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## How are firms' wages and prices linked: survey evidence in Europe

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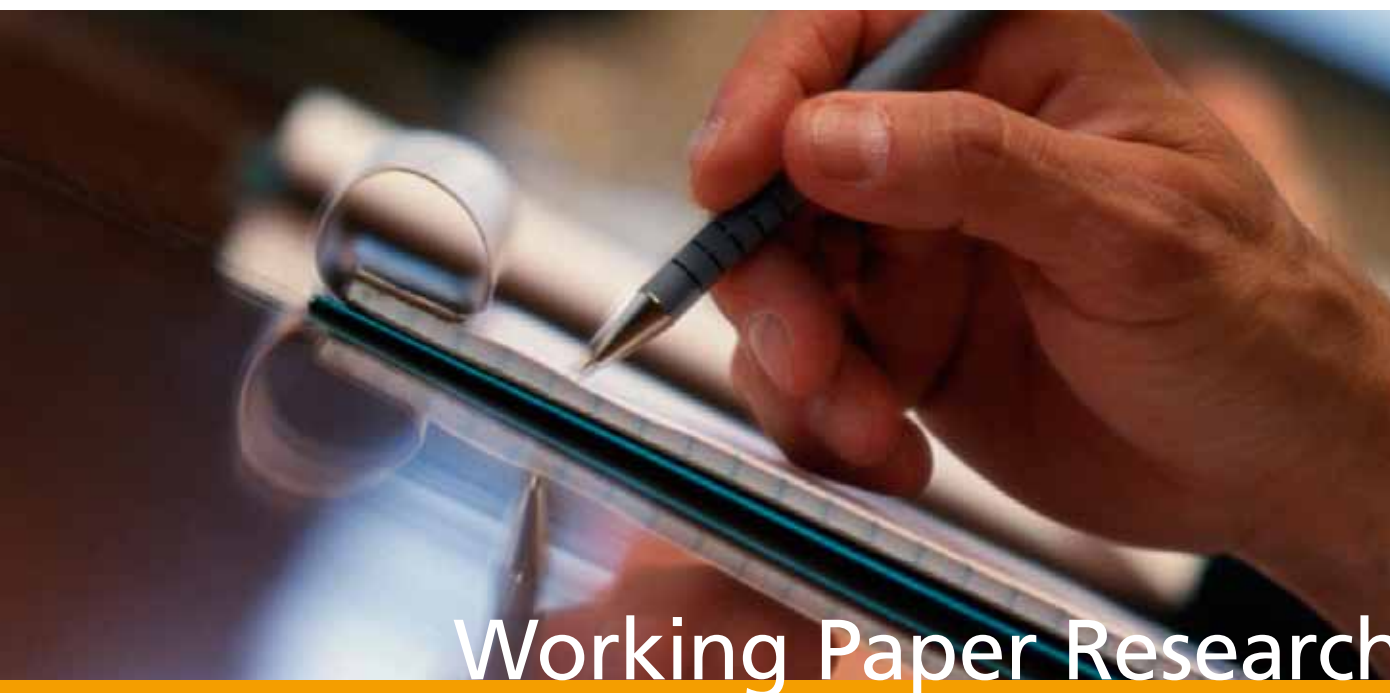
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# How are firms' wages and prices linked: survey evidence in Europe



## Working Paper Research

by Martine Druant, Silvia Fabiani, Gabor Kezdi, Ana Lamo,  
Fernando Martins and Roberto Sabbatini

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## Abstract

This paper presents new evidence on the patterns of price and wage adjustment in European firms and on the extent of nominal rigidities. It uses a unique dataset collected through a firm-level survey conducted in a broad range of countries and covering various sectors. Several conclusions are drawn from this evidence. Firms adjust wages less frequently than prices: the former tend to remain unchanged for about 15 months on average, the latter for around 10 months. The degree of price rigidity varies substantially across sectors and depends strongly on economic features, such as the intensity of competition, the exposure to foreign markets and the share of labour costs in total cost. Instead, country specificities, mostly related to the labour market institutional setting, are more relevant in characterising the pattern of wage adjustment. The latter exhibits also a substantial degree of time-dependence, as firms tend to concentrate wage changes in a specific month, mostly January in the majority of countries. Wage and price changes feed into each other at the micro level and there is a relationship between wage and price rigidity.

Key Words: survey, wage rigidity, price rigidity, indexation, institutions, time dependent

JEL Classification: D21, E30, J31

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The opinions expressed in the papers are those of the authors and do not necessarily reflect the views of the institutions they belong to.

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# 1 Introduction

This paper studies the frequency, timing and interaction of wage and price changes across firms, covering several economic sectors and a broad range of European countries. It provides new micro-founded evidence for models of wage and price staggering that have become very popular in New Keynesian DSGE models. The important role of labour markets in generating price rigidity in structural models is discussed for instance in Altissimo et al. (2006). By incorporating real wage rigidities, i.e. the slow adjustment of real wages to underlying market conditions, in the framework of a New Keynesian Philips Curve, these models seem to fit better the data. Approaching the analysis of price and wage dynamics simultaneously can also shed light on the impact of recent changes in labour market institutions on wage and labour cost dynamics. For example, it can provide useful insights on the sources behind the substantial degree of wage moderation observed in a number of European countries, which in turn could be potentially useful in terms of implications for monetary policy and structural reform.

This paper uses a new and unique cross-country dataset – unprecedented by international standards in terms of both geographical and sectoral coverage – based on an ad-hoc survey on wage and pricing policies at the firm level. The survey was developed within the Wage Dynamics Network (WDN), a research network grouping 23 central banks in the EU and coordinated by the European Central Bank. It was carried out by 17 national central banks (12 of which belonging to the euro area and 5 new EU member states) between the end of 2007 and the first half of 2008, on the basis of a harmonised questionnaire that aimed at uncovering specific features of firm's price and wage setting policies and their relationships. Overall, more than 17,000 firms were interviewed, belonging to different size classes and operating in different sectors of the economy. The uniqueness of this survey is at least twofold. First, its country coverage: given the large heterogeneity of labour markets across European countries, the harmonised questionnaire allows to widen our understanding of the effects of different labour market institutions and policies in price and wage setting practices. Second, the scope and richness of the information collected. In addition to collecting information on both price and wage setting and adjustments, the survey collects information on firm's characteristics such as the sector of activity, its size, the structure of the product market in which it operates, the intensity of competitive pressures on this market, the structure of its labour force and institutional features potentially affecting its wage and labour policies.

The use of surveys to investigate pricing policies was pioneered by the seminal work of Blinder (1991) and Blinder et al. (1998) and led to similar analyses in other countries as well as in the euro area, in the context of a previous research network grouping central banks of the Eurosystem, the Inflation Persistence Network (IPN; for the results, see Fabiani et al., 2007). The survey on which this paper is based can be regarded as the “natural” follow-up to some of the evidence on price behaviour revealed by the IPN (Altissimo et al., 2006; Fabiani et al., 2007). Indeed one of the most interesting finding of studies based on micro quantitative and survey data (see Alvarez et al., 2006; Dhyne et al., 2007; Vermeulen, et al., 2007; Fabiani et al., 2006) is the substantial heterogeneity in the degree of price stickiness across products and sectors, related among many other factors to the variability of input costs and the cost structure at the firm and sectoral level. This evidence, albeit anecdotic, raises the question of whether the observed dispersion in the frequency of price changes is the result of wage inertial behaviour, placing firms' wage setting policies at the heart of our research interests.

In the existing literature, surveys focused on wage setting at the firm level are mostly aimed at disentangling the existence and the reasons of downward wage rigidity; seminal works in this field are those by Blinder (1990), Agell and Lundborg (2003), Campbell and Kamlani (1997) and Franz and Pfeiffer (2006). This paper enriches this line of research by exploring other dimensions of wage setting, focusing explicitly on how firms set and adjust prices and wages and on the relationship

between wage and pricing policies and adjustments.<sup>1</sup> In particular, it aims at providing answers to the following questions: (i) How often are prices and base wages changed in Europe? Are adjustments synchronized or not and do they tend to take place in specific months of the year? (ii) Are there significant differences across firms, sectors and countries regarding the frequency and timing of wage and price changes and their relationship? If such differences are indeed present, how do they eventually relate to institutional and structural features such as the nature of wage negotiations, the presence of forms of indexation of wages to prices, the intensity of competitive pressures, the structure of the workforce, or the labour intensity of production as suggested by the IPN results?

The structure of the paper is the following. Section 1 briefly presents the WDN survey and the data collected. Section 2 focuses on descriptive evidence on the frequency and timing of price and wage changes at the firm level, their relationship and the variation across countries and sectors. Section 3 investigates, within a multivariate econometric analysis, the role of various explanatory factors of price and wage changes at the firm level. Section 4 summarizes the main findings.

## 2 Data and sample

The data used for this paper is a subset of the dataset collected by the WDN survey. It concentrates on 15 countries for which fully harmonised data are available; namely: Austria, Belgium, Czech Republic, Estonia, France, Greece, Hungary, Italy, Ireland, Lithuania, the Netherlands, Poland, Portugal, Slovenia and Spain. Although the national surveys were organized and carried out by each national central bank, the questionnaire and the target population of firms were very similar across countries. A “core questionnaire” was developed in a co-coordinated fashion within the WDN and was adopted by all participant countries with at most minor modifications.<sup>2</sup> Country-level micro data were pooled together into a common dataset. It covers firms employing more than 5 employees and operating in manufacturing, construction and services (trade, market services and financial intermediation).<sup>3</sup>

Sample size, sampling probabilities and non-response patterns vary across countries as well as across sectors and firms’ size within countries. In general, studies based on survey data need to handle this heterogeneity. We adopt employment-adjusted weights, where the weight attached to each firm in the sample refers to how many employees that observation represents in the population.<sup>4</sup>

Tables 1 and 2 present the sample composition by country, sector and firm size. Table 2 also shows the distribution based on the number of employees represented by the sample. The total number of firms is just below 15,000, representing almost 48 million employees. By design, the

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<sup>1</sup> Other studies produced in the context of the WDN investigate different dimensions of the survey. Babecky et al. (2008) focus on nominal and real wage rigidity by examining not only the issue of flexibility in base wages but also alternative margins of labour costs adjustment at the firm level. Bertola et al. (2008) analyse firms’ dominant adjustment strategies in reaction to unanticipated changes in demand, costs and wages and investigate some possible determinants underlying this choice. Galuscak et al. (2008) deal with the issue of wages of newly hired workers and investigate the relative importance of internal, external and institutional factors in this particular market.

<sup>2</sup> An exception is Germany, where the data collected are not fully comparable. This explains why Germany is not included in our sample.

<sup>3</sup> See Appendix 1 for details on the survey and on national samples and Appendix 2 for the questionnaire. Questions labelled as “non-core” refer to those questions that countries had the option not to include in their national questionnaires.

<sup>4</sup> The weights are defined as the sum of all employees in the population in a sampling category (by country, sector, firm size category, perhaps region) divided by the number of observations (firms) in that category. They can also be thought of as the product of three fractions: the intended sampling probability, the response rate, and employees per firm. They add up to total employment in the population the sample represents.

sample is relatively balanced across firm size categories, and its sectoral distribution closely follows that of employment.

Table 1 – Sample composition by country

Country	Number of firms	%
AT	548	3.67
BE	1,420	9.5
CZ	399	2.67
EE	366	2.45
ES	1,769	11.84
FR	2,011	13.46
GR	401	2.68
HU	1,959	13.11
IE	848	5.68
IT	952	6.37
LT	333	2.23
NL	1,068	7.15
PL	896	6
PT	1,320	8.84
SI	650	4.35
<b>Total</b>	<b>14,940</b>	<b>100</b>

Table 2 – Sample composition by sector and size and the employment population represented

(a) Number of observations

	5-19	20-49	50-199	>200	Total
Number of firms:					
Manufacturing	887	1,271	2,267	1,778	6,203
Construction	378	312	337	114	1,141
Trade	1,189	737	793	362	3,081
Market services	1,350	1,060	1,045	726	4,181
Financial services	108	35	78	113	334
<b>Total</b>	<b>3,912</b>	<b>3,415</b>	<b>4,520</b>	<b>3,093</b>	<b>14,940</b>
Employees ( <i>thousands</i> ):					
Manufacturing	2209	4202	5124	7793	19328
Construction	832	605	657	341	2435
Trade	2928	2496	1971	2405	9800
Market services	2545	2638	3056	6797	15036
Financial services	162	86	255	531	1034
<b>Total</b>	<b>8677</b>	<b>10026</b>	<b>11063</b>	<b>17867</b>	<b>47633</b>

(b) Percentages

	5-19	20-49	50-199	>200	Total
Number of firms:					
Manufacturing	5.9	8.5	15.2	11.9	41.5
Construction	2.5	2.1	2.3	0.8	7.6
Trade	8.0	4.9	5.3	2.4	20.6
Market services	9.0	7.1	7.0	4.9	28.0
Financial services	0.7	0.2	0.5	0.8	2.2
<b>Total</b>	<b>26.2</b>	<b>22.9</b>	<b>30.3</b>	<b>20.7</b>	<b>100</b>
Employees:					
Manufacturing	4.6	8.8	10.8	16.4	40.6
Construction	1.7	1.3	1.4	0.7	5.1
Trade	6.1	5.2	4.1	5.0	20.6
Market services	5.3	5.5	6.4	14.3	31.6
Financial services	0.3	0.2	0.5	1.1	2.2
<b>Total</b>	<b>18.2</b>	<b>21.0</b>	<b>23.2</b>	<b>37.5</b>	<b>100</b>

An advantage of this survey is that firms were directly asked about a number of features referring to the institutional setup within the firm or to the environment where it operates (e.g. the degree of competition or the existence of a policy at the firm level that adjusts wages to inflation). Information on these features is rarely available in administrative and other datasets. On the other hand, the survey suffers from several shortcomings inherent in ad hoc surveys, such as low rates of response and potential misunderstandings in interpreting the questions. Moreover, results may be



influenced by the specific economic situation prevailing in each country at that time interviews were carried out (around the end of 2007 and the beginning of 2008).

### **3 Price and wage adjustment: frequency, timing and interaction**

The adjustment mechanism of prices and wages followed by firms plays a crucial role on the transmission of economic shocks. In particular, the degree of price and wage rigidity determines the speed of adjustment of the economy and the amount of the related costs. A deep understanding of the extent and sources of rigidity is therefore of major importance for assessing the effects of monetary policy and calibrating macroeconomic models for policy analysis.

Despite the relevance of the issue, available empirical evidence, comparable across countries and sectors, on the stickiness of wages is rather scarce. Concerning price adjustment, instead, studies conducted within the IPN revealed a somewhat high degree of stickiness in the euro area, as measured by the frequency of price changes, especially when compared to the United States. This finding was supported consistently by evidence based on both survey data (Fabiani et al. 2007) and quantitative micro consumer and producer price data (Dhyne et al. 2007; Vermeulen et al. 2007). Another important and robust result of these studies was the substantial heterogeneity of the frequency of price changes across products and sectors, which appears to be related, among other factors, to the variability in the cost structure at the firm and sectoral level, in particular in the relative importance of labour costs.<sup>5</sup>

The information on price and wage adjustment collected by the WDN survey contributes to fill the gap related to the lack of data on wage policies at the firm level and to address the issue of the degree of price and wage stickiness simultaneously. In the rest of this section we present some descriptive evidence on three different aspects related to this issue: i) the frequency of wage and price changes; ii) the prevailing mechanism of adjustment (time vs. state dependence) and its timing; and iii) the extent to which wage changes feed into price changes and vice versa.

#### **3.1 How often are prices and wages adjusted?**

The frequency of price and wage changes provides a rough measure of the extent of nominal rigidities which are, among other things, an essential ingredient in the calibration of standard DSGE models with staggered adjustment mechanisms that are widely used for monetary policy analysis (see, among others, Woodford, 2003, Gali et al. 2003, Smets and Wouters, 2003).

On this issue, the WDN survey explicitly asked firms about the frequency of price changes for their main product (see Appendix 2, question 31) and of wage changes for their main occupational group (question 9). In the former case, firms could choose between the following range of categories: daily, weekly, monthly, quarterly, twice a year, once a year, less frequently than once a year, other. The frequency of wage adjustment was instead tackled through three separate questions capturing different types of wage changes: those due to factors unrelated to tenure and/or inflation, those due to tenure and those due to inflation. The exact wording of the question in each case is the following: “How frequently is the base wage of an employee belonging to the main occupational group in your firm typically changed?”. Respondents could choose from the options: more than once a year; once a year; once every two years; less frequently than once every two years; never / don’t know.

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<sup>5</sup> Consumer price data and survey results show that prices are changed least often in the services sector. Producer price data suggest that the frequency of price changes is highest for those products that have not undergone many transformations and, hence, whose costs are closely linked to the typically rather volatile raw material prices. A similar heterogeneity across sectors is found in the United States.

In the analysis of the answers concerning price setting, we aggregate the first three options, on the one hand, and the fourth and fifth, on the other, and end up with four categories: daily to monthly, quarterly to half-yearly, yearly and less frequent than yearly. As for wages, we aggregate the third and fourth categories into a single one, which we label as “less frequently than once a year”. In order to simplify the description of results, in the rest of this paper we consider a synthetic measure, defined as the highest frequency of firm-level wage change among the three types described above (due to factors unrelated to tenure and/or inflation, due to tenure; due to inflation).

Table 3 - Frequency of price and wage changes across sectors  
(percentages)

PRICES					
	Daily to monthly	quarterly to half yearly	yearly	less frequently than once a year	no pattern
<b>Total</b>	<b>9.2</b>	<b>15.4</b>	<b>39.2</b>	<b>7.4</b>	<b>28.5</b>
Manufacturing	5.3	16.1	43.4	7.8	27.3
Construction	7.6	20.4	29.5	7.2	35.2
Trade	22.9	20.3	27.4	3.2	26.1
Market services	5.4	10.4	44.3	9.8	29.9
Financial services	14.8	18.4	23.0	5.4	36.7
<i>Standard deviation</i>	7,6	4,1	9,7	2,5	4,7

WAGES (for any reason)				
	more frequently than once a year	yearly	less frequently than once a year	never/don't know
<b>Total</b>	<b>12.1</b>	<b>59.5</b>	<b>25.6</b>	<b>2.9</b>
Manufacturing	12.3	59.1	26.5	2.1
Construction	21.5	59.9	15.6	3.0
Trade	10.8	58.3	27.3	3.6
Market services	10.9	60.7	24.9	3.5
Financial services	15.6	59.8	23.1	1.5
<i>Standard deviation</i>	4,5	0,9	4,7	0,9

Notes: Figures weighted by employment weights, rescaled excluding non-responses.

Tables 3 and 4 show that in general price adjustments are more frequent than wage adjustments. About half of the firms change prices once a year or less frequently; a quarter do it more often, while the remaining ones do not report any particular pattern. Wages are changed less frequently: for 85 percent of firms once a year or less often, only for 12 percent more often.

The disaggregation by sector and country reveals a substantially higher dispersion in the frequency of price adjustment across sectors than across countries, whereas the opposite is true in the case of wage adjustment. Firms in manufacturing and market services adjust prices much less often than those in trade and financial services, while construction is the sector with the highest fraction of firms reporting no regular pattern in price revisions (Table 3).<sup>6</sup> As regards wages, the cross-sectoral variation is lower. Wage changes are least frequent in trade and business services, more frequent in manufacturing and most frequent in construction. Even in this latter sector, though, 60 percent of the firms report adjustments at the yearly frequency and only 22 percent at a higher frequency.<sup>7</sup>

When looking at differences across countries, the top panel of Table 4 shows that the variability in the frequency of price changes is lower than across sectors. Poland, Lithuania, Ireland and the Netherlands are the countries with the highest fraction of firms revising prices more than once a year, whereas Hungary, Spain and France are those with the lowest; for the whole euro area, this fraction is 22 percent, about ten percentage points lower than for the non-euro area aggregate.

<sup>6</sup> When interpreting the results concerning financial services, a note of caution regards, on the one hand, the concept of price, which might be difficult to capture for respondents, and, on the other, the fact that in most countries interviews were carried out in a period of exceptional turbulence on international financial markets.

<sup>7</sup> A comparable analysis has been done by size classes, as defined in Section 1. Differences in frequencies of price and wage changes by firms' size turn out to be negligible.

Substantial cross-country variation is instead observed in the case of wages (bottom panel in Table 4). Lithuanian, Greek and Slovenian firms adjust base wages most frequently, followed by Belgium, France and Estonia, while Hungary, Italy and Portugal are the countries with the lowest fraction of firms changing wages more often than yearly. The modal frequency is one year in all countries except Italy and Lithuania. Despite the large differences across individual countries, the frequency distribution is broadly similar when one compares the euro-area and non-euro area aggregates.

Table 4 - Frequency of price and wage changes across countries  
(percentages)

	PRICES				
	daily to monthly	quarterly to half yearly	yearly	less frequently than once a year	no pattern
<b>Total</b>	<b>9.2</b>	<b>15.4</b>	<b>39.2</b>	<b>7.4</b>	<b>28.5</b>
<b>Euro area</b>	<b>9.0</b>	<b>12.9</b>	<b>40.8</b>	<b>5.1</b>	<b>32.1</b>
Austria	11.6	13.2	37.3	4.9	32.9
Belgium	8.5	12.2	43.9	6.1	28.9
France	5.5	14.3	49.3	4.2	26.6
Greece <sup>1</sup>	3.6	18.2	40.8	6.6	30.8
Ireland	14.8	15.4	33.6	6.7	29.1
Italy	8.9	12.9	32.3	6.5	39.3
Netherlands	12.7	16.0	44.4	5.6	21.4
Portugal	7.9	12.2	44.2	2.1	33.6
Slovenia	7.7	17.2	37.5	6.2	26.4
Spain	10.4	7.7	47.3	3.1	31.2
<b>Non- Euro Area</b>	<b>9.9</b>	<b>22.5</b>	<b>35.0</b>	<b>13.6</b>	<b>18.6</b>
Czech Republic	9.7	12.6	36.3	8.5	32.7
Estonia	5.1	18.4	32.5	8.8	34.7
Hungary	6.1	10.3	45.2	8.6	28.0
Lithuania	8.9	27.8	20.4	11.0	30.3
Poland	11.1	27.7	34.2	16.8	10.2
<i>Standard deviation</i>	3.0	5.7	7.5	3.5	6.7

	WAGES (for any reason)			
	more frequently Than once a year	yearly	less frequently than once a year	never/don't know
<b>Total</b>	<b>12.1</b>	<b>59.5</b>	<b>25.6</b>	<b>2.9</b>
<b>Euro area</b>	<b>11.4</b>	<b>59.5</b>	<b>26.4</b>	<b>2.7</b>
Austria	6.8	84.2	5.9	3.1
Belgium	22.0	64.8	9.8	3.4
France	19.7	74.1	5.2	1.1
Greece <sup>1</sup>	33.9	56.4	9.7	0.0
Ireland	14.6	71.2	9.9	4.3
Italy	4.2	26.9	64.6	4.3
Netherlands	10.8	70.1	17.0	2.1
Portugal	5.9	82.2	8.4	3.5
Slovenia	27.2	65.6	5.9	1.3
Spain	11.9	84.1	2.5	1.5
<b>Non- Euro Area</b>	<b>14.0</b>	<b>59.5</b>	<b>23.2</b>	<b>3.3</b>
Czech Republic	11.5	64.1	23.0	1.4
Estonia	19.9	64.4	10.5	5.2
Hungary	2.6	75.0	12.2	10.2
Lithuania	42.1	44.0	7.5	6.4
Poland	13.6	56.3	28.2	1.9
<i>Standard deviation</i>	11.2	15.4	15.4	2.6

Notes : Figures weighted by employment weights, rescaled excluding non-responses. The split up between frequencies of wage changes has to be interpreted differently for Greece, as the options never/don't know were not allowed in the Greek questionnaire.

Overall, the higher dispersion in the frequency of price adjustment across sectors than across countries suggests that product market characteristics (e.g. the degree of competition, the exposure to foreign competitive pressures, the cost structure, etc.) are important determinants of firms'

pricing behaviour and potential sources of the degree of price stickiness. Conversely, the strong heterogeneity across countries that emerges with regard to wage change frequencies is a sign that the institutional setting, in particular the bargaining mechanisms, their coverage and their degree of centralisation, may be important forces behind the rigidity of wages. For instance in Italy, though expected inflation is embedded in wage negotiations, the latter are mostly centralised and carried out every two years; hence, firms consistently report very rare infra-annual wage adjustments.

The evidence on the frequency of adjustment discussed so far can also be summarised through an alternative measure of nominal rigidity, i.e. the number of months for which prices and wages remain unchanged (“duration”). The computation of the duration indicator is still based on the answers concerning the frequency of price and wage changes but requires additional specific assumptions. In particular, whereas most of those answers directly translate into durations (e.g. “once a year” translates into a duration of 12 months), a few of them refer to intervals (e.g. “less frequently than once every two years”). In order to impute expected durations in these latter cases, we assume that the underlying distribution of durations is lognormal (with different moments for prices and wages), we estimate the parameters of the distributions from the other answers, and compute the conditional expectations for these categories.

The results on duration should, therefore, be regarded as approximations, as the imputations are based on untestable distributional assumptions (see Appendix 3 for details). The impact of these assumptions on the estimates reported below is, however, quite negligible, as they concern only a minority of answers.<sup>8</sup> Another important qualification is that price durations are not computed for around one-fourth of firms that report “no pattern” to the question on the frequency of price changes. A similar omission applies to wage changes, since wage durations are not computed for firms that report “never/don’t know” to the question on the frequency of wage changes; however, in this case it is much less relevant since it concerns only 3 percent of the firms.

Table 5 shows that wages in European firms remain unchanged, on average, longer than prices (15 months against around 10). The estimate for prices is in line with the evidence emerged from the studies conducted within the IPN, which point to marginally longer durations: 11 months on the basis of survey data and around 13 months on the basis of micro-consumer price data. This slight difference might be related to both the fact that the sample of countries for which data are available is larger in the WDN survey and that the period in time to which data refer is different.

Looking at sectoral differences, our results reveal that prices set by manufacturers and business services firms tend to remain unchanged on average for just less than one year, whereas those set in trade and financial services seem to be more flexible, with durations of 7 and 8 months, respectively. Conversely, average wage durations vary much less across sectors, with a low of 13 months in construction to a high of 15 in trade. No remarkable differences emerge in price durations between euro area and non-euro area countries. In the case of wages, the relatively higher duration recorded for the euro area aggregate is entirely due to Italy, where wages remain unchanged for around 2 years, consistently with the wage bargaining institutional setup (see Du Caju et al. 2008), whereas in all the remaining countries average duration is almost 12 months.

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<sup>8</sup> The robustness of the results reported below has been assessed by computing duration measures under alternative assumptions concerning the number of months corresponding to the frequency intervals that do not directly translate into a point estimate. These robustness tests are not shown here but are available from the authors upon request.

Table 5 – Estimated average duration of price and wage spells  
(months)

	Prices	Wages
<b>Total</b>	<b>9.6</b>	<b>14.9</b>
Manufacturing	10.2	14.9
Construction	9.1	13.3
Trade	6.7	15.3
Market services	10.9	14.9
Financial intermediation	7.7	14.4
<b>Euro area</b>	<b>9.6</b>	<b>15.0</b>
Austria	9.1	12.5
Belgium	9.9	12.6
Spain	9.7	11.9
France	10.1	12.0
Greece	10.2	11.9
Ireland	8.5	12.8
Italy	9.5	20.3
Netherlands	9.1	13.9
Portugal	9.5	12.9
Slovenia	9.6	11.8
<b>Non-Euro area</b>	<b>9.6</b>	<b>14.7</b>
Czech Republic	9.7	14.6
Estonia	10.0	12.7
Hungary	10.7	13.8
Lithuania	8.4	11.4
Poland	9.5	15.4

Notes: Figures weighted by employment weights, rescaled excluding non-responses.

### 3.2 The timing of adjustment

In addition to the frequency of price and wage adjustment, and partly related to it, another indicator that signals the presence and extent of nominal rigidities is the nature of the adjustment itself. In order to account for the fact that individual firms do not continuously change their prices and wages in response to all the relevant shocks that hit them, in the literature firms' strategies are modelled either as a time-dependent process, where the timing of the adjustment is exogenously given and does not depend on the state of the economy, or as a state-dependent one. In presence of frequent shocks, the former might lead to stickier prices and wages than the latter, provided that the time frame is quite large and the cost of adjustment is low enough. Hence, which of the two approaches reflects better firms' actual behaviour has important implications for monetary policy makers.<sup>9</sup>

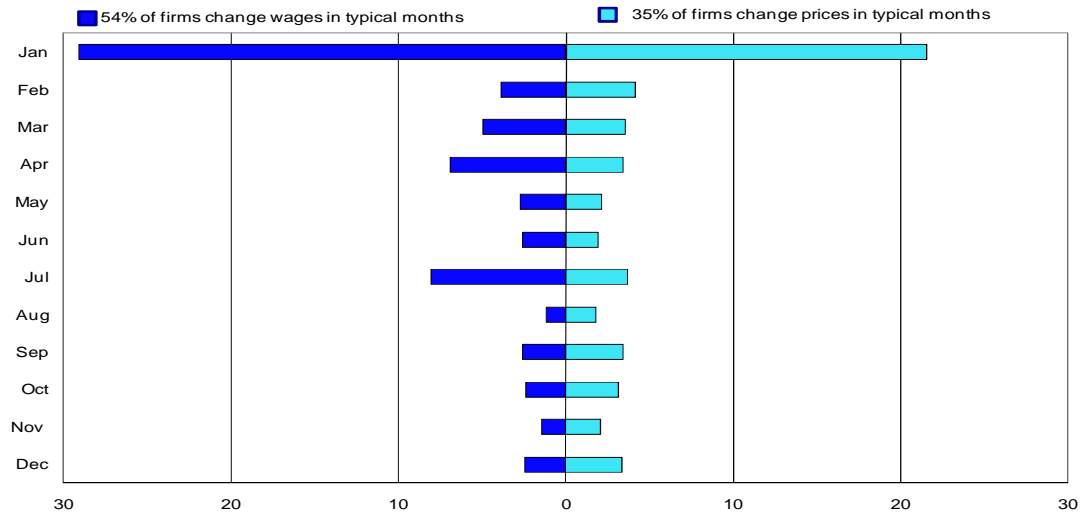
In particular, the degree of bunching of wage setting decisions may have an impact on the transmission of monetary policy decisions to the real economy. For instance, Olivei and Tenreyro (2008) show that in Japan, where most firms set their wages between February and May, in what is known as "Shunto", a monetary policy shock occurring in the first part of the year should produce a smaller impact on real activity, since this is a period of more flexible wages, than a shock occurring later in the year. Olivei and Tenreyro (2007) derive similar results for the U.S. where wage changes concentrate at the turn of the year; they find that monetary policy shocks that take place in the second half of the year have insignificant effects on aggregate activity.

With a view on obtaining more empirical evidence on these issues, in the WDN survey firms were asked to specify whether their wage and price changes take place with no predefined pattern or

<sup>9</sup> According to IPN results, firms' price setting is characterized by elements of both time and state dependence: on average 34 percent of firms use purely time-dependent rules, whereas around two-thirds adopt a mixed strategy (as in Sheshinski and Weiss 1977). Most price adjustments occur at the beginning of the year (January) and after the summer period (especially in September).

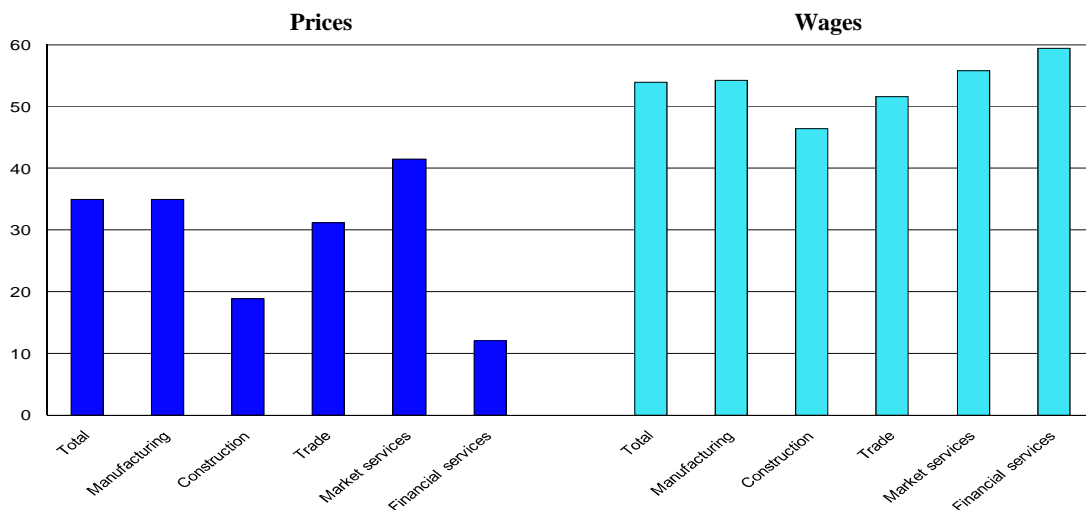
are concentrated in particular month(s) (see Appendix 2, questions 10 and 32). The results reported in Figure 2 show that time-dependent wage adjustment is significantly more widespread as a rule adopted by firms than time-dependent price adjustment. Indeed, the fraction of firms that typically change wages in specific months is 54 percent, whereas in the case of prices it amounts to 35 percent. Among these firms, there appears to be a considerable degree of synchronisation in the timing of both price and wage change, with significant clustering in January. In the case of wage adjustment, smaller peaks also appear in July and April.

**Figure 2 - Timing of wage and price changes at the firm level**  
(percentages of firms reporting to change wages/prices in a particular month)



Notes: Figures weighted by employment weights, rescaled excluding non-responses.

**Figure 3 – Time-dependent price and wage adjustment across sectors**  
(percentages of firms reporting to change wages/prices in a particular month)



Notes: Figures weighted by employment weights, rescaled excluding non-responses.

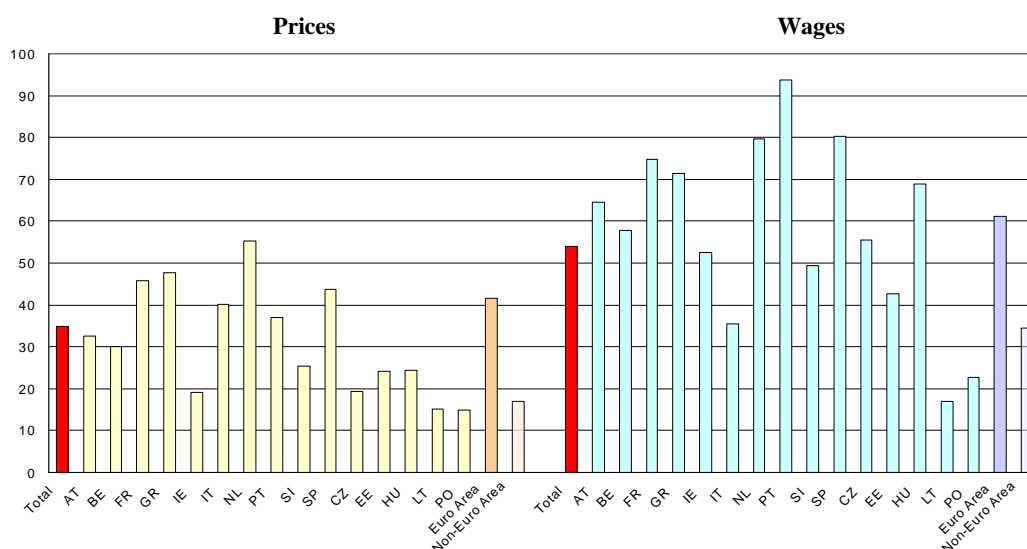
Looking at the sectoral dimension, the variability in the adoption of regular time-dependent rules in price revisions is quite remarkable, consistently with the high dispersion found in the frequency of the revisions themselves. The concentration in particular months is least common in financial services and more widespread in market services (Figure 3); in all sectors January is the month when the largest part of price changes occurs. Conversely, the pattern of concentration of wage changes is very similar across sectors, although slightly below average in construction and trade. Also in this case, wage adjustments occur mostly in January in all sectors, though July also

has some significance in manufacturing and market services and more staggering across different months is detected in financial services. While in all sectors wage changes are generally more time-dependent than price changes, the difference is particularly pronounced in financial intermediation, where only 12 percent of firms follow this type of rule for prices, as against 59 percent for wages.

The finding that time-dependent adjustment mechanisms are more widespread for wages than for prices might be related to the existence of wage indexation mechanisms in some countries, as well as to the presence of institutional arrangements within the firm itself or at the national or sectoral level. Indeed, the cross-country differences in both the incidence of time-dependence and the timing of wage changes are quite remarkable. Lithuania is the country with the lowest fraction of wage changes concentrated in specific months (17 percent); at the other extreme Portugal has the highest fraction (94 percent). This indicator of relative wage rigidity is consistent with the respectively high and low frequency of wage adjustment found in the two countries (see Section 1). More generally, the percentage of firms that adopt time-dependent wage rules exceeds 70 percent in Spain, the Netherlands, France and Greece and is overall much higher for euro area countries (61 percent) than for non-euro area ones (34 percent), possibly in relation to the more widespread diffusion of collective bargaining agreements and indexation clauses in the euro area.

There appears to be a significant geographical variability also in the timing of wage adjustments. Although in all economies the majority of time-dependent wage changes occur in January, other specific months are indicated by relatively large shares of firms: July in Belgium, France and Lithuania; May in Austria; August in Slovenia, April in Ireland and September in Greece. These country-specificities in the time-patterns of wage change are confirmed both by micro wage data available at an infra-annual level and by the analysis of collective agreements carried out in the context of the WDN (see Du Caju et al., 2008), showing that the monthly pattern of wage changes is linked to the timing of wage negotiations.<sup>10</sup> Some variation across countries can also be observed in the pervasiveness of time-dependent pricing, albeit less pronounced than in the case of wages (Figure 4). Overall, the fraction of euro area firms that carry out price adjustments with a regular timing is higher than in non-euro area countries as a whole (42 vs 17 percent, respectively). In all economies, most price changes occur in January.

Figure 4 – Time-dependent price and wage adjustment across countries  
(percentages of firms reporting to change wages/prices in a particular month)



Notes: Figures weighted by employment weights, rescaled excluding non-responses.

<sup>10</sup> The peak in the frequency of wage change in the beginning of each year emerges also from other studies conducted within the WDN on the basis of micro quantitative data for a number of individual countries (Knell and Stiglbauer 2008 for Austria; Heckel et al. 2008 for France, Lünemann and Wintr 2008 for Luxembourg).

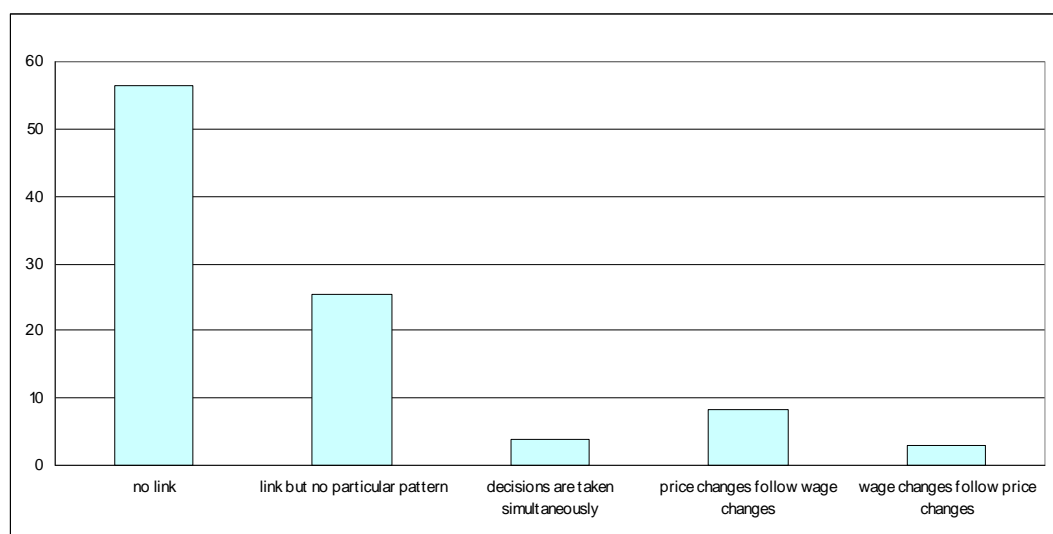
### 3.3 The interaction between wage and price adjustment

Having assessed the degree of rigidity of wages and prices as captured by the frequency and the nature of the adjustment process, we focus explicitly on the interaction between wage and pricing policies at the firm level. In this context we address both the issue of whether firms' wage and price adjustment are related (and the causal link between the two) and the extent to which they actually feed into each other.

The WDN survey provides direct information on various aspects of this relationship, such as the link between price and wage changes at the firm level, the response of the former to wage shocks, the existence and nature of internal policies adjusting wages to inflation and the frequency of wage changes due to inflation.

One of the findings stemming from the analysis in Section 2.2 is that there appears to be some broad synchronisation between the timing of price and wage changes, with peaks in January in both cases. Indeed, when looking at individual firms, it turns out that around half of those that change prices in January also adjust wages in the same month. This evidence is confirmed by the fact that, when explicitly asked about how the timing of price changes relates to that of wage changes within their company (see Appendix 2, question 33), around 40 percent of firms acknowledge the existence of some relationship between the two (Figure 5). However, only 15 percent state that this relationship is relatively strong. For half of them decisions on price changes follow those on wage changes. The opposite holds for another 3 percent, while decisions are simultaneous in the remaining 4 percent. The patterns with respect to intensity and direction of the relationship are very similar across sectors and across countries.

Figure 5 - The relationship between wage and price changes at the firm level  
(percentages)



Notes: Figures weighted by employment weights, rescaled excluding non-responses.

The finding that the majority of firms (60 percent) does not explicitly recognise a direct relationship between their “typical” price and wage change decisions does not automatically imply that the two policies are not related. Indeed, other pieces of evidence arising from the WDN survey suggest that wages and prices feed into each other at the micro level.

The existence and extent of the pass-through of wages into prices can be gauged by analysing the strategies firms declare to implement in reaction to shocks. Indeed, when asked to assess the relevance of different adjustments policies to a common permanent unexpected increase in wages about 60 percent of firms reported that they would increase prices (see Table 6 and ECB, 2009).



The possible options they could choose among where: i) a reduction in (other) costs; ii) an adjustment of prices; iii) a reduction of profit margins; iv) a reduction in output.

In a study also based on the WDN survey, Bertola et al. (2008) argue that the pass-through of wages into prices is particularly strong in firms with a high labour share, confirming previous evidence from the IPN that prices are stickier in sectors typically characterised by a high incidence of labour costs. Conversely, the extent to which wages feed into prices is inversely related to the intensity of competitive pressures faced by the firms, their exposure to foreign markets and their size.<sup>11</sup> Additional empirical evidence, based on alternative data and methods, of wage changes having a substantial impact on price dynamics at the firm level is rather limited. Studies carried out in the context of the WDN, focused on national micro data, find in general a significant but very low elasticity of prices to wages or labour costs (see Loupias and Sevestre, 2008; Rosolia and Venditti, 2008; Carlsson and Nordstrom Skans, 2008).

Table 6 –Adjustment strategies to shocks  
(firms answering "relevant" or "very relevant", percentages)

	Cost-push shock	Wage shock	Demand shock
Reduce (other) costs	67.6	59.0	78.0
Adjust prices	65.6	59.2	50.5
Reduce margins	53.5	49.8	56.6
Reduce output	21.4	22.5	49.9

Notes: Figures weighted by employment weights, rescaled excluding non-responses. Greece is excluded from all the calculations and in addition Italy and Spain are excluded in the case of a demand shock.

Turning to the evidence concerning the impact of prices on wages, an important element is the extent and speed to which wage changes in the firms are related to the general inflationary outlook. The existence and strength of this relationship is determined both by companies internal strategies adapting wages to inflation and by the characteristics of the national institutional settings, in particular the presence or not of indexation rules. The nature of these mechanisms – specific to the firm or set at the national level, formal or informal, forward or backward looking – is, hence, of extreme relevance from a policy perspective. Two questions on this issue were included in the survey (see Appendix 2, questions 6 and 7). Firms were first asked whether or not they have an internal policy that adapts changes in base wages to inflation. If so, they had to report whether the adjustment (a) is automatic or not, (b) is subject to a formal rule, (c) refers to past or expected inflation (“backward” or “forward” looking).

Figure 6 shows that on average only one-third of the firms have an internal policy adapting wages to inflation. Among them, nearly half adopt an automatic indexation mechanism, mostly of a backward looking nature, while the other half takes inflation into account without applying any formal rule. There is some variability across sectors: the existence of an internal indexation policy is less common in market services and more widespread in financial intermediation and construction.

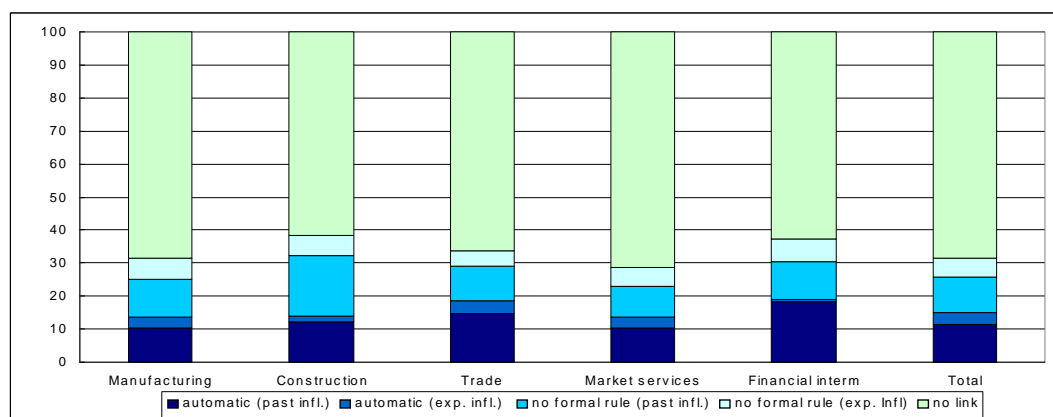
Table 7 summarises the information on formal and informal indexation mechanisms at the firm level across countries. It shows that the adjustment of wages to inflation is very common in Belgium and Spain (98 and 70 percent, respectively), where automatic indexation mechanisms are prevalent. Dutch and Italian firms, on the other hand, do not (or do it only marginally) adapt wages to inflation. In the remaining countries these internal mechanisms, mostly informal, are used to some extent. Expected inflation is more relevant for wage setting than past inflation only in Portugal.<sup>12</sup> Overall, informal policies that link base wages to inflation are more widespread in non-

<sup>11</sup> All these results are confirmed by the multivariate regression analysis reported in Section 3.

<sup>12</sup> In the case of Germany, firms were not explicitly asked whether or not they have a policy that adapts changes in base wages to inflation. Nevertheless, when asked about the two main factors that determined the most recent wage increases, 27 percent of German firms replies that inflation was one of them.

euro area countries than in euro area ones, while the opposite holds in the case of formal automatic adjustment mechanisms.

Figure 6 - Adjustment of base wages to inflation across sectors  
(percentages)



Notes: Figures weighted by employment weights, rescaled excluding non-responses.

The firm-level evidence reported so far complements information available from other sources on indexation at the country and sectoral level. The dataset on wage bargaining institutions collected within the WDN (see Du Caju et al., 2008) provides an overview of existence and coverage of formal wage indexation mechanisms across countries, developing a summary indicator of country-level indexation. According to this measure, reported in the last column of Table 7, workers are to some extent covered by formal wage indexation clauses in only seven of the countries examined here, coverage being particularly high in Belgium and Spain, low in Slovenia and very low in Austria, France, Italy and Poland.

Table 7 - Adjustment of base wages to inflation: country overview (1)  
(percentages)

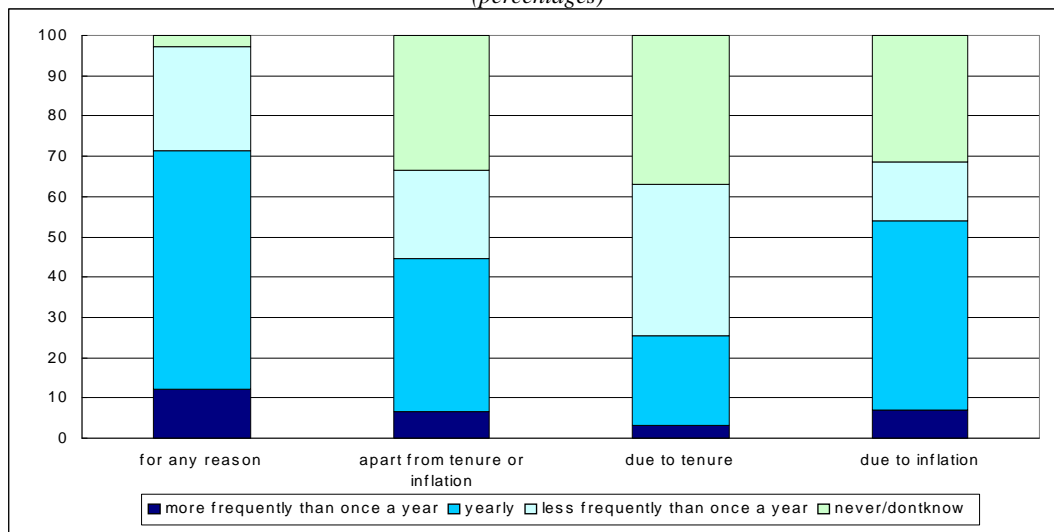
	(percentages)				Country-level indexation (3)	
	Firm-level policies (2)					
	Automatic link to inflation		No formal rule, but inflation considered			Total
	Past	Expected	Past	Expected		
AT	8.6	1.3	9.2	2.8	22.0	Very low
BE	98.2	0.0	0.0	0.0	98.2	High
CZ	5.8	2.6	26.4	22.1	56.9	None
EE	2.6	1.3	31.4	15.0	50.3	None
ES	38.3	16.2	10.9	5.0	70.4	High
FR	4.9	1.0	16.5	4.9	27.3	Very low
GR	14.8	5.2	12.1	10.6	42.7	None
HU	7.2	4.2	14.0	5.9	33.0	None
IE	2.4	2.8	11.2	9.5	26.1	None
IT	1.2	0.5	2.6	1.5	5.8	Very low
LT	7.3	3.7	24.3	12.9	48.1	
NL	0.0	0.0	0.0	0.0	0.0	None
PL	4.7	2.5	17.3	6.1	30.6	Very low
PT	2.7	6.5	13.3	29.1	51.6	None
SI	20.3	2.7	32.2	5.1	60.3	Low
Total	11.5	3.3	10.9	5.8	31.7	
Euro area	13.8	3.5	7.8	4.5	29.7	
Non Euro area	5.3	2.8	19.3	9.5	37.2	

Notes: (1) Since some firms use a number of different methods of adjustment to inflation, the total may not be equal to the sum of the four methods. (2) Figures weighted by employment weights, rescaled excluding non-responses. (3) Percentage of workers covered by wage indexations clauses: Very low: 1-25%; Low: 26-50%; Moderate: 51-75%; High: 76-100% (Source: Du Caju et al., 2008).

Overall, information obtained from the WDN firm-level survey and the analysis of national wage bargaining systems suggest that, though formal or institutional indexation mechanisms are not a common feature across Europe, price developments are an important factor entering firms' wage policies in many countries. Indeed, in the Czech Republic, Estonia, Greece, Hungary, Ireland and Portugal, inflation is taken into account by a significant fraction of firms without relying on automatic or formal rules.

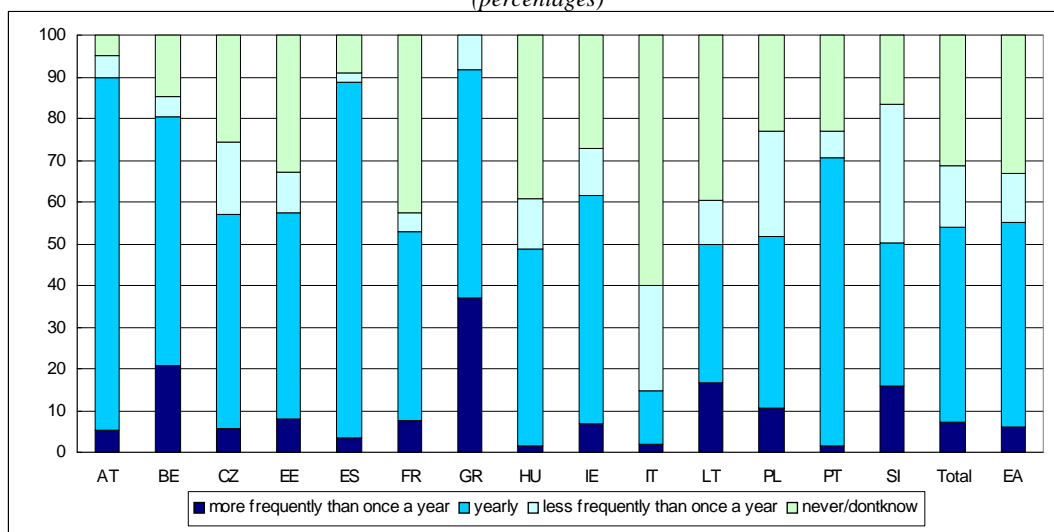
A final piece of evidence provided by the WDN survey on how inflation developments affect firms' wage decisions concerns the frequency of wage adjustments due to inflation. Figure 7 shows that inflation stands out as the prevalent factor triggering frequent wage adjustment (at an annual or infra-annual frequency). Sectoral heterogeneity is quite limited in contrast with the variability across countries which is, instead, remarkably large (Figure 8):<sup>13</sup> while in Austria, Belgium and Spain over 80 percent of firms change wages annually or more frequently due to inflation, in Italy only 15 percent do that (60 percent report that they never adopt this policy).<sup>14</sup>

Figure 7 - Frequency of wage changes  
(percentages)



Notes: Figures weighted by employment weights, rescaled excluding non-responses.

Figure 8 - Frequency of wage changes due to inflation across countries  
(percentages)



Notes: Figures weighted by employment weights, rescaled excluding non-responses.

<sup>13</sup> The Netherlands was not considered as Dutch firms do not adapt wages to inflation.

<sup>14</sup> Data for Greece here have a slightly different interpretation, as the option "never/don't know" was not allowed in the Greek questionnaire, the percentages are within the firms that actually change wages due to inflation.

## 4 A firm level analysis of price and wage policies in a multivariate framework

In this section we investigate, within a multivariate framework, the potential factors that may lie behind the frequency of price and wage changes at the firm level. We account for differences that could be country, sector or firm size specific and focus on the features that could potentially affect firms' strategies. Some of them reflect the institutional setup, like the degree of wage indexation and the nature and coverage of collective bargaining, both at the firm and the country level. Other differences are related to the economic and technological environment, such as the degree of product market competition, the firms' exposure in terms of external trade, labour intensity and the characteristics and composition of the labour force (share of white collars, of high skill workers, of permanent jobs, etc.). The factors considered in this analysis are described below.

***Intensity of product market competition.*** Whereas in the theoretical literature the relationship between market power and price stickiness is not clear-cut, there is an ample number of studies providing empirical evidence on the issue. Carlton (1986) and Hall et al. (2000) find that more competitive firms tend to adjust prices faster than firms facing less elastic demand. Geroski (1992) shows that price reaction to shocks is faster in more competitive industries. Álvarez and Hernando (2007) analyze the relationship between price flexibility and competition, focusing on euro area manufacturing and services industries. They conclude *inter alia* that price setting strategies of the most competitive firms give them greater room of manoeuvre to react to shocks.

From an empirical viewpoint, measuring the degree of competition and in particular disentangling a situation of perfect competition and price taking agents from one of imperfect competition is not straightforward. This difficulty is even more pronounced in the context of survey data, where only qualitative information at the firm level is available, whereas the typical measures adopted in the literature rely on quantitative sectoral indicators or, at the micro level, on measures such as the number of competitors or the firm's market share. The information provided by the WDN survey allows constructing a number of proxies for the intensity of competitive pressures faced by the firms. The first is the relevance of competitors' pricing strategies; firms are asked (Appendix 2; question 30) to report the likelihood that a price reduction by competitors leads to a similar reaction by them. The second measure is based on the firms' own assessment of the intensity of competition in their reference market (question 29).<sup>15</sup> Since this indicator, which would be the preferred candidate to be used in our empirical analysis, is not available for 4 countries, we have to rely primarily on the first proxy. However, we will show below that our results are robust to the choice of the competition measure.

Finally, as a large number of the firms included in the WDN survey operate on foreign markets, to capture the specific competitive pressures faced by them, we construct an indicator of the firm's international exposure, proxied by the share of exports on total sales (question 27).

***Share of labour costs in total costs*** - Evidence arising from studies carried out in the context of the IPN, based both on survey firm-level information and on quantitative producer prices micro data (see Fabiani et al., 2007, and Vermeulen et al., 2008) suggests a negative relationship between the incidence of labour on total costs and the frequency of price adjustment. The WDN survey allows addressing this potential relationship by directly asking firms the fraction of their total costs due to labour (question 40).

***Characteristics and flexibility of the workforce*** – Price and wage adjustment strategies at the firm level could be influenced by the relative easiness of adjustment of the labour force. This depends on both the composition of the workforce and the prevailing nature of the relationship

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<sup>15</sup> Based on the IPN results, questions on these more standard measures (number of competitors and the market share) were not included in the WDN survey, to reduce the burden on the firms. Indeed, in the survey studies conducted within the IPN the indicator based on firms' reaction to competitors' pricing strategies, proved to be highly correlated with the standard measures (see Fabiani et al., 2007).

between the firm and its employees. The WDN survey provides information on these aspects through a number of indicators: i) the incidence of permanent full-time employees on the total workforce (question 34); ii) the share of high-skilled and of white-collar employees (question 1); iii) for some countries, the tenure structure of the firms' labour force (question 38).

**Other adjustment means** – Information available from the survey allows considering also margins of adjustment at the disposal of firms other than changing base wages and prices, which could affect price and wage change mechanisms. The indicators capturing these aspects in our regressions are the turnover of the workforce and the flexible component of the wage, namely the share of bonuses on the firm's total wage bill.

**Labour market institutions** – The theoretical literature assigns an important role to wage bargaining institutions for wage stickiness and in particular to the degree of centralisation of wage settlements. Although the availability of comparable empirical data at an international level is quite limited due to the non-standardised nature of measures, the incomplete coverage of countries, periods and institutional features, empirical results based on micro data suggest that agreements bargained at the firm level tend to lead to higher wage flexibility by leaving firms greater margins for manoeuvre for reacting to economic fluctuations. The WDN survey allows to overcome the data limitations described above and to test this relationship on the basis of the information reported by firms on the characteristics of wage negotiations, both firm-specific and institutionally driven. Our empirical analysis relies on a set of covariates that include: i) the degree of centralisation of collective pay agreements, in particular, whether wages are mostly negotiated outside the firm, either at the national or sectoral level (question 2); ii) the existence of firm-level collective agreements (question 3); iii) the percentage of the firm's employees covered by collective agreements, irrespective of their nature (question 4); iv) the existence within the firm of internal policies (automatic or not) aimed at adapting salaries to past or expected inflation (questions 6 and 7). In the wage frequency equation, we also include an indicator of the stringency of employment protection legislation, based on OECD data extended to eastern European countries following Tonin (2005).

Finally, we control for other firm's characteristics through a set of variables that capture the economic sector of activity (manufacturing, construction, trade, business services, financial services), the size in terms of number of employees (5-19, 20-49, 50-199, >199), the country the firm belongs to. These dummies also help to account for unobserved characteristics of the firm that might impact on the frequency of price and base wage changes but are not captured by the other explanatory variables.

#### 4.1 *Ordered probit estimation*

To better understand whether and to what extent the features described above are related to the rigidity of prices and base wages, both expressed in terms of frequency of adjustments, we estimate an ordered probit. In the case of prices, the dependent variable is a categorical one increasing with the degree of stickiness, it takes values from 1 to 4, where 1= the firm change prices at a daily to monthly frequency; 2= the firm changes the price of the main product quarterly-half-yearly or twice a year; 3=the price of the main product is changed once a year; 4=changed less frequently than once a year. Also in the case of wages, the value categories of the dependent variable are increasing in the degree of stickiness, from 1 to 3, where 1=the firm changes wages more frequently than yearly; 2= changes wages yearly; 3=changes wages less frequently than yearly.<sup>16</sup>

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<sup>16</sup> In the case of prices, we drop category 5 ("no pattern"), as we do not have information on the effective frequency of price changes, and estimate the model only on the firms that have explicitly indicated that they have a pattern when changing prices, excluding about 25 percent of the initial sample. In the case of wages we also drop the last category ("never/don't know") which hardly amounts to 3 percent of the sample. In the regressions displayed in the text we

Table 8 contains the probit estimates for frequency of price changes and Table 9 those for the frequency of wage changes.<sup>17</sup> In both tables, several specifications exploring the role of the features described above are shown. Tables A4.1 and A4.2 in Appendix 4 display the marginal effect of each variable when estimating the preferred specification (reported in column 5 of Table 8 for prices, and column 7 of Table 9 for wages).

The results confirm that cross-sectoral differences matter both for the flexibility of prices and of wages. Our baseline specification (column 1 in both tables) shows that for firms operating in construction, trade and financial intermediation prices tend to be adjusted more frequently than in manufacturing (which is the reference category in the regression), while they are stickier in market services. In all services sectors, including trade, wages turn out to be significantly stickier than in manufacturing, whereas they are adjusted more frequently in construction.

We do not find strong evidence of relevant country-specific patterns for price change frequency.<sup>18</sup> This turns out not to be the case for wage adjustment, as many of the country effects have a positive and significant coefficient, meaning that wages adjust somewhat less frequently than in the reference country, that is Estonia, whose labour market is one of the most flexible of the EU. Only for Greece, Lithuania and Slovenia the coefficient is negatively signed and significant.

Firms' size influences the pattern of both price and wage adjustment, which in both cases is likely to happen more frequently in larger firms than in small ones (the omitted category in the regression is that of small firms with 5 to 19 employees).

As already mentioned, our survey allows to explicitly assess to what extent the flexibility of the firm's cost structure, proxied by the share of labour on total costs, affects the duration of prices and wages. The estimates reported in column 2 in Table 8 show that the higher the fraction of firms' costs accounted by labour, the lower the frequency of price changes. Interestingly, once we control for this variable the result that prices are stickier in market services vanishes, reflecting the fact that this sector is in general the one with the highest share of labour costs.<sup>19</sup> The flexibility of the cost structure does not appear instead as being significantly correlated with wage behaviour (column 2, Table 9).

Turning to the role played by the economic environment and market forces, our estimates (columns 3) highlight that the degree of product market competition, proxied by the likelihood that a price reduction by competitors leads to a similar reaction in the firm, is negatively related to price stickiness. This result, which is robust to the use of the alternative measures of competitive pressures described above (as shown in Table 10), confirms earlier IPN findings that also pointed to a systematic positive relationship between the frequency of price revisions and changes and the intensity of competition pressures. These factors, instead, are not significant for wage adjustment. Prices are adjusted more frequently also in firms that are more exposed to foreign competition, as captured by the share of turnover generated on foreign markets.

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consider the frequency of wage adjustment due to any reasons. However, a similar analysis conducted separately on the frequency of wage changes due to (i) reasons different from inflation and tenure (ii) inflation (iii) tenure, gives broadly similar results.

<sup>17</sup> The ordered probit model may have some drawbacks. If, for example, all firms in a given country fall into the middle wage frequency category, the inclusion of the country dummy would affect the probability of firms falling in the other two categories, not enabling to draw sound conclusions on the lower or higher flexibility of wages. This however does not turn out to be a problem in our sample. First, in no case such an event occurs. Second, regressions based on a multinomial probit model provide similar results to those reported in Tables 8 and 9 (results are available upon request).

<sup>18</sup> Although country dummies are jointly significant in the price frequency regression, their exclusion, which is not shown in the table, does not change the size and significance of the other coefficients and the overall fit of the equation declines only slightly.

<sup>19</sup> We also tried to allow for a non-linear relationship by, first, introducing the variable squared, which turned out to be not significant and, second, constructing categorical dummies for different ranges of the labour cost share [20, 40, 80, 100] but the results did not support non-linearity.

The composition of the labour force and job-specific characteristics (columns 4 in Tables 8 and 9) only matter for the degree of price stickiness, the frequency of adjustment being negatively associated to the share of highly skilled personnel and of white-collars.

Table 8 – Price rigidity  
(ordered probit estimates, unweighted)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Construction	-0.331**	-0.354**	-0.355**	-0.349**	-0.313**	-0.369**	-0.369**
Trade	-0.689**	-0.699**	-0.745**	-0.778**	-0.753**	-0.77**	-0.77**
Market services	0.088**	0.033	-0.022	-0.041	-0.006	-0.035	-0.036
Financial intermediation	-0.566**	-0.644**	-0.621**	-0.825**	-0.746**	-0.672**	-0.67**
20-49	-0.022	-0.031	-0.028	-0.008	-0.019	-0.018	-0.019
50-199	-0.15**	-0.149**	-0.148**	-0.126**	-0.131**	-0.124**	-0.125**
>200	-0.241**	-0.226**	-0.207**	-0.162**	-0.176**	-0.168**	-0.164**
AT	0.111	0.117	0.115	0.065	0.059	0.071	0.059
BE	-0.026	0.025	-0.209	-0.122	-0.205	-0.217	-0.203
CZ	-0.002	-0.018	-0.007	0.066	0.068	0.061	0.063
ES	0.012	0.007	-0.036	-0.018	0.001	-0.007	-0.002
FR	-0.05	-0.072	-0.106	-0.129	-0.151	-0.111	-0.117
GR	0.113	0.085	0.118	0.018			
HU	0.214**	0.179*	0.154	0.162	0.135	0.129	0.12
IE	-0.1	-0.134	-0.158	-0.158	-0.19	-0.203	-0.212
IT	-0.005	0.01	-0.014	-0.01	-0.026	-0.015	-0.032
LT	-0.438**	-0.496**	-0.533**	-0.506**	-0.6	-0.613**	-0.614**
NL	-0.112*	-0.172*	-0.126	-0.122	-0.153	-0.161	-0.179
PL	-0.06	-0.051	-0.036	-0.044	-0.091	-0.104	-0.114
PT	-0.075	-0.068	-0.065	-0.072	-0.095	-0.092	-0.093
SI	0.031	0.037	0.086	0.114	0.076		
labour cost share		0.42**	0.425**	0.448**	0.426**	0.508**	0.504**
competitive pressures			-0.327**	-0.32**	-0.314**	-0.301**	-0.3**
export (% of sales)			-0.109*	-0.131**	-0.106*	-0.139*	-0.141*
share of white collars				0.153**	0.168**	0.167**	0.169**
share of high skilled workers				0.076*	0.075*	0.087*	0.088*
share of full time permanent workers				0.106	0.025	-0.009	-0.008
workforce turnover					-0.162**	-0.15**	-0.151**
share of bonuses on total wage bill					0.02	0.01	0.01
collective agreement outside the firm						-0.067	-0.066
collective agreement at the firm level						-0.03	-0.029
coverage of collective agreement						0.055	0.054
internal policy adjusting wages to prices							-0.033
Observations	10191	9294	8483	6879	6031	5340	5333
Pseudo R <sup>2</sup>	0.037	0.039	0.051	0.052	0.053	0.053	0.053

Notes: (\*) and (\*\*) denote statistical significance at 5 and 1 percent, respectively. The dependent variable increases with the degree of rigidity, ranging from 1 to 4, where 1=prices changed at a daily to monthly frequency and 4=prices changed less frequently than once a year.

Firms experiencing high labour force turnover seems to adjust more often both prices and wages (columns 5). In addition, firms that use other means of wage adjustments than base wages, as for example bonuses, also seem to adjust base wages more often.<sup>20</sup>

The introduction of the set of covariates capturing the institutional environment underlying wage policies and the functioning of the labour market (columns 6 and 7 in Table 8) does not improve the equation explaining price stickiness, as all these variables turn out as being not significant. Conversely, collective bargaining at the firm level improves the relative flexibility of wages (columns 6 and 7 in Table 9), whereas the stringency of employment protection legislation (EPL) and the coverage of collective agreements act in the opposite direction (columns 6 and 7). Finally, the existence of internal policies that adapt base wages to (past or expected) inflation turns

<sup>20</sup> The difference between the wage paid by firms and the base wage, the so-called “wage cushion” (Cardoso and Portugal, 2005), could be a strategic buffer against adverse shocks; above all in a context where the downward nominal wage rigidity becomes an active restriction.

out to be positively correlated with the frequency of wage change, confirming that inflation stands as an important driving force of infra-annual or annual wage adjustment (as shown in Figure 8). The results described above for the other covariates hold also when this variable is included, despite its potential endogeneity (see column 7 in Table 9).

Table 9 – Wage rigidity  
(ordered probit estimates, unweighted)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Construction	-0.331**	-0.314**	-0.113*	-0.118*	-0.133**	-0.198**	-0.213**
Trade	0.067*	0.08**	0.088**	0.059	0.125**	0.108**	0.108**
Market services	0.122**	0.136**	0.138**	0.13**	0.145**	0.12**	0.12**
Financial intermediation	0.093	0.121	0.269**	0.232**	0.285**	0.21*	0.24**
20-49	-0.054	-0.063*	-0.102**	-0.105**	-0.083*	-0.094*	-0.1*
50-199	-0.174**	-0.176**	-0.217**	-0.243**	-0.183**	-0.207**	-0.208**
>200	-0.319**	-0.311**	-0.347**	-0.348**	-0.309**	-0.331**	-0.313**
AT	0.208*	0.205*	0.195*	0.158	0.221*	0.282*	0.161
BE	-0.136	-0.125	0.156	0.075	0.351	0.15	0.305
CZ	0.648**	0.656**	0.69**	0.624**	0.725**	0.854**	0.852**
ES	-0.032	-0.037	-0.017	-0.019	-0.08	-0.372*	-0.308*
FR	-0.09	-0.095	-0.065	-0.11	-0.115	-0.271**	-0.365**
GR	-0.357**	-0.349**	-0.316**	-0.379**			
HU	0.517**	0.471**	0.493**	0.473**	0.467**	0.715**	0.626**
IE	0.161	0.169	0.174	0.13	0.134	0.537**	0.443**
IT	1.681**	1.696**	1.754**	1.753**	1.678**	1.651**	1.459**
LT	-0.455**	-0.455**	-0.469**	-0.406**	-0.511**	-0.681**	-0.692**
NL	0.456**	0.423**	0.419**	0.356**	0.338**	0.352**	0.138
PL	0.534**	0.531**	0.527**	0.487**	0.505*	0.565**	0.474**
PT	0.37**	0.361**	0.378**	0.379**	0.414**		
SI	-0.259**	-0.265**	-0.27**	-0.299**	-0.269**		
labour cost share		-0.035	-0.019	0.003	0.031	0.054	0.026
competitive pressures			-0.026	-0.023	-0.003	0.01	0.012
export (% of sales)			-0.016	0	-0.017	-0.013	-0.023
share of white collars				0.057			
share of high skilled workers				0.012			
share of full time permanent workers				0.03			
workforce turnover					-0.157**	-0.144**	-0.17**
share of bonuses on total wage bill					-0.167**	-0.172**	-0.16**
collective agreement outside the firm						-0.055	-0.047
collective agreement at the firm level						-0.112*	-0.088*
coverage of collective agreement						0.089*	0.092*
EPL						0.104**	0.133**
internal policy adjusting wages to prices							-0.393**
Observations	14121	12741	11605	9396	10070	8993	8974
Pseudo R <sup>2</sup>	0.095	0.094	0.097	0.093	0.100	0.101	0.117

Notes: (\*) and (\*\*) denote statistical significance at 5 and 1 percent, respectively. The dependent variable increases with the degree of rigidity, ranging from 1 to 3, where 1=wages changed more frequently than once a year and 4=wages changed less frequently than once a year.

Table 10 - Price rigidity and alternative measures of competitive pressures  
(ordered probit estimates, unweighted)

	(1)	(2)	(3)	(4)
Perceived competition is severe or strong	-0.324**			
Very likely or likely to follow price reduction by competitors		-0.327**		
Perceived competition is severe				-0.489**
Perceived competition is strong				-0.305**
Perceived competition is weak				-0.070
Very likely to follow price reduction by competitors			-0.489**	
Likely to follow price reduction by competitors			-0.301**	
Not likely to follow price reduction by competitors			-0.057	
Observations	7065	9555	9555	7065

Notes: (\*) and (\*\*) denote statistical significance at 5 and 1 percent, respectively. Other covariates, not shown in the table, include country, sector and firm size dummies. The dependent variable increases with the degree of rigidity, ranging from 1 to 4, where 1=prices changed at a daily to monthly frequency and 4=prices changed less frequently than once a year.



Various pieces of evidence provided by the regressions, such as the relevance of the labour cost share in explaining the rigidity of price adjustment and the positive relationship between firm level policies adjusting wages to inflation point to a positive relationship between the duration of prices and that of wages at the firm level.<sup>21</sup> This relationship is however likely to be affected by simultaneity and interdependences, which are formally addressed in the next section.

#### 4.2 *Disentangling the simultaneous relationship of price and wage rigidity*

The connection between price and wage rigidities has long been investigated in the economic literature (see Taylor, 1999 and Rotemberg and Woodford, 1999, also for a review of the literature). The empirical studies have mainly focused on the behaviour of real wages over the business cycle, reaching little consensus on the cyclical pattern of the markup of price over costs. The richness of firm-level information contained in our survey, which however does not have a time dimension, allows to address this issue from a different perspective, namely focusing on the mechanism through which wage and price rigidities feed into each other.

The empirical analysis described in the previous section suggests that, indeed, there is an interaction between price and wage stickiness at the firm level. This result corroborates the evidence that a substantial share of firms acknowledge a relationship between the timing of their wage and price adjustment decisions, with half of those changing prices in January also adjusting wages in the same month.

Here we acknowledge the possible simultaneity of these two variables and allow for the relationship to run in both directions by estimating a system of equations of price and wage change frequencies:

$$freq_{pi} = \beta'_{pi} x_i + \gamma' z_{pi} + \kappa freq_{wi} + u_i$$

$$freq_{wi} = \beta'_{wi} x_i + \delta' z_{wi} + \lambda freq_{pi} + v_i$$

where  $freq_{pi}$  and  $freq_{wi}$  are, respectively, the frequency of price and wage changes in firm  $i$ , as in case of the probits in the previous section these are categorical variables increasing with the degree of stickiness, vector  $x_i$  contains covariates common to both equations (it also includes variables on sector and size; see below about the omission of country dummies), vector  $z_{pi}$  those variables that are assumed to affect the frequency of prices but not that of wages and, conversely, vector  $z_{wi}$  those affecting the frequency of wages but not that of prices;  $u_i$  and  $v_i$  represent unobserved heterogeneity in price and wage change frequencies, respectively, and are allowed to be correlated.

The parameters of main interest are  $\kappa$  and  $\lambda$ : the former captures the effect of the duration of wages on prices, the latter that running from prices to wages. Both are identified by the exclusion restrictions, i.e. the presence of the  $z_{pi}$  and  $z_{wi}$  variables (instruments), whose choice is, therefore, of crucial importance.

The key principle in selecting the instruments relies on the notion that wage setting is affected by institutional factors that have no direct effect on prices, whereas price setting is influenced by product market characteristics that have no direct effect on wages, as emerged from the probit analysis carried out above. On this basis, the instruments in the price equation ( $z_{pi}$ ) are our measure of the degree of product market competition, the exposure to foreign markets, the share of labour costs on total costs, and some characteristics of the labour force at the firm level. Instruments in the wage equation ( $z_{wi}$ ) include, instead, the turnover of the firms' workforce, the share of bonuses on the total wage bill, the presence of collective wage agreements at the firm level, their coverage and the degree of employment protection. In principle, if the instruments in the wage equation are to reflect institutional differences, they should come to a large extent from cross-country variation.

<sup>21</sup> This is confirmed by the strong and significant correlation found when the frequency of price change is introduced as a covariate in the equation of wage changes and vice versa (results are not shown in Tables 8 and 9).

Controlling for country dummies in  $x_i$  might therefore take out the most important source of variation in the instruments. This consideration has led us to run two different experiments. In the first, we remove all country dummies; in the second, we assume that the cross-country variation in wage setting strategies is due to institutional factors which do not affect prices, and therefore include country dummies in vector  $z_{wi}$ . Results from both specifications are presented in Table 11.

It is important to remark that the evidence provided by the system estimates of  $\kappa$  and  $\lambda$  does not necessarily have to be consistent with the direct evidence from firms' answers on the existence of a link between the timing of price and wage change decisions. In fact, the system estimates the relationship of price and wage change frequency by looking at whether those firms that, for some exogenous reason, change prices (wages) more frequently are also induced to change wages (prices) more frequently. Instead, the survey question is about the link of price and wage setting in general, with the answers spelling out the timing patterns. Though related, the two concepts are not the same. Furthermore, in the system the effects are identified by assumption from the exogenous variation in the frequency variables induced by their instruments.

Because of these differences it is possible to have firms that change wages more frequently when for some exogenous reason prices are also changed more frequently and at the same time to find no link or specific pattern in price and wage setting in general. Nevertheless, it is hard to imagine that in firms that report having a link running in one direction, the duration in price (wage) is not induced by that in wage (price). We can thus interpret the system estimates as looking at a specific kind of relationship between wage and price setting at the firm level as opposed to the more general link investigated before.

The system is estimated by three-stage least squares. Table 11 presents the results of the most important parameters.<sup>22</sup> The estimates establish a statistically significant relationship from the frequency of wage changes to that of prices; the effect in the opposite direction is not significant. The instruments are strong and show effects that are intuitive in most cases and are similar to the previous probit estimates (where the price and wage frequency equations can be viewed as reduced-form versions of the system estimated here). Prices are adjusted significantly more often in firms that (a) face stronger product market competition, (b) are more export-oriented, (c) have a more flexible structure of the workforce, and (d) present a lower incidence of labour costs.

Table 11 – System estimates on price and wage rigidity  
(3-stage least squares, unweighted)

	(1)		(2)		(3)	
	<i>freq. of wage change</i>	<i>freq. of price change</i>	<i>freq. of wage change</i>	<i>freq. of price change</i>	<i>freq. of wage change</i>	<i>freq. of price change</i>
<b>frequency of price change</b>	<b>0.069</b>		<b>0.065</b>		<b>0.07</b>	
<b>frequency of wage change</b>		<b>0.507**</b>		<b>0.135*</b>		<b>0.124*</b>
labour cost share		0.26**		0.284**		0.281**
competitive pressures		-0.207**		-0.215**		-0.215**
export (% of sales)		-0.092*		-0.089*		-0.091*
share of white collars		0.106**		0.106**		0.108**
share of high skilled workers		0.074**		0.066**		0.066
share of bonuses on total wage bill	-0.005		-0.052**		-0.046**	
workforce turnover	-0.08**		-0.073**		-0.079**	
collective agreement at the firm level	-0.051**		-0.031		-0.022	
coverage of collective agreement	0.085**		0.028		0.027	
EPL	-0.126**		0.763**		0.792**	
internal policy adjusting wages to prices					-0.15**	
country dummies	No	No	Yes	Yes	Yes	Yes
sector and firm size	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5217	5217	5217	5217	5211	5211

Notes: (\*) and (\*\*) denote statistical significance at 5 and 1 percent, respectively. The dependent variables increase with the degree of rigidity (see notes to Tables 8 and 9).

<sup>22</sup> The full set of results is available from the authors upon request.

## 5 Conclusions

This paper provides new evidence on firms' price and wage adjustment across European firms, with a particular emphasis on the presence and degree of nominal rigidities. It focuses on three specific aspects related to this issue: the frequency of wage and price changes; the prevailing mechanism of adjustment and its timing; the extent to which wage and price changes feed into each other. The main conclusions are the following.

Firms adjust wages less frequently than prices. The former tend to remain unchanged for about 15 months on average, while the latter for around 10 months (in line with previous estimates from the IPN).

The cross-sectoral variation in the frequency of price adjustment is large compared to that of wage adjustment. Instead, country differences are larger for wage change frequencies than for price change frequencies. This evidence possibly reflects the fact that the economic context in which individual firms operate, which is likely to differ substantially across sectors, is crucial for pricing strategies, whereas the institutional setting, which is strongly country-specific, matters mostly in shaping wage adjustments strategies.

Indeed, a multivariate analysis of the determinants of price and wage rigidity at the firm level confirms that more frequent price adjustments are associated with higher intensity of competitive pressures and exposure to foreign markets, as well as with a lower share of labour costs on total costs (consistently, prices are found to be stickier in business services). Conversely, wages tend to be more flexible in the presence of firm-level collective wage agreements whereas the stringency of employment protection legislation (EPL) and the coverage of collective agreements act in the opposite direction. There is also a correlation between frequency of wage changes and the presence of (formal or informal) indexation mechanisms of wages to inflation.

The extent of wage and price rigidities is also related to the adjustment mechanisms adopted by firms, time-dependent strategies delivering, in general, higher rigidity. On average, 54 percent of firms report that wage changes are concentrated in a particular month, mostly January. On the contrary, only one-third of firms adopt time-dependent pricing rules. For both prices and wages the concentration of adjustments in specific months is significantly higher in euro area countries than in new EU member states. In the case of wages, this might reflect the more widespread adoption of indexation clauses in the euro area as well as the higher importance of collective wage agreements, which enhance coordinated wage adjustments.

Various pieces of evidence confirm that wages and prices feed into each other at the micro level and that there is a relationship between wage and price rigidity. First, around half of the firms that change prices in January also change wages in that month. Second, 40 percent of the firms acknowledge a relationship (formal or informal) between the timing of their wage and price adjustment decisions. Third, when asked to assess the relevance of different adjustments policies to a common permanent unexpected increase in wages, about 60 percent of firms report that they would increase prices. Fourth, firm-level wage changes appear to be related to the general inflationary outlook, whether due to the existence of internal policies adapting wages to inflation or to the national institutional setting. Fifth, firms with a high labour cost share report a tighter link between price and wage changes and a lower frequency of price adjustment. Finally, even accounting for the likely simultaneity between price and wage changes, a statistically significant relationship is found, running from the frequency of wage changes to that of prices.

The results can help to improve the calibration of New Keynesian macro models with price and wage stickiness. In particular, the implication of our empirical evidence regarding for instance average wage and price duration, synchronization between wage and price adjustment, the presence of a "January effect", have started to be investigated more closely in the context of the WDN (see De Walque et al., 2009). It must be kept in mind, however, that the surveys were carried out in a period characterized by a relatively stable economic environment. Firms' price and wage setting in the context of exceptionally unstable economic and financial conditions is ongoing research.

## Appendix 1 – The survey

The WDN-survey project involved all euro area countries except Finland and Malta<sup>23</sup>, as well as Estonia, the Czech Republic, Hungary, Lithuania and Poland (in total, 17 countries). The group opted for a decentralised approach in which each National Central Bank was responsible for carrying out the survey within its country. However, strong coordination guaranteed that the national questionnaires, at least with respect to a subset of clearly pre-defined “core questions”, were almost fully harmonized.

This paper is based on results for all countries except Luxembourg and Germany: for the former results were not available yet at the time of completing the paper, while for the latter country results turned out not to be comparable due to major differences in the questionnaire actually sent to German firms.

The national surveys were carried out between the second half of 2007 and the first half of 2008. Their main characteristics are summarised in Table A1.1. In most cases the survey was outsourced to an external company, which collected the answers from firms mainly by traditional mail or the internet. Operational instructions were added to the questionnaire, in particular regarding (i) the person who preferably was required to fill in the questionnaire (the CEO or the Human Resource Manager), (ii) the business unit answers should refer to (the firm and not the establishment), and (iii) the reference period (period covered by the latest 12-month profit and loss account, or, for a few questions, the end of the reference period). All NCB's pre-tested the questionnaire on a pilot sample.

The branches of activity underlying the samples vary across countries; for the purpose of the common empirical analysis, firms have been grouped in 6 sectors: manufacturing, trade, market services, construction, energy and financial intermediation; as shown in Table A1.1, all national samples cover the first three sectors (except Germany, where trade is not covered); in many surveys construction, energy and financial intermediation were also considered, whereas non-market services were included in five country samples only. Because of the poor coverage in terms of number of interviewed firms, the energy sector and non-market services were excluded from the cross-country analysis.

Concerning firm size, the sample was split up into four classes: 5 to 19 employees, 20 to 49 employees, 50 to 199 employees and 200 employees and more. Since very small firms (with less than 5 employees) were covered in Germany, Greece, Lithuania, Luxembourg, Spain and Poland only, they were excluded from the harmonised analysis of the results.

The sample size was quite different across countries, ranging from 1,400 in Estonia to 6,500 in France. In terms of response rate, three broad groups can be identified: Austria, Greece and Lithuania with a response rate below 20 percent; a large group of countries with response rates between 20 and 50 percent; and Hungary, Ireland, the Netherlands, Poland and Spain with above 50 percent. Overall, more than 17,000 firms were surveyed. In this paper, results for almost 15,000 firms are analyzed.

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<sup>23</sup> The survey was conducted in Cyprus at a later stage.

**Table A1.1 – The main characteristics of the national surveys**

Country	Sectoral coverage	Firms' size	Sample size	Number of respondents (response rate)	Ad hoc survey?	Geographical breakdown	Who carried out the survey	How was the survey carried out
Austria	Manufacturing (+energy) Construction Trade Market services Fin. intermed.	≥ 5	~ 3,500	557 (16%)	Ad hoc	No	External Company (WIFO)	Traditional mail and Internet
Belgium	Manufacturing (+energy) Construction Trade Market services Fin. intermed.	≥ 5	~ 4,100	1,431 (35%)	Ad hoc on the business survey sample	No	NBB	Traditional mail
Czech Rep.	Manufacturing Construction Trade Market services	≥ 20	1,591	399 (25%)	Ad hoc	No	CNB branches	Internet
Estonia	Manufacturing Construction Trade Market services	≥ 5	~ 1,400	366 (26%)	Ad hoc	Yes (Tallinn–non-Tallinn)	External company	Internet
France	Manufacturing Trade Market. services Non-market services	≥20 industry ≥ 5 services	~ 6,550	2,029 (31%)	Ad hoc	Yes	Local branches	Phone, mail, and face to face
Germany	Manufacturing Market services Non-market services	All	4,600	1,832 (40%)	Attached to IFO business survey	East-West	IFO	Traditional mail
Greece	Manufacturing Trade Market services Non-market services	All	5,000	429 (9%)	Ad hoc	All regions	External company	Traditional mail
Hungary	Manufacturing (+energy) Construction Trade Market services Fin. intermed.	≥ 5	3,785	2,006 (53%)	Ad hoc	All regions, stratified by NUTS1 regions	External company	Face-to-face interview
Ireland	Manufacturing (+energy) Construction Trade Market. services Fin. intermed. Non-market services	≥ 5	~ 4,000	985 (25%)	Ad hoc	No	External company	Traditional mail, phone
Italy	Manufacturing Trade Market services Fin. intermed.	≥ 5	~ 4,000	953 (24%)	Ad hoc	Yes	External company	Internet
Lithuania	Manufacturing (+energy) Construction Trade Market services Fin. intermed.	All	2,810	343 (12%)	Ad hoc	No	External company	Phone, mail, face-to-face
Luxembourg	Manufacturing (+energy) Construction Trade Market. services Fin. Intermed.	≥1	>7,000	survey not finished yet	Ad hoc	No	BCL	Email
Netherlands	Manufacturing Construction Trade Market services Fin. intermed.	≥ 5	2,116	1,068 (50%)	Ad hoc	No	External company	Internet
Poland	Manufacturing (+energy) Construction Trade Marketservices Fin. intermed.	All	~1,600	1,161 (73%)	Ad hoc + attached to the labour market survey	All regions	National Bank of Poland (branches)	Traditional mail
Portugal	Manufacturing (+energy) Construction Trade Market services Fin. intermed. Non-market services	≥ 10	~5,000	1,436 (29%)	Ad hoc	No	Banco de Portugal	Traditional mail and internet
Slovenia	Manufacturing (+energy) Construction Trade Market services Fin. intermed.	≥ 5	~ 3,000	666 (22%)	Ad-hoc	No	Banka Slovenije	Traditional mail and internet
Spain	Manufacturing (+energy) Trade Market Services	All	3,000	1,835 (61%)	Ad-hoc	No	External company	Mail, phone, fax or internet

## Appendix 2 - The WDN survey questionnaire

Wage setting and wage changes					
This section focuses on information on wage setting practices, on the frequency and timing of wage changes. It also collects information on how the wages of new workers are set relative to those of existing workers. Unless otherwise indicated, answers should refer to "normal conditions and practices".					
<b>1 – How were your firm's employees distributed across the following occupational groups at the end of the reference period ?</b> <b>For the definition of employees and of occupational groups, see the Appendix.</b>					
Low skilled blue collar/Production		_____ %			
High skilled blue collar/Technical		_____ %			
Low skilled white collar/Clerical		_____ %			
High skilled white collar/Professional		_____ %			
Other		_____ %			
TOTAL (= 100%)		100 %			
<b>2 – Does your firm apply a collective pay agreement bargained and signed outside the firm (at the national, regional, sectoral or occupational level) ?</b>					
No, such an agreement does not exist		<input type="checkbox"/>			
No, we opt out		<input type="checkbox"/>			
Yes, we apply such an agreement		<input type="checkbox"/>			
<b>3 – Notwithstanding your answer to question 2, does your firm apply a collective pay agreement signed at the firm level ?</b>					
Yes		<input type="checkbox"/>			
No		<input type="checkbox"/>			
<b>4 – If "yes" in questions 2 or 3, what percentage of your firm's employees are covered by a collective pay agreement (at any level) ?</b>					
_____ %					
<b>5 – What percentage of your total wage bill in the "reference period" was related to individual or company performance related bonuses or benefits?</b> <b>Definition of bonuses / benefits (flexible wage components) - part of compensation different from the base wage and usually linked to individual's performance.</b>					
_____ %					
<b>6 – Does your firm have a policy that adapts changes in base wages to inflation ?</b> <b>Definition of base wage - direct remuneration excluding bonuses (regular wage and salary, commissions, piecework payments).</b>					
No		<input type="checkbox"/>	→ GO TO QUESTION 8		
Yes		<input type="checkbox"/>			
<b>7 – If "yes" in question 6, please select the options that best reflects the policy followed:</b>					
Wage changes are <u>automatically linked</u> to:		<input type="checkbox"/>			
- past inflation		<input type="checkbox"/>			
- expected inflation		<input type="checkbox"/>			
Although there is no formal rule, wage changes <u>take into account</u> :		<input type="checkbox"/>			
- past inflation		<input type="checkbox"/>			
- expected inflation		<input type="checkbox"/>			
<b>8 – NON-CORE What is the principle of remuneration for the main occupational group (as defined in question 1)?</b> <b>Please choose a single option</b> <b>Definition of hourly, piece-rate and monthly base wage - base wage per hour worked, per month worked, or per pieces produced.</b>					
Hourly base wage		<input type="checkbox"/>			
Piece-rate base wage		<input type="checkbox"/>			
Monthly base wage (or other period-specific wage)		<input type="checkbox"/>			
Other (please specify) _____		<input type="checkbox"/>			
<b>9 – How frequently is the base wage of an employee belonging to the main occupational group in your firm (as defined in question 1) typically changed in your firm?</b> <b>Please tick an option for each of the three types of wage changes listed below.</b>					
	<i>more than once a year</i>	<i>once a year</i>	<i>once every two years</i>	<i>less frequently than once every two years</i>	<i>never / don't know</i>
Wage changes apart from tenure and/or inflation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wage changes due to tenure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wage changes due to inflation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>10 – Under normal circumstances, are base wage changes concentrated in any particular month / months?</b>					
No	<input type="checkbox"/>				
Yes:	Jan. <input type="checkbox"/>	Feb. <input type="checkbox"/>	Mar. <input type="checkbox"/>	Apr. <input type="checkbox"/>	May <input type="checkbox"/>
	June <input type="checkbox"/>	July <input type="checkbox"/>	Aug. <input type="checkbox"/>	Sept. <input type="checkbox"/>	Oct. <input type="checkbox"/>
	Nov. <input type="checkbox"/>	Dec. <input type="checkbox"/>			
<b>11 – Considering the main occupational group in your firm (as identified in question 1), please indicate among the following options which is the most relevant factor in determining the entry wage of newly hired employees:</b> <b>Please choose a single option</b>					
Collective pay agreement (signed at any level)		<input type="checkbox"/>			
Wage of similar employees in the firm		<input type="checkbox"/>			
Wage of similar workers outside the firm		<input type="checkbox"/>			
Availability of workers with similar characteristics in the labour market		<input type="checkbox"/>			
Other reasons (please specify) _____		<input type="checkbox"/>			
<b>12 – NON-CORE If there is abundance in the labour market of workers you need to hire, do you pay newly hired employees significantly lower wage than that of similar (in terms of experience and qualification) employees already in the firm?</b>					
Yes	<input type="checkbox"/>				
No, because (please choose a single option, the most important reason):					
a) It would be perceived as unfair and earn the firm bad reputation	<input type="checkbox"/>				
b) it would have a negative effect on the work effort of the new employees	<input type="checkbox"/>				
c) It is not allowed by labour regulation or collective pay agreement	<input type="checkbox"/>				
d) Unions would contest such action	<input type="checkbox"/>				
e) Other reasons (please specify) _____	<input type="checkbox"/>				

<b>13 – NON-CORE</b> If there is a shortage in the labour market of workers you need to hire and attracting new workers is difficult, do you give newly hired employees significantly higher wage than that of similarly qualified employees already in the firm?					
Yes <input type="checkbox"/> No, because (please choose a single option, the most important reason): <div style="display: flex; justify-content: space-between;"> <div style="width: 60%;">           a) It would be perceived as unfair by existing employees            b) It would have a negative effect on work effort of the employees in the firm            c) It is not allowed by labour regulation or collective pay agreement            d) It would generate pressure for wage increases by existing employees            e) Other reasons (please specify) _____         </div> <div style="width: 35%;"> <input type="checkbox"/>  <input type="checkbox"/>  <input type="checkbox"/>  <input type="checkbox"/>  <input type="checkbox"/> </div> </div>					
Downward wage rigidity and the adjustment to shocks					
This section addresses the issue of the presence of (potential) obstacles to downward wage adjustments and the reaction of firms to different shocks.					
<b>14 – Over the last five years, has the base wage of some employees in your firm ever been frozen ?</b> <u>Definition of freeze in base wage - base wage in nominal terms remains unchanged from a pay negotiation to the next.</u>					
- No <input type="checkbox"/> - Yes (indicate for what percentage of your employees) _____ %					
<b>15 – Over the last five years, has the base wage of some employees in your firm ever been cut ?</b> <u>Definition of cut in base wage - base wage in nominal terms decreases from a pay negotiation to the next.</u>					
- No <input type="checkbox"/> - Yes (indicate for what percentage of your employees) _____ %					
<b>16 – NON-CORE</b> If “yes” in either question 14 or 15, what was the main reason for freezing/reducing the base wage? <u>Please choose a single option, the most important reason.</u>					
Profitability and/or sales went down <input type="checkbox"/> Other costs increased <input type="checkbox"/> Jobs were at risk <input type="checkbox"/> It was imposed by legislation or a higher level collective agreement <input type="checkbox"/> Because worker performance was not satisfactory <input type="checkbox"/> Other reasons (please specify) _____ <input type="checkbox"/>					
<b>17 – How relevant is each one of the following reasons in preventing base wage cuts?</b> <u>Please tick an option for each line.</u>					
	<i>not relevant</i>	<i>of little relevance</i>	<i>relevant</i>	<i>very relevant</i>	<i>don't know</i>
Labour regulation/collective agreements prevent wages from being cut	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
It would reduce employees' efforts, resulting in less output or poorer service	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
It would have a negative impact on employees' morale	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
It would damage the firm's reputation as an employer, making it more difficult to hire workers in the future	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
In presence of a wage cut the most productive employees might leave the firm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
A wage cut would increase the number of employees who quit, increasing the cost of hiring and training new workers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
It would create difficulties in attracting new workers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Workers dislike unpredictable reductions in income. Therefore workers and firms reach an implicit understanding that wages will neither fall in recessions nor rise in expansions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Employees compare their wage to that of similarly qualified workers in other firms in the same market	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>18 – NON-CORE</b> Has any of the following strategies ever been used in your firm to reduce labour costs? <u>Please choose as many options as apply to your firm.</u>					
Reduction or elimination of bonus payments <input type="checkbox"/> Reduction or elimination of non-pay benefits <input type="checkbox"/> Change in shift assignments <input type="checkbox"/> Slowdown or freeze of the rate at which promotions are filled <input type="checkbox"/> Recruitment of new employees (with similar skills and experience) at lower wage than those who left (e.g due to voluntary quits and retirement) <input type="checkbox"/> Use of early retirement to replace high wage employees by entrants with lower wages <input type="checkbox"/> Other strategies (please specify) _____ <input type="checkbox"/>					
<b>19 – NON-CORE</b> Has it become easier over the last decade to adjust wages to reduce labour costs?					
Yes <input type="checkbox"/> No <input type="checkbox"/> → GO TO QUESTION 21 Don't know <input type="checkbox"/> → GO TO QUESTION 21					
<b>20 – NON-CORE</b> If “yes”, why ? <u>Please choose a single option, the most important reason.</u>					
Competition has become more intense <input type="checkbox"/> More workers are available on the market <input type="checkbox"/> Trade unions have less power in collective bargaining <input type="checkbox"/> Employment protection has become less tight <input type="checkbox"/> Production is outsourced in markets where labour is cheaper <input type="checkbox"/> Price inflation and inflation expectations are lower and more stable <input type="checkbox"/>					
The next six questions investigate how your firm adjusts wages, prices, total costs, employment and margins to shocks. In answering, for <u>prices</u> please refer to the “main product or service, defined as the one that generated the highest fraction of turnover in the “reference year”, and for <u>employment and wages</u> please refer to the main occupational group in your firm (as identified in question 1)					
<b>21 – How relevant are each one of the following strategies when your firm faces an unanticipated slowdown in demand ?</b> <u>Please tick an option for each line.</u>					
	<i>not relevant</i>	<i>of little relevance</i>	<i>relevant</i>	<i>very relevant</i>	<i>don't know</i>
Reduce prices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce margins	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce output	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce costs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

<b>22 – If the reduction of costs is of any relevance in your answer to question 21, please indicate the main channel through which this goal is achieved:</b> <b>Please choose a single option, the most important factor.</b>					
Reduce base wages	<input type="checkbox"/>				
Reduce flexible wage components (for example bonuses, benefits, etc.)	<input type="checkbox"/>				
Reduce the number of permanent employees	<input type="checkbox"/>				
Reduce the number of temporary employees / other type of workers	<input type="checkbox"/>				
Adjust the number of hours worked per employee	<input type="checkbox"/>				
Reduce non-labour costs	<input type="checkbox"/>				
<b>23 – How relevant are each one of the following strategies when your firm faces an unanticipated increase in the cost of an intermediate input (e.g. an oil price increase) affecting all firms in the market?</b> <b>Please tick an option for each line.</b>					
	<i>not relevant</i>	<i>of little relevance</i>	<i>relevant</i>	<i>very relevant</i>	<i>don't know</i>
Increase prices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce margins	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce output	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce other costs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>24 – If the reduction of other costs is of any relevance in your answer to question 23, please indicate the main channel through which this goal is achieved:</b> <b>Please choose a single option, the most important factor.</b>					
Reduce base wages	<input type="checkbox"/>				
Reduce flexible wage components (for example bonuses, benefits, etc.)	<input type="checkbox"/>				
Reduce the number of permanent employees	<input type="checkbox"/>				
Reduce the number of temporary employees / other type of workers	<input type="checkbox"/>				
Adjust the number of hours worked per employee	<input type="checkbox"/>				
Reduce other non-labour costs	<input type="checkbox"/>				
<b>25 – How relevant are each one of the following strategies when your firm faces an unanticipated permanent increase in wages (e.g. due to the renewal of the national contract) affecting all firms in the market?</b> <b>Please tick an option for each line.</b>					
	<i>not relevant</i>	<i>of little relevance</i>	<i>relevant</i>	<i>very relevant</i>	<i>don't know</i>
Increase prices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce margins	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce output	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce other costs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>26 – If the reduction of other costs is of any relevance in your answer to question 25, please indicate the main channel through which this goal is achieved:</b> <b>Please choose a single option, the most important factor.</b>					
Reduce flexible wage components (for example bonuses, benefits, etc.)	<input type="checkbox"/>				
Reduce the number of permanent employees	<input type="checkbox"/>				
Reduce the number of temporary employees / other type of workers	<input type="checkbox"/>				
Adjust the number of hours worked per employee	<input type="checkbox"/>				
Reduce non-labour costs	<input type="checkbox"/>				
<b>Price setting and price changes</b>					
This section collects information on price setting and the frequency of price changes.					
If your firm produces (or sells) more than a 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 "reference year". For instance, if your firm produces (or sells) several types of hats and shoes, by "product" we mean "hats" and "shoes" (irrespective of the specific type), whereas by "main product" we mean the one that generated the highest revenue in the "reference year".					
<b>27 – What share of the revenue generated by your firm's main product in the reference period was due to sales in:</b>					
Domestic market	_____ %				
Foreign markets	_____ %				
Total (= 100%)	100 %				
<b>28 – How is the price of your firm's main product set in its main market ?</b> <b>Please choose a single option.</b>					
There is no autonomous price setting policy because:					<input type="checkbox"/>
- the price is regulated, or is set by a parent company / group					<input type="checkbox"/>
- the price is set by the main customer(s)					<input type="checkbox"/>
The price is set following the main competitors					<input type="checkbox"/>
The price is set fully according to costs and a completely self-determined profit margin					<input type="checkbox"/>
Other (please specify) _____					<input type="checkbox"/>
<b>29 – NON-CORE To what extent does your firm experience price competition for its main product?</b> <b>Please choose a single one option.</b>					
Severe competition	<input type="checkbox"/>				
Strong competition	<input type="checkbox"/>				
Weak competition	<input type="checkbox"/>				
No competition	<input type="checkbox"/>				
Don't know / no answer	<input type="checkbox"/>				
<b>30 – Suppose that the main competitor for your firm's main product decreases its prices; how likely is your firm to react by decreasing its own price?</b> <b>Please choose a single option.</b>					
Very likely	<input type="checkbox"/>				
Likely	<input type="checkbox"/>				
Not likely	<input type="checkbox"/>				
Not at all	<input type="checkbox"/>				
It doesn't apply	<input type="checkbox"/>				
<b>31 – Under normal circumstances, how often is the price of the firm's main product typically changed?</b> <b>Please choose a single option, the one that best describes the situation in your firm</b>					
More than once a year:					<input type="checkbox"/>
- daily					<input type="checkbox"/>
- weekly					<input type="checkbox"/>



- monthly - quarterly - half-yearly Once a year Once every two years Less frequently than once every two years Never There is not a defined pattern	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>																		
<b>32 – Under normal circumstances, are these price changes concentrated in any particular month / months?</b>																			
No <input type="checkbox"/> Yes: Jan. <input type="checkbox"/> Feb. <input type="checkbox"/> Mar. <input type="checkbox"/> Apr. <input type="checkbox"/> May <input type="checkbox"/> June <input type="checkbox"/> July <input type="checkbox"/> Aug. <input type="checkbox"/> Sept. <input type="checkbox"/> Oct. <input type="checkbox"/> Nov. <input type="checkbox"/> Dec. <input type="checkbox"/>																			
<b>33 – How does the timing of these price changes relate to that of wage changes?</b>																			
<b>Please choose a single option</b>																			
There is no link between the two There is a link but no particular pattern Decisions are taken simultaneously Price changes tend to follow wage changes Wage changes tend to follow price changes Don't know	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>																		
<b>Information about the firm</b>																			
<b>34 – How many workers (including employees and other types of workers) did your firm have at the end of the reference period?</b>																			
<b>Definition of employees is provided in the Appendix. Other definitions:</b>																			
<b>Permanent full-time</b> - those who have no set termination date, and whose regular working hours are the same as the collectively agreed or customarily worked.																			
<b>Permanent part-time</b> - those who have no set termination date, whose working hours are less than those specified for permanent full-time.																			
<b>Temporary</b> - those who have a set termination date or a specific period of employment.																			
Number of employees: _____ of which: <table border="0" style="width: 100%;"> <tr> <td></td> <td style="text-align: center;">Percentages</td> <td style="text-align: center;">Number</td> </tr> <tr> <td><b>(fill in one of the two columns, as you prefer: levels or %)</b></td> <td></td> <td></td> </tr> <tr> <td>permanent full-time</td> <td style="text-align: center;">_____ %</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>permanent part-time</td> <td style="text-align: center;">_____ %</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>temporary</td> <td style="text-align: center;">_____ %</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>TOTAL (= 100%)</td> <td style="text-align: center;">100 %</td> <td style="text-align: center;">_____</td> </tr> </table> Number of other types of workers (e.g. people employed by agencies, freelance, consultants, apprenticeships, students, other casual workers, etc.) _____			Percentages	Number	<b>(fill in one of the two columns, as you prefer: levels or %)</b>			permanent full-time	_____ %	_____	permanent part-time	_____ %	_____	temporary	_____ %	_____	TOTAL (= 100%)	100 %	_____
	Percentages	Number																	
<b>(fill in one of the two columns, as you prefer: levels or %)</b>																			
permanent full-time	_____ %	_____																	
permanent part-time	_____ %	_____																	
temporary	_____ %	_____																	
TOTAL (= 100%)	100 %	_____																	
<b>35 – How many employees left the firm during the reference period?</b>																			
<b>Please refer to all types of employees: temporary and permanent, see definition in question 34.</b>																			
_____																			
<b>36 – How many employees joined the firm during the reference period?</b>																			
<b>Please refer to all types of employees: temporary and permanent, see definition in question 34.</b>																			
_____																			
<b>37 – NON-CORE How were your firm's employees distributed across the following age classes at the end of the reference period?</b>																			
Less than 24 years old 24-54 years old 55-65 years old >65 years old TOTAL (= 100%)	_____ % _____ % _____ % _____ % 100 %																		
<b>38 – NON-CORE How were your firm's permanent employees distributed according to tenure at the end of the reference period?</b>																			
Less than 1 year Between 1 and 5 years More than 5 years TOTAL (= 100%)	_____ % _____ % _____ % 100 %																		
<b>39 – NON-CORE According to the current business register, what was the first year of operation of your firm?</b>																			
<b>Definitions needed here (see appendix and discuss)</b>																			
_____																			
<b>40 – What percentage of your firm's total costs were due to labour costs in the reference period ?</b>																			
<b>Definitions: Total costs</b> - all operating expenses. <b>Labour costs</b> - wages, salaries, bonuses, social contributions, training, tax contributions, contributions to pension funds																			
_____ %																			
<b>41 – How was your firm's revenue in the reference period compared to the previous year?</b>																			
Much lower Lower Approximately the same Higher Much higher	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>																		

### Appendix 3 – Computing expected durations

The frequencies reported in Section 2 allow identifying the duration of prices (for the firm's main product) and wages (for the firm's typical worker) with the help of some additional assumptions. In the context of the survey, price and wage duration can be interpreted as the time interval for which these variables remain unchanged. The information collected by the survey of frequency of price and wage changes comes in categories, which identify points (e.g. annual changes correspond to 12 months duration) and intervals on the support of the duration distribution. While points translate directly into durations, we need a distributional assumption in order to impute an expected duration to each interval. Three such intervals need this assumption: a) expected wage duration if it is shorter than one year (frequency more than once a year); b) expected wage duration if it is longer than two years (frequency less than once every two years); c) expected price duration if it is longer than one year (frequency less than yearly).

We assume a lognormal distribution for both wage and price durations. Note that the support of the lognormal is the positive real line appropriate for durations, and the shape of the histogram of point answers is close to the shape of a lognormal density function both for wages and prices. The distributional assumption is necessarily ad-hoc but it is consistent with a positive support of durations. At the same time, the reported large mass of probability at specific points (e.g. once a year that translates into 12 months exactly) is at odds with the lognormal or any other continuous distribution. With these caveats in mind, one should think of the duration results as being an approximation.

We define durations in months. Let  $d_w$  denote the duration of wages and  $d_p$  that of prices. As already mentioned, the three durations that need to be imputed are the following:

- $E[d_w|d_w < 12]$ : expected duration for wages if duration shorter than one year;
- $E[d_w|d_w > 24]$ : expected duration for wages if duration longer than two years;
- $E[d_p|d_p > 12]$ : expected duration for prices if duration longer than one year.

The information that we use the computation of expected wage duration is that on the changes that identify various points. We denote these points, that will serve as thresholds in the exercise,  $\tau_{wj}$ :

$\tau_{w1}$  = more than once a year,  
 $\tau_{w2}$  = once a year,  
 $\tau_{w3}$  = once every two years,  
 $\tau_{w4}$  = less frequently than once every two years.

These thresholds imply the following probabilities of duration intervals:

$$\begin{aligned} P(d_w \leq 11) &= P(\tau_{w1}) \\ P(d_w \leq 12) &= P(\tau_{w1}) + P(\tau_{w2}) \\ P(d_w \leq 24) &= P(\tau_{w1}) + P(\tau_{w2}) + P(\tau_{w3}) \\ P(d_w > 24) &= P(\tau_{w4}) \text{ (this last one is redundant)} \end{aligned}$$

The analogous data for price duration with thresholds  $\tau_{pi}$  are the following:<sup>24</sup>

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<sup>24</sup> For the imputation exercise, we collapsed the four high-frequency categories into one, for simplicity and in order to get identification from the upper-duration (low-frequency) part of the distribution – latter makes sense because here it is only the upper duration point that we want to impute. Note that it is only for the imputation exercise that we collapsed the shorter-duration categories  $E[d_p|d_p > 12]$ , and no information was discarded for the eventual translation of frequencies into durations.

$\tau_{p1}$ =daily, weekly, monthly, or quarterly

$\tau_{p2}$ =half-yearly/twice a year,

$\tau_{p3}$ =once a year,

$\tau_{p4}$ = less frequently than once a year

Implied probabilities of duration intervals ( $d_p$ )

$$P(d_p \leq 4) = P(\tau_{p1})$$

$$P(d_p \leq 6) = P(\tau_{p1}) + P(\tau_{p2})$$

$$P(d_p \leq 12) = P(\tau_{p1}) + P(\tau_{p2}) + P(\tau_{p3})$$

$$P(d_p > 12) = P(\tau_{p4}) \text{ (this last one is redundant)}$$

The first step is to estimate the parameters of the unconditional distributions. We assume lognormality so that the natural log of durations (denoted as  $ld$ ) is normally distributed:

$$ld_j = \log(d_j) \sim N(\mu_j, \sigma_j), j=p, w.$$

Then

$$P(d_j \leq a) = P(ld_j \leq \log(a)) = P[(ld_j - \mu_j)/\sigma_j \leq (\log(a) - \mu_j)/\sigma_j] = \Phi[(\log(a) - \mu_j)/\sigma_j]$$

where  $\Phi$  is the standard normal c.d.f. Take inverse of normal c.d.f. of two sides to get

$$\Phi^{-1}[P(d_j \leq a)] = (\log(a) - \mu_j)/\sigma_j$$

For prices, we have four such equations, for wages, three. Both are overidentified: two equations would identify  $\mu_j, \sigma_j$ . A minimum distance or least squares approach (if unweighted) is numerically equivalent to taking all possible exactly identified estimates and take their average. Exactly identified solutions are the following:

$$\Phi^{-1}[P(d \leq a)] = (\log(a) - \mu)/\sigma \quad \text{and} \quad \Phi^{-1}[P(d \leq b)] = (\log(b) - \mu)/\sigma$$

$$\sigma = (\log(a) - \mu) / \Phi^{-1}[P(d \leq a)]$$

and therefore

$$\Phi^{-1}[P(d \leq b)] = (\log(b) - \mu) \Phi^{-1}[P(d \leq a)] / (\log(a) - \mu)$$

so that

$$\mu = [\log(b) - \log(a) B/A] / [1 - B/A] \text{ where } A = \Phi^{-1}[P(d \leq a)] \text{ and } B = \Phi^{-1}[P(d \leq b)]$$

Data from the survey answers define fractions of firms that are estimates of each probability interval defined above (i.e.  $P(\tau_{p1}) + P(\tau_{p2})$ ). We use employment weights and discard missing answers for estimating these fractions. The unconditional parameters are estimated to be the following:

for price duration:  $\mu=2.0, \sigma=0.6$

for wage duration:  $\mu=2.4, \sigma=0.4$

Given these unconditional parameters of the lognormal distribution, we computed the conditional expectations by simulation and we find that these imputed conditional expectations are:

$$E[d_w | d_w < 12] = 8.3, \quad E[d_w | d_w > 24] = 27.4 \quad \text{and} \quad E[d_p | d_p > 12] = 17.7$$

## Appendix 4 – The frequency of price and wage changes: marginal effects

The tables below show average partial effects evaluated at sample means. Such effects measure discrete changes in the probability of each outcome as the covariate increases by  $dx$  in the case of a continuous variable and by a unit 1 in the case of dummies or count variables.

**Table A4.1 – Frequency of price changes: marginal effects**

(col. 5 in Table 8)

	prob. of changing price daily/monthly	prob. of changing price quarterly/twice a year	prob. of changing price yearly	prob. of changing price less frequently than yearly
Construction	0.013**	0.032**	0.061**	-0.106**
Trade	0.025**	0.070**	0.173**	-0.268**
Market services	0.000	0.001	0.001	-0.002
Financial intermediation	0.021**	0.061**	0.184**	-0.266**
Firm size 20-49	0.001	0.002	0.003	-0.006
Firm size 50-199	0.007**	0.015**	0.020*	-0.042*
Firm size > 200	0.009**	0.020**	0.029**	-0.058**
AT	0.001	0.002	0.002	-0.005
BE	0.012	0.029	0.055	-0.095
CZ	0.000	0.001	0.001	-0.002
ES	0.004	0.009	0.012	-0.025
FR	0.004	0.009	0.012	-0.024
GR	0.011**	0.025**	0.039*	-0.075**
IE	-0.003	-0.007	-0.008	0.019
IT	0.012**	0.028**	0.050*	-0.090*
LT	0.005	0.011	0.017	-0.033
NL	0.020**	0.057**	0.162**	-0.240**
PL	0.010**	0.025**	0.041*	-0.076*
PT	0.008*	0.018*	0.029	-0.055*
SI	0.008*	0.019*	0.029*	-0.056*
Labour cost share	-0.023**	-0.050**	-0.063**	0.136**
Competitive pressures	0.017**	0.038**	0.045**	-0.100**
Export (% of sales)	0.006*	0.012*	0.016*	-0.034
Share of white collars	-0.009**	-0.020**	-0.025**	0.054**
Share of high skilled workers	-0.004*	-0.009*	-0.011*	0.024*
Share of full time permanent workers	-0.001	-0.003	-0.004	0.008
Workforce turnover	0.009**	0.019**	0.024**	-0.052
Share of bonuses on total wage bill	-0.001	-0.002	-0.003	0.006

**Table A4.2 – Frequency of wage changes: marginal effects**

(col. 7 in Table 9)

	prob. of changing wages more frequently than yearly	prob. of changing wages yearly	prob. of changing wages less frequently than yearly
Construction	0.026**	0.034*	-0.060**
Trade	-0.015*	-0.013**	0.028*
Market services	-0.017**	-0.015**	0.032**
Financial intermediation	-0.037*	-0.022**	0.059**
Firm size 20-49	0.013*	0.014*	-0.027*
Firm size 50-199	0.027**	0.030**	-0.057**
Firm size > 200	0.038**	0.050**	-0.089**
AT	0.015	0.017	-0.031
BE	-0.015	-0.012	0.026
CZ	-0.099**	-0.022**	0.121**
ES	0.028**	0.039*	-0.068*
FR	0.047**	0.067**	-0.114**
GR	0.055**	0.088**	-0.143**
IE	-0.038**	-0.025**	0.063**
LT	-0.298**	0.096**	0.202**
NL	0.072**	0.195**	-0.267**
PL	0.015	0.016	-0.031
PT	-0.032*	-0.021**	0.054**
Labour cost share	-0.004	-0.003	0.007
Competitive pressures	-0.002	-0.002	0.003
Export (% of sales)	0.003	0.003	-0.006
Workforce turnover	0.023**	0.022**	-0.045**
Share of bonuses on total wage bill	0.023**	0.019**	-0.042**
Collective agreement outside the firm	0.006	0.006	-0.013
Collective agreement at the firm level	0.012*	0.012*	-0.024*
Coverage of collective agreement	-0.013*	-0.012*	0.025*
EPL	-0.018**	-0.017**	0.035**
Internal policy adjusting wages to prices	0.051**	0.058**	-0.109**

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