603	3.174	779
Size						
20 or less employees	0.365	0.336	181	628	0.715	809
21–100 employees	0.464	0.467	181	628	–0.059	809
101 or more employees	0.171	0.197	181	628	–0.788	809
Share of labour costs in total costs						
Up to 10%	0.052	0.109	174	587	–2.259	761
11–25%	0.247	0.332	174	587	–2.129	761
26–50%	0.489	0.388	174	587	2.362	761
51–100%	0.213	0.170	174	587	1.275	761
Remuneration						
Hourly wage	0.369	0.289	176	588	2.025	764
Piece-rate wage	0.250	0.260	176	588	–0.271	764
Monthly wage	0.381	0.451	176	588	–1.644	764
Wage change frequency						
More than once a year	0.163	0.162	172	575	0.033	747
Once a year	0.622	0.603	172	575	0.438	747
Less than once a year	0.215	0.235	172	575	–0.537	747
State-dependent wage setting	0.434	0.480	182	629	–1.096	811
Bonus	0.722	0.741	180	615	–0.515	795
Collective agreement	0.066	0.083	182	629	–0.737	811
Survey year						
2005	0.055	0.175	182	629	–4.049	811
2007	0.242	0.358	182	629	–2.938	811
2009	0.703	0.467	182	629	5.715	811

A7.2: Output price shock

Variable	Mean (asym. reaction)	Mean (other)	Observa-tions (asym. reaction)	Observa-tions (other)	t-stat.	Observa-tions
Main occupational group						
Low-skilled blue collar	0.248	0.273	109	572	–0.539	681
High-skilled blue collar	0.587	0.552	109	572	0.668	681
Low-skilled white collar	0.055	0.077	109	572	–0.802	681
High-skilled white collar	0.110	0.098	109	572	0.389	681
Sector						
Manufacturing, etc	0.312	0.326	109	571	–0.282	680
Construction	0.275	0.159	109	571	2.912	680
Trade	0.101	0.205	109	571	–2.553	680
Services	0.312	0.310	109	571	0.040	680
Level of competition						
No/marginal competition	0.046	0.102	108	550	–1.821	658
Average competition	0.472	0.527	108	550	–1.046	658
Severe competition	0.481	0.371	108	550	2.159	658
20 or less employees	0.306	0.349	108	571	–0.862	679
21–100 employees	0.519	0.468	108	571	0.971	679
101 or more employees	0.176	0.184	108	571	–0.196	679
Share of labour costs in total costs						
Up to 10%	0.066	0.104	106	540	–1.195	646
11–25%	0.189	0.311	106	540	–2.546	646
26–50%	0.491	0.407	106	540	1.586	646
51–100%	0.255	0.178	106	540	1.847	646
Remuneration						
Hourly wage	0.349	0.323	106	539	0.526	645
Piece-rate wage	0.264	0.286	106	539	–0.450	645
Monthly wage	0.387	0.391	106	539	–0.090	645
Wage change frequency						
More than once a year	0.133	0.175	105	519	–1.048	624
Once a year	0.648	0.626	105	519	0.414	624
Less than once a year	0.219	0.198	105	519	0.479	624
State-dependent wage setting	0.459	0.474	109	572	–0.288	681
Bonus	0.822	0.739	107	559	1.837	666
Collective agreement	0.092	0.086	109	572	0.206	681
Survey year						
2005	0.028	0.117	109	572	–2.836	681
2007	0.367	0.367	109	572	–0.003	681
2009	0.606	0.516	109	572	1.722	681

A7.3: Labour productivity shock

Variable	Mean (asym. reaction)	Mean (other)	Observa-tions (asym. reaction)	Observa-tions (other)	t-stat.	Observa-tions
Main occupational group						
Low-skilled blue collar	0.276	0.275	123	799	0.025	922
High-skilled blue collar	0.528	0.554	123	799	–0.539	922
Low-skilled white collar	0.081	0.081	123	799	–0.002	922
High-skilled white collar	0.114	0.089	123	799	0.890	922
Sector						
Manufacturing, etc	0.374	0.362	123	798	0.254	921
Construction	0.211	0.155	123	798	1.566	921
Trade	0.179	0.197	123	798	–0.466	921
Services	0.236	0.286	123	798	–1.149	921
Level of competition						
No/marginal competition	0.066	0.112	122	767	–1.554	889
Average competition	0.451	0.524	122	767	–1.505	889
Severe competition	0.484	0.364	122	767	2.539	889
20 or less employees	0.390	0.291	123	797	2.228	920
21–100 employees	0.455	0.476	123	797	–0.418	920
101 or more employees	0.154	0.233	123	797	–1.959	920
Share of labour costs in total costs						
Up to 10%	0.085	0.107	118	749	–0.730	867
11–25%	0.263	0.351	118	749	–1.888	867
26–50%	0.492	0.383	118	749	2.239	867
51–100%	0.161	0.159	118	749	0.059	867
Remuneration						
Hourly wage	0.440	0.310	116	751	2.773	867
Piece-rate wage	0.224	0.268	116	751	–0.991	867
Monthly wage	0.336	0.422	116	751	–1.751	867
Wage change frequency						
More than once a year	0.132	0.158	114	729	–0.719	843
Once a year	0.649	0.641	114	729	0.176	843
Less than once a year	0.219	0.202	114	729	0.434	843
State-dependent wage setting	0.496	0.476	123	799	0.420	922
Bonus	0.754	0.748	122	781	0.150	903
Collective agreement	0.057	0.096	123	799	–1.416	922
Survey year						
2005	0.041	0.153	123	799	–3.373	922
2007	0.301	0.399	123	799	–2.090	922
2009	0.659	0.448	123	799	4.392	922

A7.4: Competitors' wage shock

Variable	Mean (asym. reaction)	Mean (other)	Observations (asym. reaction)	Observations (other)	t-stat.	Observations
Main occupational group						
Low-skilled blue collar	0.238	0.290	63	544	–0.870	607
High-skilled blue collar	0.667	0.546	63	544	1.829	607
Low-skilled white collar	0.032	0.064	63	544	–1.023	607
High-skilled white collar	0.063	0.099	63	544	–0.913	607
Sector						
Manufacturing, etc	0.397	0.326	63	543	1.129	606
Construction	0.206	0.164	63	543	0.851	606
Trade	0.127	0.201	63	543	–1.404	606
Services	0.270	0.309	63	543	–0.644	606
Level of competition						
No/marginal competition	0.048	0.057	63	525	–0.310	588
Average competition	0.492	0.550	63	525	–0.879	588
Severe competition	0.460	0.392	63	525	1.039	588
Size						
20 or less employees	0.206	0.287	63	541	–1.344	604
21–100 employees	0.524	0.470	63	541	0.816	604
101 or more employees	0.270	0.244	63	541	0.450	604
Share of labour costs in total costs						
Up to 10%	0.115	0.108	61	518	0.157	579
11–25%	0.262	0.311	61	518	–0.777	579
26–50%	0.426	0.402	61	518	0.371	579
51–100%	0.197	0.180	61	518	0.329	579
Remuneration						
Hourly wage	0.373	0.341	59	511	0.495	570
Piece-rate wage	0.203	0.258	59	511	–0.918	570
Monthly wage	0.424	0.401	59	511	0.334	570
Wage change frequency						
More than once a year	0.339	0.145	59	497	3.837	556
Once a year	0.525	0.662	59	497	–2.080	556
Less than once a year	0.136	0.193	59	497	–1.071	556
State-dependent wage setting	0.492	0.507	63	544	–0.229	607
Bonus	0.902	0.787	61	531	2.117	592
Collective agreement	0.111	0.092	63	544	0.494	607
Survey year						
2005						
2007	0.619	0.443	63	544	2.665	607
2009	0.381	0.557	63	544	–2.665	607

A7.5: Company reacts asymmetrically to any shock (3 variables)

Shocks in sales turnover, output price and/or labour productivity

Variable	Mean (asym. reaction)	Mean (other)	Observa-tions (asym. reaction)	Observa-tions (other)	t-stat.	Observa-tions
Main occupational group						
Low-skilled blue collar	0.269	0.267	271	784	0.089	1055
High-skilled blue collar	0.554	0.546	271	784	0.216	1055
Low-skilled white collar	0.066	0.096	271	784	–1.464	1055
High-skilled white collar	0.111	0.092	271	784	0.905	1055
Sector						
Manufacturing, etc	0.325	0.369	271	783	–1.313	1054
Construction	0.225	0.130	271	783	3.742	1054
Trade	0.151	0.212	271	783	–2.171	1054
Services	0.299	0.289	271	783	0.320	1054
Level of competition						
No/marginal competition	0.057	0.132	264	752	–3.329	1016
Average competition	0.458	0.540	264	752	–2.285	1016
Severe competition	0.485	0.328	264	752	4.572	1016
Size						
20 or less employees	0.389	0.304	270	782	2.561	1052
21–100 employees	0.444	0.464	270	782	–0.561	1052
101 or more employees	0.167	0.231	270	782	–2.238	1052
Share of labour costs in total costs						
Up to 10%	0.077	0.109	259	722	–1.476	981
11–25%	0.266	0.361	259	722	–2.787	981
26–50%	0.452	0.380	259	722	2.039	981
51–100%	0.205	0.150	259	722	2.054	981
Remuneration						
Hourly wage	0.362	0.314	260	732	1.398	992
Piece-rate wage	0.265	0.251	260	732	0.445	992
Monthly wage	0.373	0.434	260	732	–1.723	992
Wage change frequency						
More than once a year	0.152	0.157	256	708	–0.168	964
Once a year	0.637	0.630	256	708	0.192	964
Less than once a year	0.211	0.213	256	708	–0.078	964
State-dependent wage setting	0.465	0.489	271	784	–0.669	1055
Bonus	0.738	0.722	267	766	0.501	1033
Collective agreement	0.063	0.098	271	784	–1.768	1055
Survey year						
2005	0.059	0.194	271	784	–5.294	1055
2007	0.306	0.388	271	784	–2.404	1055
2009	0.635	0.418	271	784	6.255	1055

Appendix 8: Probit and Heckman probit regressions: separate regressions for shocks in different variables

A8.1: Sales turnover shock

		Structural equation		Selection equation	
	Probit	**Heckman probit**	**Modified Heckman**	**Heckman probit**	**Modified Heckman**
Main occupational group (Reference group: Low-skilled blue-collar)					
High-skilled blue-collar	0.001	–0.003	–0.002	0.070**	0.060**
	(0.980)	(0.939)	(0.949)	(0.042)	(0.044)
Low-skilled white-collar	–0.022	–0.035	–0.021	0.028	0.015
	(0.745)	(0.568)	(0.692)	(0.632)	(0.840)
High-skilled white-collar	0.044	0.017	0.032	0.025	0.056
	(0.529)	(0.798)	(0.579)	(0.682)	(0.314)
Sector (Reference group: Manufacturing)					
Construction sector	0.087	0.095*	0.075	0.063	0.050
	(0.122)	(0.062)	(0.137)	(0.166)	(0.193)
Trade sector	–0.018	0.005	–0.013	0.210***	0.128***
	(0.724)	(0.916)	(0.763)	(0.000)	(0.002)
Services' sector	0.025	0.042	0.020	0.145***	0.043
	(0.580)	(0.281)	(0.580)	(0.000)	(0.181)
Competition (Reference group: No/marginal competition)					
Average competition	0.061	0.063	0.057	0.048	0.101**
	(0.236)	(0.123)	(0.262)	(0.295)	(0.042)
Severe competition	0.139**	0.138***	0.129**	0.082*	0.118**
	(0.013)	(0.003)	(0.033)	(0.090)	(0.018)
Size (Reference group: 20 or less employees)					
21–100 employees	–0.033	–0.026	–0.029	0.009	0.012
	(0.396)	(0.452)	(0.338)	(0.789)	(0.624)
101 or more employees	–0.028	–0.020	–0.027	–0.055	–0.039
	(0.571)	(0.651)	(0.457)	(0.184)	(0.210)
Share of labour costs in total costs (Reference group: Up to 10%)					
11–25%	0.069	0.062	0.072	0.050	0.016
	(0.185)	(0.149)	(0.252)	(0.330)	(0.704)
26–50%	0.149***	0.154***	0.155**	0.103**	0.072*
	(0.004)	(0.000)	(0.015)	(0.044)	(0.083)
51–100%	0.182***	0.178***	0.209**	0.139**	0.097*
	(0.004)	(0.002)	(0.015)	(0.019)	(0.098)
Survey year (Reference group: Survey 2009)					
Survey 2005	–0.180***	–0.187***	–0.131***	–0.351***	–0.230***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Survey 2007	–0.146***	–0.147***	–0.109***	–0.181***	–0.140***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wage change frequency (Reference group: lower than annual)					
Higher than annual	0.085	0.052	0.073	0.202***	0.118***
	(0.173)	(0.345)	(0.196)	(0.000)	(0.000)
Annual	0.075*	0.076**	0.062*	0.078**	0.030
	(0.068)	(0.031)	(0.076)	(0.021)	(0.287)

		Structural equation		Selection equation	
	Probit	Heckman probit	Modified Heckman	Heckman probit	Modified Heckman
State-dependent wage setting	–0.007	–0.012	–0.004	–0.044	–0.009
	(0.828)	(0.709)	(0.870)	(0.150)	(0.704)
Remuneration (Reference group: Monthly)					
Piece-rate remuneration	0.049	0.061	0.040	0.126***	0.006
	(0.334)	(0.159)	(0.342)	(0.000)	(0.855)
Hourly remuneration	0.045	0.063	0.039	–0.014	–0.013
	(0.292)	(0.113)	(0.294)	(0.686)	(0.646)
Bonus (%)	–0.082	–0.042	–0.047	0.214**	0.170***
	(0.412)	(0.708)	(0.597)	(0.017)	(0.002)
Collective agreement	–0.044	–0.090*	–0.036	–0.062	–0.030
	(0.410)	(0.069)	(0.354)	(0.282)	(0.420)
Rho			0.050		
			(0.604)		
Chi-square statistic		10.25***			51.96***
		(0.001)			(0.000)
Observations	629	921	627	921	921

*Notes: Marginal effects are reported. Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1.*

A8.2: Output price shock

	Probit	Structural equation Heckman probit	Modified Heckman	Selection equation Heckman probit	Modified Heckman
Main occupational group (Reference group: Low-skilled blue-collar)					
High-skilled blue-collar	0.030	0.030	0.044	–0.055	–0.029
	(0.424)	(0.385)	(0.341)	(0.124)	(0.396)
Low-skilled white-collar	0.044	0.048	0.063	–0.048	–0.021
	(0.564)	(0.545)	(0.521)	(0.428)	(0.763)
High-skilled white-collar	–0.003	0.000	0.021	–0.070	–0.068
	(0.959)	(0.996)	(0.807)	(0.268)	(0.369)
Sector (Reference group: Manufacturing)					
Construction sector	0.112*	0.101*	0.061	0.176***	0.175***
	(0.054)	(0.081)	(0.403)	(0.000)	(0.000)
Trade sector	–0.100**	–0.094**	–0.135*	0.133***	0.124***
	(0.018)	(0.015)	(0.073)	(0.004)	(0.008)
Services sector	–0.032	–0.024	–0.058	0.095**	0.091**
	(0.458)	(0.601)	(0.355)	(0.028)	(0.025)
Competition (Reference group: No/marginal competition)					
Average competition	0.065	0.071	0.080	0.047	0.046
	(0.192)	(0.110)	(0.306)	(0.344)	(0.438)
Severe competition	0.102*	0.109**	0.118	0.078	0.078
	(0.055)	(0.021)	(0.162)	(0.135)	(0.195)
Size (Reference group: 20 or less employees)					
21–100 employees	0.019	0.019	0.013	–0.007	0.017
	(0.612)	(0.580)	(0.760)	(0.845)	(0.693)
101 or more employees	0.018	0.020	0.036	–0.099**	–0.065
	(0.715)	(0.717)	(0.584)	(0.031)	(0.172)
Share of labour costs in total costs (Reference group: Up to 10%)					
11–25%	0.035	0.036	0.071	–0.037	0.004
	(0.412)	(0.368)	(0.421)	(0.519)	(0.944)
26–50%	0.143***	0.138***	0.195**	0.056	0.060
	(0.002)	(0.001)	(0.022)	(0.317)	(0.271)
51–100%	0.177***	0.173***	0.226**	0.120*	0.121*
	(0.002)	(0.001)	(0.027)	(0.062)	(0.054)
Survey year (Reference group: Survey 2009)					
Survey 2005	–0.127***	–0.097*	–0.051	–0.413***	–0.417***
	(0.001)	(0.062)	(0.583)	(0.000)	(0.000)
Survey 2007	0.006	0.021	0.044	–0.130***	–0.129***
	(0.873)	(0.646)	(0.482)	(0.000)	(0.000)
Wage change frequency (Reference group: lower than annual)					
Higher than annual	–0.067	–0.069	–0.108	0.221***	0.141***
	(0.149)	(0.106)	(0.145)	(0.000)	(0.001)
Annual	–0.011	–0.002	–0.028	0.138***	0.030
	(0.797)	(0.964)	(0.587)	(0.000)	(0.545)
State-dependent wage setting	0.011	0.023	0.013	–0.017	–0.029
	(0.732)	(0.512)	(0.726)	(0.607)	(0.445)

	Probit	Structural equation Heckman probit	Modified Heckman	Selection equation Heckman probit	Modified Heckman
Remuneration (Reference group: Monthly)					
Piece-rate remuneration	–0.047	–0.038	–0.066	0.160***	0.097**
	(0.230)	(0.330)	(0.239)	(0.000)	(0.046)
Hourly remuneration	–0.051	–0.024	–0.055	0.028	–0.002
	(0.180)	(0.522)	(0.232)	(0.460)	(0.963)
Bonus (%)	0.067	0.077	0.032	0.017	0.200
	(0.514)	(0.440)	(0.796)	(0.841)	(0.185)
Collective agreement	0.015	–0.025	–0.004	0.048	0.017
	(0.792)	(0.614)	(0.945)	(0.420)	(0.774)
Rho			–0.136		
			(0.310)		
Chi-square statistic		0.0912			22.75**
		(0.763)			(0.019)
Observations	532	915	532	915	915

*Notes: Marginal effects are reported. Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1.*

A8.3: Labour productivity shock

	Probit	Structural equation Heckman probit	Structural equation Modified Heckman	Selection equation Heckman probit	Selection equation Modified Heckman
Main occupational group (Reference group: Low-skilled blue-collar)					
High-skilled blue-collar	0.006	0.023	0.024	0.071*	0.031
	(0.845)	(0.437)	(0.530)	(0.050)	(0.210)
Low-skilled white-collar	0.109	0.121*	0.176*	0.039	–0.015
	(0.106)	(0.083)	(0.069)	(0.524)	(0.807)
High-skilled white-collar	0.059	0.046	0.087	0.013	–0.002
	(0.335)	(0.434)	(0.317)	(0.845)	(0.971)
Sector (Reference group: Manufacturing)					
Construction sector	0.021	0.012	–0.004	0.084*	0.088**
	(0.622)	(0.791)	(0.948)	(0.083)	(0.031)
Trade sector	–0.036	–0.041	–0.039	0.218***	0.014
	(0.359)	(0.292)	(0.376)	(0.000)	(0.746)
Services sector	–0.044	–0.041	–0.047	0.137***	0.016
	(0.188)	(0.248)	(0.241)	(0.001)	(0.562)
Competition (Reference group: No/marginal competition)					
Average competition	0.040	0.004	0.062	0.047	–0.003
	(0.291)	(0.930)	(0.281)	(0.333)	(0.939)
Severe competition	0.079*	0.062	0.086	0.083	0.058
	(0.058)	(0.193)	(0.184)	(0.101)	(0.183)
Size (Reference group: 20 or less employees)					
21–100 employees	–0.040	–0.018	–0.060	0.029	0.054*
	(0.212)	(0.584)	(0.178)	(0.411)	(0.063)
101 or more employees	–0.089**	–0.088**	–0.106**	–0.049	0.101***
	(0.013)	(0.016)	(0.039)	(0.274)	(0.001)
Share of labour costs in total costs (Reference group: Up to 10%)					
11–25%	0.031	–0.009	0.121	0.039	0.014
	(0.386)	(0.831)	(0.136)	(0.460)	(0.646)
26–50%	0.103***	0.082*	0.209**	0.087*	–0.005
	(0.007)	(0.067)	(0.016)	(0.098)	(0.859)
51–100%	0.060	0.038	0.183	0.132**	0.020
	(0.188)	(0.448)	(0.103)	(0.032)	(0.618)
Survey year (Reference group: Survey 2009)					
Survey 2005	–0.132***	–0.133***	–0.114***	–0.417***	–0.289***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Survey 2007	–0.081***	–0.090***	–0.067**	–0.200***	–0.081***
	(0.002)	(0.000)	(0.035)	(0.000)	(0.000)
Wage change frequency (Reference group: lower than annual)					
Higher than annual	–0.011	0.008	–0.029	0.217***	0.048
	(0.792)	(0.872)	(0.565)	(0.000)	(0.369)
Annual	0.013	0.033	–0.002	0.098***	0.033
	(0.681)	(0.286)	(0.958)	(0.006)	(0.342)
State-dependent wage setting	0.029	0.049	0.019	–0.039	–0.013
	(0.258)	(0.115)	(0.529)	(0.229)	(0.492)

	Probit	Structural equation Heckman probit	Structural equation Modified Heckman	Selection equation Heckman probit	Selection equation Modified Heckman
Remuneration (Reference group: Monthly)					
Piece-rate remuneration	0.020	0.043	0.031	0.125***	0.058**
	(0.618)	(0.323)	(0.549)	(0.002)	(0.021)
Hourly remuneration	0.064*	0.058	0.092*	–0.026	–0.028
	(0.082)	(0.135)	(0.058)	(0.493)	(0.286)
Bonus (%)	–0.181**	–0.129	–0.270*	0.235***	0.156**
	(0.039)	(0.123)	(0.083)	(0.008)	(0.036)
Collective agreement	–0.024	–0.032	–0.089*	–0.016	0.043
	(0.569)	(0.499)	(0.068)	(0.796)	(0.442)
Rho			–0.105		
			(0.178)		
Chi-square statistic		1.527			90.13***
		(0.217)			(0.000)
Observations	708	844	664	844	904

*Notes: Marginal effects are reported. Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1.*

A8.4: Competitors' wage shock

		Structural equation		Selection equation	
	Probit	Heckman probit	Modified Heckman	Heckman probit	Modified Heckman
Main occupational group (Reference group: Low-skilled blue-collar)					
High-skilled blue-collar	0.027	0.028	0.022	0.016	–0.021
	(0.401)	(0.345)	(0.420)	(0.645)	(0.912)
Low-skilled white-collar	–0.120	–0.085***	–0.064*	–0.066	–0.117
	(0.127)	(0.000)	(0.077)	(0.245)	(0.589)
High-skilled white-collar	–0.030	–0.034	–0.019	0.032	0.027
	(0.623)	(0.402)	(0.695)	(0.563)	(0.770)
Sector (Reference group: Manufacturing)					
Construction sector	–0.013	–0.011	–0.003	0.147***	0.512
	(0.761)	(0.825)	(0.944)	(0.007)	(0.844)
Trade sector	–0.066	–0.043	–0.039	0.097*	0.211***
	(0.175)	(0.307)	(0.361)	(0.066)	(0.003)
Services' sector	–0.029	–0.010	–0.018	0.140***	0.215*
	(0.458)	(0.783)	(0.638)	(0.001)	(0.087)
Competition (Reference group: No/marginal competition)					
Average competition	0.039	0.055	0.037	0.081	0.088
	(0.577)	(0.161)	(0.522)	(0.134)	(0.719)
Severe competition	0.076	0.052	0.071	0.091*	0.081
	(0.279)	(0.142)	(0.294)	(0.100)	(0.682)
Size (Reference group: 20 or less employees)					
21–100 employees	0.032	–0.004	0.029	0.057	0.085
	(0.391)	(0.918)	(0.352)	(0.185)	(0.581)
101 or more employees	0.029	–0.000	0.029	0.087**	0.090
	(0.507)	(0.998)	(0.463)	(0.046)	(0.384)
Share of labour costs in total costs (Reference group: Up to 10%)					
11–25%	–0.029	–0.036	–0.030	–0.006	–0.117**
	(0.557)	(0.604)	(0.417)	(0.928)	(0.047)
26–50%	0.011	0.022	0.004	0.041	–0.072
	(0.818)	(0.737)	(0.929)	(0.518)	(0.577)
51–100%	0.015	0.008	0.008	0.053	–0.069
	(0.790)	(0.913)	(0.876)	(0.432)	(0.626)
Survey year (Reference group: Survey 2009)					
Survey 2005					
Survey 2007	0.080***	0.068**	0.072*	–0.089***	0.019
	(0.008)	(0.033)	(0.051)	(0.010)	(0.593)
Wage change frequency (Reference group: lower than annual)					
Higher than annual	0.059	0.125*	0.064	0.092	0.228
	(0.192)	(0.052)	(0.232)	(0.105)	(0.560)
Annual	–0.022	0.001	–0.014	0.059	0.146
	(0.583)	(0.970)	(0.744)	(0.136)	(0.828)
State-dependent wage setting	–0.012	–0.013	–0.012	0.058	0.018
	(0.688)	(0.675)	(0.612)	(0.103)	(0.771)

	Probit	Structural equation Heckman probit	 Modified Heckman	Selection equation Heckman probit	 Modified Heckman
Remuneration (Reference group: Monthly)					
Piece-rate remuneration	–0.091**	–0.064**	–0.059	0.053	0.094
	(0.027)	(0.041)	(0.126)	(0.153)	(0.759)
Hourly remuneration	–0.025	–0.014	–0.019	0.021	0.019
	(0.459)	(0.686)	(0.496)	(0.605)	(0.783)
Bonus (%)	0.134	0.160	0.109	0.119	0.018
	(0.124)	(0.149)	(0.192)	(0.344)	(0.977)
Collective agreement	0.001	0.030	0.006	0.066	0.071
	(0.987)	(0.630)	(0.891)	(0.327)	(0.371)
Rho			0.025		
			(0.780)		
Chi-square statistic		1.817			45.61***
		(0.178)			(0.000)
Observations	475	682	474		682

*Notes: Marginal effects are reported. Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1.*

Appendix 9: Probit and Heckman probit regressions: combined measure of asymmetric reaction

Shocks in sales turnover, output price and/or labour productivity

		Structural equation		Selection equation	
	Probit	Heckman probit	Modified Heckman	Heckman probit	Modified Heckman
Main occupational group (Reference group: Low-skilled blue-collar)					
High-skilled blue-collar	–0.002	0.001	0.038	0.022	0.045**
	(0.957)	(0.976)	(0.300)	(0.390)	(0.037)
Low-skilled white-collar	–0.001	–0.008	0.039	0.023	0.057*
	(0.988)	(0.888)	(0.578)	(0.520)	(0.070)
High-skilled white-collar	0.035	0.018	0.072	–0.045	0.006
	(0.593)	(0.745)	(0.321)	(0.351)	(0.898)
Sector (Reference group: Manufacturing)					
Construction sector	0.139***	0.146***	0.122*	0.084***	0.075**
	(0.006)	(0.002)	(0.095)	(0.007)	(0.017)
Trade sector	–0.006	0.007	–0.011	0.040	0.041
	(0.899)	(0.855)	(0.802)	(0.198)	(0.135)
Services sector	0.029	0.040	0.023	0.056**	0.035
	(0.487)	(0.256)	(0.593)	(0.047)	(0.138)
Competition (Reference group: No/marginal competition)					
Average competition	0.113***	0.115***	0.128**	0.031	0.026
	(0.008)	(0.001)	(0.020)	(0.350)	(0.386)
Severe competition	0.209***	0.198***	0.246***	0.051	0.056*
	(0.000)	(0.000)	(0.000)	(0.122)	(0.057)
Size (Reference group: 20 or less employees)					
21–100 employees	–0.090**	–0.070**	–0.077**	0.029	0.014
	(0.013)	(0.030)	(0.032)	(0.223)	(0.492)
101 or more employees	–0.127***	–0.099**	–0.107***	0.033	0.024
	(0.004)	(0.012)	(0.008)	(0.264)	(0.312)
Share of labour costs in total costs (Reference group: Up to 10%)					
11–25%	0.062	0.057	0.100	0.027	0.057**
	(0.192)	(0.169)	(0.103)	(0.473)	(0.028)
26–50%	0.133***	0.122***	0.167***	0.017	0.051**
	(0.005)	(0.003)	(0.007)	(0.653)	(0.041)
51–100%	0.177***	0.164***	0.201**	0.065	0.070*
	(0.003)	(0.002)	(0.017)	(0.111)	(0.069)
Survey year (Reference group: Survey 2009)					
Survey 2005	–0.218***	–0.222***	–0.162***	–0.294***	–0.252***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Survey 2007	–0.123***	–0.108***	–0.099***	–0.061*	–0.077***
	(0.000)	(0.000)	(0.001)	(0.062)	(0.000)
Wage change frequency (Reference group: lower than annual)					
Higher than annual	0.075	0.074	0.048	0.108***	0.082**
	(0.184)	(0.162)	(0.429)	(0.000)	(0.020)
Annual	0.080**	0.083***	0.070*	0.074***	0.040

		Structural equation		Selection equation	
	Probit	Heckman probit	Modified Heckman	Heckman probit	Modified Heckman
	(0.036)	(0.010)	(0.070)	(0.002)	(0.101)
State-dependent wage setting	0.000	–0.008	–0.002	0.006	0.002
	(0.999)	(0.767)	(0.933)	(0.782)	(0.901)
Remuneration (Reference group: Monthly)					
Piece-rate remuneration	0.082*	0.093**	0.069	0.072***	0.064***
	(0.072)	(0.026)	(0.155)	(0.002)	(0.002)
Hourly remuneration	0.045	0.040	0.033	–0.047*	–0.032
	(0.256)	(0.261)	(0.417)	(0.090)	(0.132)
Bonus (%)	–0.103	–0.091	–0.197*	0.065	0.085*
	(0.265)	(0.267)	(0.068)	(0.247)	(0.052)
Collective agreement	–0.060	–0.065	–0.115**	0.084***	0.071***
	(0.226)	(0.153)	(0.022)	(0.002)	(0.000)
Rho			–0.063		
			(0.596)		
Chi-square statistic		11.09***			99.55***
		(0.001)			(0.000)
Observations	801	917	738	917	936

*Notes: Marginal effects are reported. Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1.*