Eurosystem Wage Dynamics Network

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

by

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Abstract

This paper presents new evidence on the patterns of price and wage changes and the link between price and wage stickiness in European firms. It uses a unique data set collected from a firm-level survey conducted in a broad range of European countries. The typical frequency of wage changes in European firms is once per year and than prices change more frequently than wages. The frequency of price changes varies across sectors and depends on the degree of competition, the share of labour costs in total cost and other economic features. Instead the country differences in wage change frequencies are larger than is the case of price change frequencies, as wage changes respond most to institutional variables. Wage-setting is time-dependent with more than 54% if firms in Europe wage changes are concentrated in a particular month. In this regard, there is a notable "January effect". Finally, results in this paper point to a degree of synchronisation at the firm level between the timing of wage and price changes and a relationship between price and wage stickiness. When examining the links between prices and wages we find that wages partially feed into prices and the frequency of wage changes influences that of price changes.

Introduction

This paper studies the frequency, timing and interaction of changes in wages and prices across firms, covering several economic sectors in a broad range of countries in the EU. 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 context of New Keynesian Philips Curve framework, these models seem to fit better the data. In general, the analysis of price and wage dynamics simultaneously can also shed some light on the impact of recent changes in labour market institutions on wage and labour cost dynamics. For example, it can give some indications about 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 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 (Austria, Belgium, Czech Republic, Estonia, France, Germany, Greece, Hungary, Italy, Ireland, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Slovenia and Spain) 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 firm's characteristics such as sector of activity, 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 survey collects information on both price and wage setting and adjustments.

The use of surveys to investigate pricing policies was pioneered by the seminal work of Blinder (1991) and Blinder et al. (1998). Their approach has led to similar analyses in other countries and was recently adopted within the Eurosystem Inflation Persistence Network (IPN) in a number of studies that explored pricing decisions of firms in the euro area (for the results, see Fabiani et al., 2007). The survey on which this paper is based can be somehow viewed as the "natural" follow-up to some of the results on the behaviour of prices 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 Dhyne et al., 2007, Vermeulen, et al., 2007, and 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 and hence put firms' wage setting policies at the heart of out 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

Wolfgang and Pfeiffer (2006). This paper, and more generally the studies based on the WDN survey, somehow enrich this research approach as they explore also 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, hence complementing previous IPN results.

In particular, this study 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?

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.

The structure of this paper is the following. Section 1 briefly present 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 performs a multivariate econometric analysis that exploits the richness of firm-level information to assess the main features of price and wage setting strategies and their causal relationship. Some conclusions are summarized in Section 4.

1   The data

The data used for this paper is a sub-set of the harmonised sample of the WDN survey. The survey covers 17 European countries, 12 from the euro area and five of the new EU member states. Although the national surveys were organized 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 and individual country surveys made very few modifications to the structure of this set of common questions; the national questionnaires could also include other questions aimed at analysing specific issues particularly relevant for each economy. The country-level data were harmonised into a common dataset by the WDN staff.

The sub-sample used in this paper consists of 15 countries for which fully harmonized data are available; it does not contain Germany (due to comparability problems) and Luxemburg (where the survey has not been completed yet). It also excludes very small firms and those operating in the energy sector. Broadly speaking, it contains firms employing more than five employees in manufacturing, construction and services (trade, business services and financial intermediation). Appendix 1 discusses some more details on the survey methodology and presents the most important information on the individual country samples.

Table 1 – Sample composition by country

Country	Number of firms	%
AT	548	3.67
BE	1,420	9.51
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	13.12
IE	848	5.68
IT	952	6.37
LT	333	2.23
NL	1,065	7.13
PL	896	6
PT	1,320	8.84
SI	650	4.35
Total	**14,937**	**100**

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

(a) Number of observations

	5-19	20-49	50-199	>200	Total
Number of firms:					
Manufacturing	886	1,271	2,267	1,778	6,202
Construction	378	312	337	114	1,141
Trade	1,188	737	793	362	3,080
Market services	1,350	1,060	1,045	725	4,180
Financial services	108	35	78	113	334
Total	3,910	3,415	4,520	3,092	14,937
Employees (*thousands*):					
Manufacturing	2190	4184	5079	7701	19155
Construction	825	592	632	323	2373
Trade	2887	2457	1924	2363	9631
Market services	2497	2578	2990	6737	14803
Financial services	149	78	246	511	985
Total	8550	9890	10871	17635	46947

(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
Total	26.2	22.9	30.3	20.7	100.0
Employees:					
Manufacturing	4.7	8.9	10.8	16.4	40.8
Construction	1.8	1.3	1.3	0.7	5.1
Trade	6.1	5.2	4.1	5.0	20.5
Market services	5.3	5.5	6.4	14.3	31.5
Financial services	0.3	0.2	0.5	1.1	2.1
Total	18.2	21.1	23.2	37.6	100.0

The sample size, sampling probabilities and non-response patterns vary across countries as well as by sector and firm size within countries, All studies based on survey data need to handle this sort of problem in one way or another. Here, we adopt a weighting scheme both for the descriptive analysis and for the regressions, where the latter also condition on country, sector and firm size. The weights used are the employment-adjusted weights produced by the WDN staff and available in the harmonised dataset (see Appendix 1 for details). Attached to each observation (firm) in the sample, such weights show how many employees that observation represents in the population. They 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.

Tables 1 and 2 present the number of observations and the distributions by country, sector and firm size. Table 2 also shows the distribution based on the number of employees represented by the sample. The total sample size is a little below 15,000, representing 47 million employees. By design, the sample is relatively balanced across firm size categories, and its sectoral distribution closely follows the distribution of employment.

An advantage of this survey is that firms were directly asked about a number of features referring to the institutional set up within the firm or to the environment where the firm operates (e.g. the degree of competition or the existence of a policy at the firm level that adjusts wages to inflation). These features are rarely available in administrative and household datasets. In addition, in firm-level surveys the information on wages usually suffers from less measurement errors than in the case of data from household surveys. Among the shortcomings of this kind of ad hoc surveys we should mention, however, the typical low rates of response and the potential misunderstandings in interpreting the questions. Finally, it should be borne in mind that the survey was conducted around the end of 2007 and the beginning of 2008, and replies may be influenced by the specific economic situation prevailing in each country at that time.

2   Descriptive evidence on price and wage changes: frequency, timing and the link between them

Studies conducted within the IPN (summarised in Fabiani et al. 2007) revealed that euro area firms change their prices infrequently, in particular when compared to the United States. This finding is supported by the evidence from quantitative micro consumer and producer price data (Dhyne et al. 2007; Vermeulen et al. 2007) and from survey data from nine euro area countries. Moreover, the frequency of price changes varies systematically across sector. This variability reflects, among other factors, differences in the cost structure of the firm and in particular the differences in the share of labour costs, which is a sizable component of total costs.[1] Our dataset allows to examine wage and price adjustments simultaneously; it also provides useful information to calibrate standard DSGE models with sticky prices and wages.

2.1   Frequency of price and wage changes

We first focus on the degree of flexibility of firms' price and wage setting policies, measured by the frequency of price and wage changes, and, as complementary information, by duration.

Regarding price adjustment, the WDN survey asked firms about the frequency of price changes for their main product (see Appendix 2, question 31). Firms could choose between a range of categories: 1=daily, 2=weekly, 3=monthly, 4=quarterly, 5=half-yearly/twice a year, 6=once a year, 7=less frequently than once a year, 8=other/ never/ there is not a defined pattern.

The process of wage setting was investigated through three separate questions about the frequency 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 is the following: "How

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[1] 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. The variation across countries is instead found to be much less pronounced.

frequently is the base wage of an employee belonging to the main occupational group in your firm typically changed?" (See Appendix 2, question 9). Respondents could choose from the following five options: 1=more than once a year; 2=once a year; 3=once every two years; 4=less frequently than once every two years; 5=never / don't know.

When analyzing the answers concerning price setting, we aggregate the first three options, on the one hand, and the fourth and fifth, on the other hand, into two categories, respectively 1=daily to monthly; 2=quarterly to half-yearly. As for wages, we aggregated the third and fourth categories into a single one, which we labelled as "less frequently as once a year". We also created a synthetic variable for the frequency of wage changes for any of the listed three reasons considered, defined as the highest frequency of wage change at the firm level independently of the reason behind it.

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
Total	**9.2**	**15.4**	**39.3**	**7.4**	**28.4**
Manufacturing	5.3	16.1	43.4	7.8	27.2
Construction	7.4	20.5	29.5	7.4	34.9
Trade	22.7	20.2	27.5	3.2	26.2
Market services	5.4	10.3	44.3	9.9	29.9
Financial services	15.1	19.0	22.9	5.3	35.9

| | **WAGES (for any reason)** | | | |
	more frequently than once a year	yearly	less frequently than once a year	never/don't know
Total	**12.1**	**59.3**	**25.8**	**2.8**
Manufacturing	12.3	59.0	26.6	2.1
Construction	21.6	59.5	15.8	3.1
Trade	10.8	58.1	27.6	3.5
Market services	11.0	60.5	25.1	3.4
Financial services	16.0	58.4	24.0	1.5

Figures weighted by employment weight, rescaled excluding non-responses.

In general firms change prices more often than they change wages. About half of them change prices once a year or less frequently; a quarter do it more often, while 28 percent do not have a particular pattern. Wages are adjusted less frequently: around 86 percent of firms change their base wages once a year or less often, while only 12 percent do it more often.

The analysis by sector reveals that firms in manufacturing and market services adjust prices much less frequently that those in trade and financial services. Construction is the sector with the highest fraction of firms reporting no regular time-dependent pattern in price revisions. 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.

As regards wages, there is little variation across sectors, with construction being the only sector to exhibit some differences. Wage changes are least frequent in trade and business services, more frequent in manufacturing and most frequent in construction. Even in construction, though, 60 percent of the firms reported wage adjustments at the yearly frequency and only 22 percent reported a higher frequency.[2]

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[2] 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.

When looking at cross-country differences, the top panel of Table 4 shows that there is little variability in the frequency of price changes. Poland, Lithuania and the Netherlands seem to be the countries where prices change more frequently, whereas Hungary, Spain and France are those with the lowest share of firms adjusting more frequently than yearly. There are no major differences between 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
Total	**9.2**	**15.4**	**39.3**	**7.4**	**28.4**
Euro area	**8.9**	**12.8**	**40.9**	**5.1**	**32.1**
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[1]	3.6	18.2	40.8	6.6	30.8
Ireland	13.5	13.3	31.4	11.2	30.2
Italy	8.9	12.9	32.3	6.5	39.3
Netherlands	12.9	15.9	44.2	5.5	21.3
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
Non- Euro Area	**9.9**	**22.5**	**35.0**	**13.6**	**18.6**
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
Standard deviation	*2.9*	*5.7*	*7.7*	*3.7*	*6.7*
	WAGES (for any reason)			
	more frequently than once a year	yearly	less frequently than once a year	never/don't know
Total	**12.1**	**59.3**	**25.8**	**2.8**
Euro area	**11.4**	**59.2**	**26.7**	**2.7**
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[1]	33.9	56.4	9.7	0.0
Ireland	9.2	71.8	12.9	6.1
Italy	4.2	26.9	64.6	4.3
Netherlands	11.1	69.9	16.9	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
Non- Euro Area	**14.0**	**59.5**	**23.2**	**3.3**
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
Standard deviation	*11.4*	*15.4*	*15.4*	*2.7*

Figures weighted by employment weight, rescaled excluding non-responses.
(1) 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

However, substantial cross-country variation is observed in the case of wage changes, reflected in the higher standard deviation of wage changes between countries compared to price

changes (Table 4). Lithuanian, Greek and Slovene firms seem to change the base wage most frequently, followed by Belgium, France and Estonia, while Hungarian, Italian and Portuguese firms change wages the least frequently. Apart from Italy and Lithuania, though, the modal frequency is one year in all countries. The results show very little difference between firms in euro-area and non-euro area EU member countries as a group. The fact that the frequency of price changes varies a lot across sectors but not much across countries, and vice versa for wages changes, suggests that economic factors play an important role in pricing behaviour, while social, cultural or institutional elements might be at work for wage changes.

Table 5 reports similar information on the flexibility of price and wage changes, but now in terms of the number of months for which they remain unchanged ("duration"). The computation is based on firms' answers to questions regarding the frequency of price and wage changes. Most answers directly translate into durations (e.g. "once a year" translates to duration of 12 months). A few of the answer categories define intervals (e.g. "less frequently than once every two years") and thus do not translate directly into a point. In order to impute expected durations for those categories, we assumed an underlying lognormal distribution of duration of prices and wages, estimated the parameters of the distributions from the other answers, and computed the conditional expectations for the categories. The duration results should therefore be thought of as approximations, as the imputations are based on an ad-hoc distributional assumption (see Appendix 4 for details).

Prices tend to remain unchanged on average for almost 10 months. Somewhat longer durations were calculated within the IPN: according to survey results it was 11 months, the implied average duration of a CPI-price spell was 13 months. Consumer prices are adjusted more often in the United States, where the average duration is slightly above half a year. Differences with the United States are not due to any particular product category but hold for almost all items.

Looking at sectoral differences, our results reveal that prices set by manufacturers and services firms tend to remain unchanged on average for just less than one year, whereas those set in trade and financial services are more flexible (their duration amounts to 7 and 8 months, respectively).

Durations are longer for wages, as they remain unchanged on average for 15 months. There is little variation across sectors, as emerged from the computation of average frequencies, with average duration ranging from 13 to 15 months. Finally, durations are somewhat shorter for the euro area than in the other European countries as a group included in our sample.

Table 5 - Average duration of price and wage changes
(months)

	Prices	Wages
Total	9.6	15.0
Euro area	9.6	14.7
Non-Euro area	9.6	15.1
Sector		
Manufacturing	10.2	15.0
Construction	9.2	13.4
Trade	6.8	15.4
Business services	10.9	15.0
Financial services	7.7	14.5

Figures weighted by employment weight, rescaled excluding non-responses.

2.2   *Timing of price and wage changes*

Together with the frequency of adjustment, other features of price and wage setting that may affect the degree of flexibility with which firms move their nominal variables to changing conditions is the "typical" price and wage change strategy. In the literature, firms' pricing strategies are modelled either as a time-dependent process, where the timing of price adjustment is exogenously given and does not depend on the state of the economy, or as a state-dependent process. Which of the two modelling approaches reflects better firms' actual behaviour and the degree of synchronisation of price revisions have important implications for monetary policy makers.

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

With a view on obtaining more empirical evidence on these issues in the WDN, firms were asked to specify whether their price changes take place with no predefined pattern or are concentrated in particular month(s) (see Appendix 2, question 32). This latter option was chosen by about 35 percent of the sample (Figure 2). Looking at the month in which adjustments typically take place, there appears to be a considerable degree of synchronisation among firms, as about two-thirds of those reporting the presence of some time regularity indicate January as the month in which prices are typically changed.

Just like for price changes, firms were asked some details concerning the timing of the wage-adjustment process (see Appendix 2, question 10). More than half of firms (54 percent) stated that wage changes are concentrated in particular month(s) (Figure 2).

Figure 2: Timing of wage and price changes at the firm level
(percentages of firms reporting to change wages/prices in a particular month)
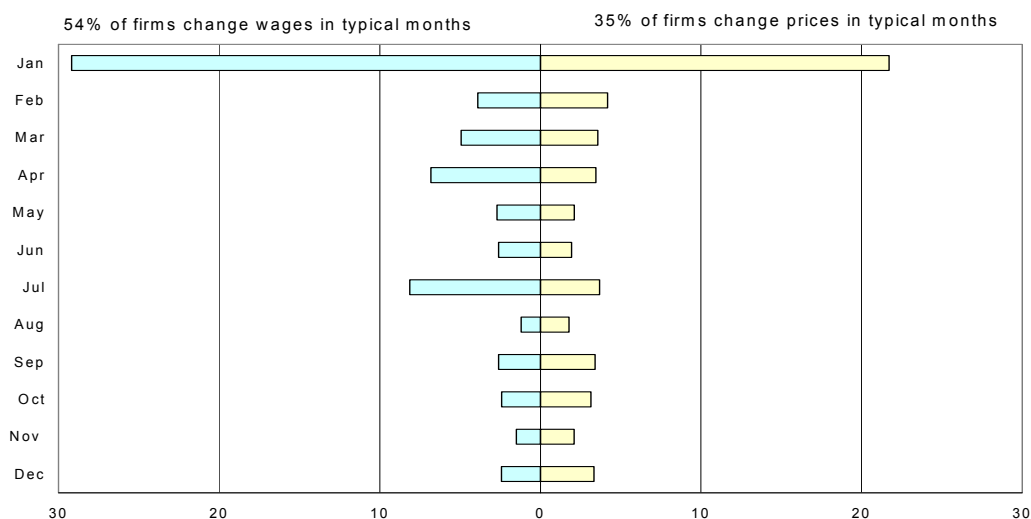
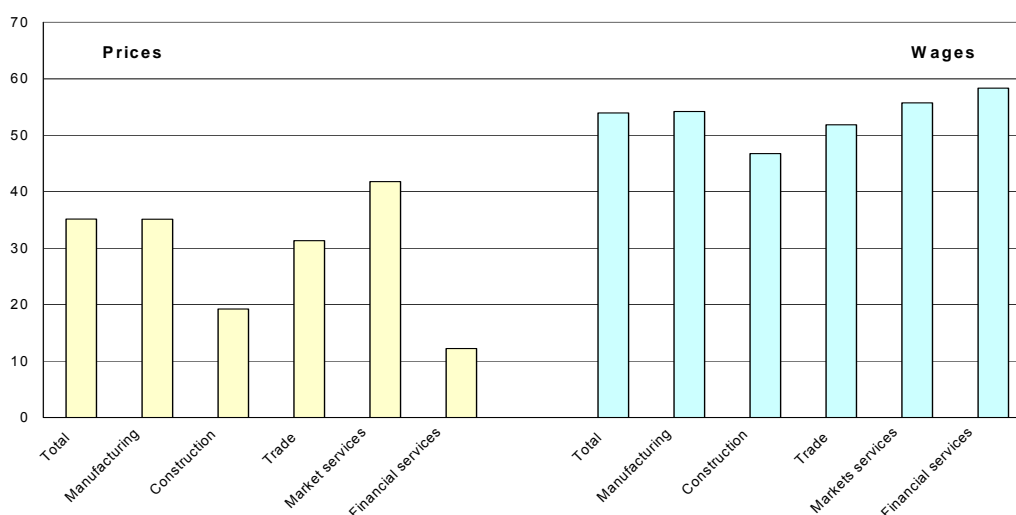Figures weighted by employment weights, rescaled excluding non-responses.

The fact that time-dependent wage adjustment is more often applied than time-dependent price adjustment could be related to the use of wage indexation mechanisms in some countries, or to the presence of institutional arrangements within the firm itself or at the national or sectoral level, in the form of collective bargaining agreements. As for prices, a considerable degree of synchronisation among firms is observed, with a prominent "January effect" in all countries: on

average 30 percent of wage changes take place in January. Other, although smaller, peaks occur in July (8 percent) and April (7 percent). The other months represent shares below 5 percent.

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 a period of more flexible wages, than a shock occurring later in the year. Olivei and Tenreyro (2007) derive similar results for the US 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. Accordingly, our results suggest that monetary policy decisions taken in the last quarter of the year are likely to have a larger impact on prices and less on output.

The concentration of price adjustments in particular months is least common in financial services and more widespread in market services (Figure 3). These results are consistent with a higher, respectively lower frequency of adjustment found in these sectors. It indicates the existence of price rigidity in the business services sector, hence confirming IPN results. In all sectors, January is the month in which the largest part of price changes occurs.

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

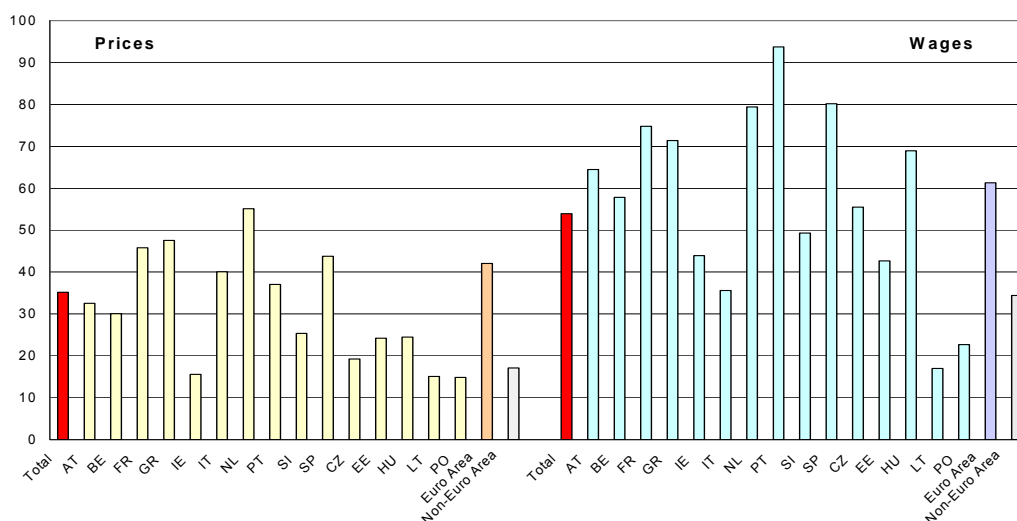Figures weighted by employment weights, rescaled excluding non-responses.

The pattern of concentration of wage changes in particular month(s) is very similar across sectors. It is below average in construction and trade. In all sectors, January is the month in which the largest part of wage changes occurs. Wage changes are more scattered among different months in financial services. While all sectors show a similar behaviour with respect to the fact that the wage changes are more concentrated than price adaptations, this pattern is much more pronounced in financial services: 58 percent of firms state that wage changes typically happen at a specific time of the year, while only 12 percent for prices. Financial intermediation is of course a very particular sector with respect to price setting. In market services, however, wage changes are concentrated as on average (56 percent of firms), but price change time-dependence is considerably above average (42 percent).

Regarding the use of time-dependent pricing, some variation can also be observed across countries (Figure 4). The fraction of "time-dependent" firms ranges from a minimum in Poland (15 percent) to a maximum in the Netherlands (55 percent). It exceeds 40 percent in Greece, France and

Spain as well. It is much higher for the euro area aggregate (42 percent) than for non-euro area countries as a group (17 percent). In all countries, most price changes occur in January.

As to wages, concentration is the least in Lithuania (17 percent) and the highest in the Portugal (94 percent), consistent with the respectively high and low frequencies of wage changes in these countries. The share of time-dependent wage adjustment also exceeds 70 percent in Spain, the Netherlands, France and Greece. As for prices, it is much higher for euro area countries (61 percent) than for non-euro area countries (34 percent). In all countries, most wage changes occur in January. Besides, in some countries, another specific month is indicated by a relatively large share of firms: July in Belgium, France and Lithuania; May in Austria; August in Slovenia and September in Greece. These large country differences are consistent with the evidence from Du Caju et al. (2008) that the monthly pattern of wage changes is linked to the timing of wage negotiations. Moreover, our results show that it is probably also related to the use of wage indexation mechanisms in some countries.

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

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

2.3   *The relationship between wage and price changes and indexation*

In this section we investigate the relationship between price and wage changes. 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 inflation, in general, feeds into wage adjustments. In doing so, we rely on information, contained in the survey, on the relationship between price and wage change decisions at the firm level, on the existence and nature of internal policies adjusting wages to inflation and on the frequency of wage changes due to inflation. We also complement our analysis with country/sector level indexation measures collected by other sources within the WDN.

In order to assess the existence and direction of a link between wage and price revisions, firms were asked how the timing of price changes relates to that of wage changes (see Appendix 2, question 33). The intensity, as well as the direction of the relationship between the two strategies are summarized in Figure 5.

The apparent synchronisation between price and wage changes at the firm level emerged in the previous section is confirmed by the fact that around 40 percent of firms, when asked directly,

acknowledge the existence of some relationship between the timing of price and wage revisions within their company. However, only 15 percent state that this relationship is quite strong. Within this latter fraction, decisions are taken simultaneously for 4 percent of the firms, prices follow wages in 8 percent of the cases and wages follow prices in the remaining 3 percent. For about two thirds of the firms, no link exists between the timing of their own price changes and those of wages.[3] This, however, does not necessarily imply that wage ad price changes at the firm level are not related , in fact when asked about potential reactions to shocks , about 60 percent of firms surveyed declare that they would use a strategy of increasing prices when faced with a permanent unexpected increase in wages. Furthermore, the pass-through of wages into prices is particularly relevant in firms with a high labour share; the frequency of price adjustment is lower in firms with a high labour cost share, confirming evidence from the IPN. Firms with a high labour cost share report more frequently that there is a tight link between price and wage changes.[4]

More generally wage changes in the firms are related to the general inflationary outlook captured by the dynamics of consumer prices in the whole economy. The extent and speed with which inflation feeds through into wage changes is influenced on the one hand, by companies internal wage indexation strategies, on the other, by the characteristics of the prevailing institutional setting in each country. In both cases, from a policy perspective if it crucial to assess whether the indexation mechanism is formal or informal, forward or backward looking.

Figure 5 - The relationship between wage and price changes at the firm level
(percentages)
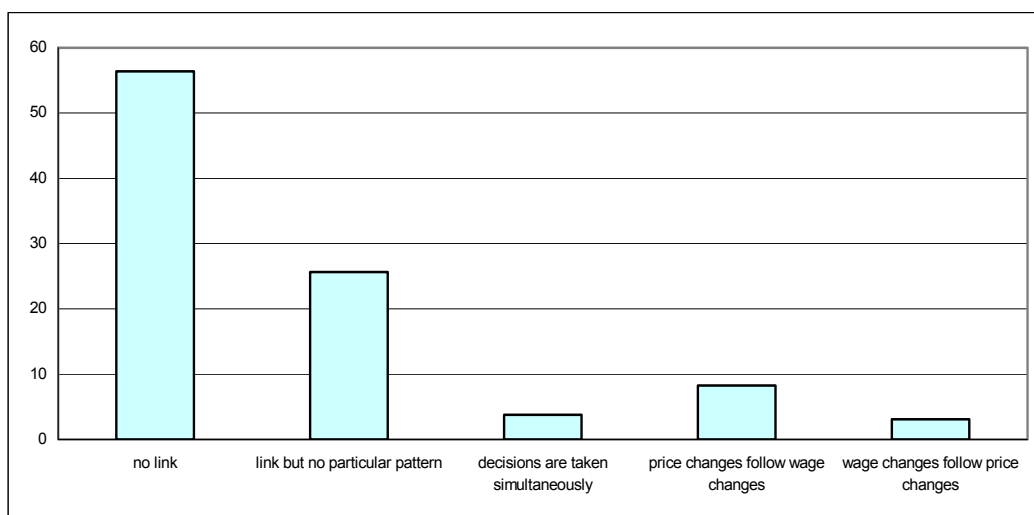
Figures weighted by employment weights, rescaled excluding non-responses.

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 is automatic or not, is subject to a formal rule, and whether it refers to past or expected inflation.

Figure 6 shows that on average two-thirds of the firms do not have an internal policy that adapts base wages to inflation. Of the remaining fraction, nearly half adopt an automatic indexation mechanism, mostly based on past inflation. The other half takes inflation into account without applying any formal rule (9 percent referring to past inflation and 8 percent to expected inflation).

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[3]   The patterns with respect to intensity and direction of the relationship are very similar across sectors and across countries.

[4]   This is further confirmed by regression analysis in section 3 of this paper.

Figure 6 - Adjustment of base wages to inflation across sectors
(percentages)
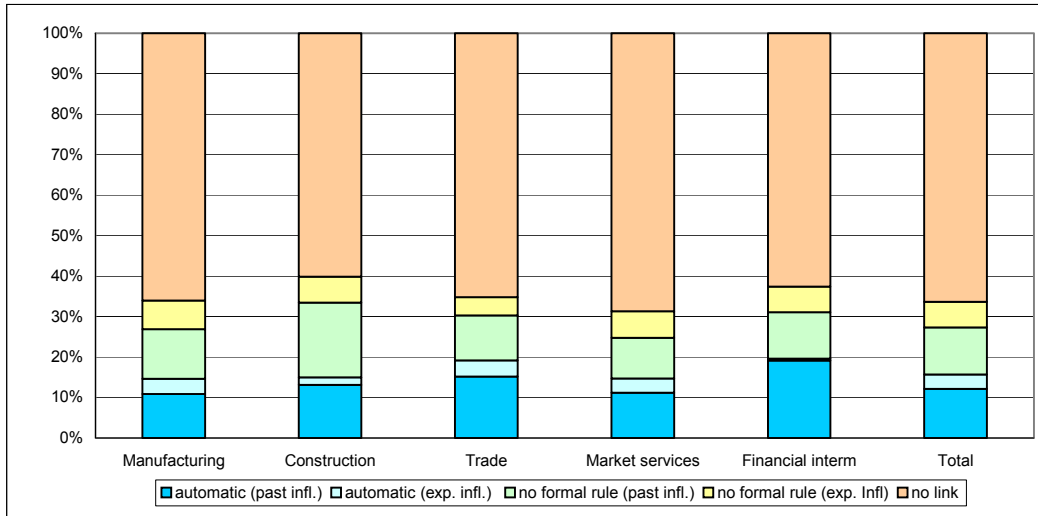
Figures weighted by employment weights, rescaled excluding non-responses.

There is some variability across sectors: the existence of an internal indexation policy is less common in business services and more widespread in financial intermediation and construction. Mostly, these rules are not formal and tend to be backward looking, i.e. take into account past inflation.

Table 6 summarises the information on 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); in these two countries automatic indexation mechanisms are prevalent. Dutch and Italian firms, on the other hand, report not to adapt wages to inflation. In all other countries, internal policies of adjusting wages to inflation are used to some extent, though they are mostly informal. Expected inflation seems to be more important than past inflation for wage setting in Portugal only.[5] Overall, the existence of informal policies of adjusting base wages to inflation seems more common in non euro area countries than in euro area ones, while the opposite is true for automatic adjustment of base wages to inflation.

The information discussed so far covers both formal and informal indexation mechanisms at the firm level, complementing information available from other sources on indexation at the country and sector level. For example, the dataset on wage bargaining institutions collected within the WDN (see Du Caju et al., 2008) provides a measure of existence and coverage of formal wage indexation mechanisms (see Appendix 2 for a description of the questions).[6] According to this measure, reported in the last column of Table 6, 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. This evidence is not inconsistent with the fact that in our survey firms in twelve countries report having

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[5] 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.

[6] The questionnaire on wage bargaining institutions extends its analysis, using a broader definition on adapting wages to inflation, however, without providing for a quantitative measure. It asks to consider some broad categories of factors entering collective wage negotiations and to provide details on the way that these are taken into account. These categories were: prices, labour productivity, competitiveness and changes in taxation or social contributions. Prices came out to be the most important determinant in most countries, a result being in line with the conclusions from the wage and price setting survey.

policies that adapt wages to inflation. In fact, price developments may be just one of the factors entering wage negotiations at the firm level, even if no formal or institutional indexation mechanism is present. This is so for the Czech Republic, Estonia, Greece, Hungary, Ireland and Portugal. Indeed, the vast majority of firms in these countries indicate that no formal rule is applied.

Table 6 - Policy of adjusting base wages to inflation: country overview
(percentages)

| | Firm-level indexation (1) | | | | | Country-level indexation (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	23.6	Very low
BE	98.2	0.0	0.0	0.0	98.2	High
CZ	7.0	5.2	27.9	24.1	59.8	None
EE	2.9	1.8	35.4	20.8	53.8	None
ES	38.3	16.2	10.9	5.0	70.4	High
FR	8.9	2.0	21.2	8.0	33.1	Very low
GR	14.8	5.2	12.1	10.6	47.1	None
HU	7.2	4.2	14.0	5.9	33.0	None
IE	6.0	2.7	18.5	10.4	30.0	None
IT	1.2	0.5	2.6	1.5	6.2	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	51.8	None
SI	20.3	2.7	32.2	5.1	60.3	Low
Total	12.3	3.6	11.7	6.4	33.0	
Euro area	14.6	3.7	8.7	5.0	31.1	
Non Euro area	5.5	3.2	19.8	10.2	38.1	

(1) Figures weighted by employment weights, rescaled excluding non-responses. - (2) Percentage of workers covered by wage indexations clauses: Very low: 0-25%; Low: 26-50%; Moderate: 51-75%; High: 76-100% (Source: Du Caju et al., 2008).

Another source of information available from the survey on how inflation developments may affect firms' wage decisions is the frequency of wage adjustments due to inflation. Figure 7 shows that inflation indeed stands out as the prevalent factor triggering frequent wage adjustment (at an annual or infra-annual frequency).

Figure 7 - Frequency of wage changes
(percentages)
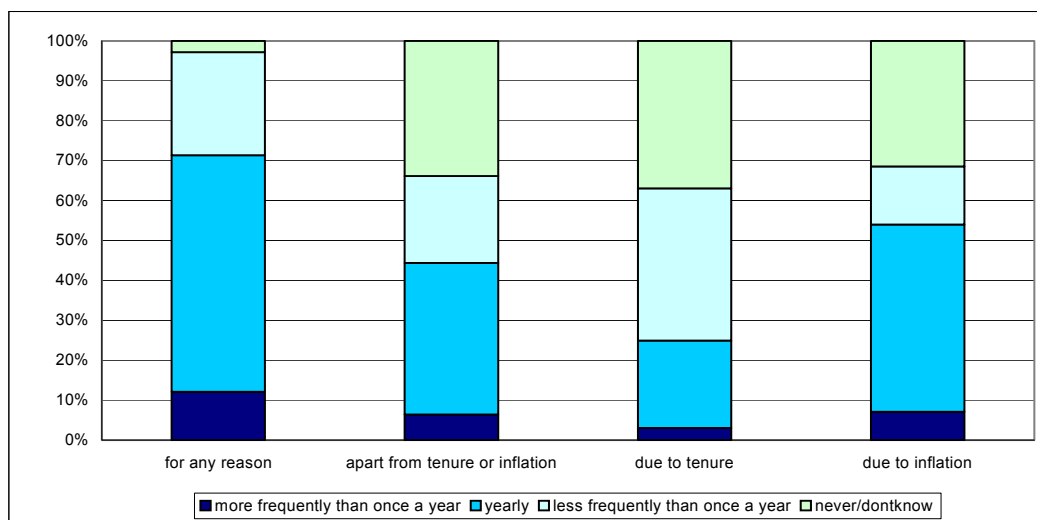
Figures weighted by employment weights, rescaled excluding non-responses.

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Although sectoral heterogeneity in this respect is quite limited, the variability across countries is instead remarkably large (Figure 8).[7] While in Austria, Belgium or Spain over 80 percent of firms change wages annually or more frequently due to inflation, in Italy only 15 percent of firms seem to do that and 60 percent do never change wages due to inflation.[8]

Figure 8 - Frequency of wage changes due to inflation across countries
(percentages)
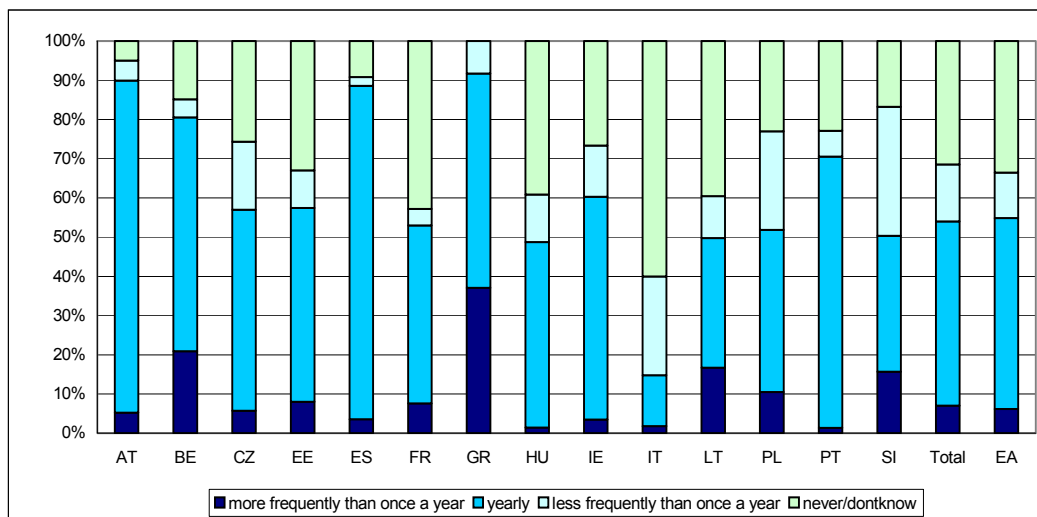
Figures weighted by employment weights, rescaled excluding non-responses.

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

3.1 *Ordered probit estimation*

In this section we estimate, within a multivariate framework, the determinants of the pattern of price and wage changes at the firm level, accounting for differences that could be country, sector or size specific and taking into account the possible interaction between price and wage policies.

We 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 in the firm and at the country level. Others 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.).

Using an ordered probit approach, we examine whether these features are significantly related to: i) the rigidity of prices, expressed in terms of the frequency of price changes; ii) the rigidity of wages, expressed in terms of the frequency of wage changes for any reason[9]; iii) the intensity of the link between price and wage changes at the firm level. In the case of prices, the dependent variable is a categorical one increasing with the degree of price stickiness, from 1 to 4, where 1=daily-

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7   The Netherlands is not in this figure as Dutch firms do not adapt wages to inflation.
8   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.
9   A similar analysis conducted separately on the frequency of wage changes due to (i) reasons different from inflation and tenure (ii) inflation (iii) tenure, give broadly similar results to the ones presented below.

monthly; 2=quarterly-half-yearly/twice a year; 3=once a year; 4=less frequently than once a year.[10] Also in the case of wages, the value categories of the dependent variable are increasing in the degree of wage stickiness, from 1 to 3, where 1=more frequently than yearly; 2=yearly; 3=less frequently than yearly.[11] As for the intensity of the relationship between price and wage setting, the dependent variable takes value 1 if the two aspects are unrelated, 2 if the firm states the existence of some link between them and 3 in presence of a strong link.[12]

As for the possible explanatory factors, we consider the following sets of covariates (in brackets we report the name of the variable; see Appendix 3 for details).

- A set of dummy variables for the firm's economic sector of activity (*sector*: manufacturing, construction, trade, business services, financial services), its size in terms of employees (*size*: 5-19, 20-49, 50-199, >199), the country it belongs to (*country*); These dummies also help to account for unobserved characteristics of the firm that might impact on the relationship between price and wage changes but are not captured by the other explanatory variables;

- A group of proxies for the intensity of product market competition. There are number of empirical papers linking price stickiness and the degree of competition. 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. In addition, Carlton (1986) and Hall et al. (2000) find that more competitive firms tend to adjust prices faster that firms facing less elastic demand; Geroski (1992) shows that price reaction to shocks is faster in more competitive industries. From an empirical viewpoint, whereas the concept of perfect competition and price taking agents is well defined, there are a multitude of ways to model imperfect competition. Moreover, the fact that strategic complementarities strengthen price rigidity does not lend support to the often-made assertion that the larger the market power of a firm (defined as a low elasticity of demand), the stickier prices are.

  On the basis of our questionnaire we can compute two proxies for the degree of competition. The first is the relevance of competitors' prices in triggering a reduction in the firm's own prices. It is based on answers to question 30 (see Appendix 2), that measures the likelihood that a price reduction by competitors leads to a similar reaction in the firm (*perceived_competition*). It is worth remarking that the intensity of competition is typically proxied in the literature by the number of competitors or the firm's market share. In the context of the IPN, however, a high correlation was detected between these indicators and that of perceived competition. As the latter was available for all countries participating to the IPN project, it was used as the preferred measure of the intensity of competition. Here we follow the same strategy, as the WDN survey does not contain information on the number of competitors or the market share. The survey, however, allows to test for the robustness of the results to alternative ways of capturing competitive pressures. In particular, we define a second measure based on the firm's price setting policy (question 28; see Appendix 2). It is a dummy variable taking value 1 if the firm's price is determined following the ones set by its competitors (*price_follows_competitors*). A third indicator of

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[10] We drop category 5 ("no pattern"), as we do not have information on the effective frequency of price changes, and estimate an ordered probit with the sample of firms that have explicitly indicated that they have a pattern when changing prices, hence excluding about 25 percent of the initial sample.

[11] Also in this case we drop the last category ("never/don't know") which hardly amounts to 3 percent of the sample.

[12] The results are in line with those, available upon request, obtained by carrying out a SURE estimation exercise where the relative flexibility/rigidity of prices and wages is defined in terms of log durations. The SURE approach allows for correlation between the equations residuals, which appears to be statistically significant especially as concerns price and wage duration.

the degree of competitive pressures faced by the firm is its international exposure, proxied by the share of exports on total sales (*export_share*; see Appendix 2, question 27);

- A set of variables reflecting the characteristics and the flexibility of the firm's workforce. Anecdotic evidence found in previous IPN studies (see Fabiani et al. 2007) suggests a negative relationship between the labour share and the frequency of price adjustment. We investigate this issue here through the answers provided by firms on the share of labour on their total costs (*labour_cost_share*; see Appendix 2, question 40). Furthermore, we capture the relative strength of the workforce in shaping the firm's wage policies with the nature of the relationship between the firm and its employees (temporary or permanent; *share_permanent*). Finally, we consider a higher fraction of high-skilled employees (*high_skilled*) and a higher share of white collars (*white_collars*) as proxies for technologically flexible firms (see Appendix 2, questions 1 and 34);

- A final group of covariates capturing firm-specific and institutionally driven characteristics related to wage negotiations. They include a dummy for firms that have a policy adapting salaries to past or expected inflation (*indexation*) (see Appendix 2, questions 6 and 7), two dummies capturing the existence of collective pay agreements signed either outside the firm (*coll_agr_out*) or at the firm level (*coll_agr_firm*), and a variable indicating the percentage of the firm's employees covered by these collective agreements (*coverage*) (see Appendix 2, questions 2,3 and 4).

In order to account for the possible correlation between the flexibility of prices and that of wages, we also include in the equations for the frequency of price (wage) changes the frequency of wage (price) changes. We further explore the relationship between the two, accounting for the potential endogeneity problem, in the system estimation presented in the next section.

The results, presented in Table 7, confirm that cross-sectoral differences matter both for the flexibility of prices and of wages. In firms operating in construction, trade and financial intermediation prices tend to change more frequently than in manufacturing (which is the reference category in the regression), while the difference with market services is slightly less significant. In all services sectors, wages turn out to be significantly stickier than in manufacturing.

We do not find strong evidence of relevant country-specific patterns with respect to price change frequency. Although country dummies are jointly significant in the regression, their exclusion, as shown in the second column of the table, does not change the size and significance of the other coefficients and the overall fit of the equation declines only slightly. This turns out not to be the case for wages, 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 labor market is one of the most flexible of the EU.

Firms' size influences the pattern of both price and wage adjustment, which in both cases is likely to happen more frequently in larger firms (with more than 50 employees) than in small ones (the omitted category in the regression is the 5-19 dimension).

Turning to the role played by market forces in affecting price and wage adjustment strategies, we first consider the degree of product market competition faced by firms. Here we focus on the indicator of perceived competition, which measures the likelihood that a price reduction by competitors leads to a similar reaction in the firm; however, results are robust to the use of the alternative proxy for competition described above. The simple frequency distribution reported in Table 8 indicates indeed that stronger competition is positively associated with higher price flexibility, while the same analysis for wages, not reported below, does not suggest any major correlation. IPN results also pointed to a systematic relationship between the frequency of price changes and the intensity of competitive pressures, as firms facing more intense competition were found to review and change their price more often.

Our ordered probit analysis confirms that firms operating in more competitive environments are likely to change prices more often: both the indicator of perceived competition and the one capturing firms' exposure to foreign markets have a significant negative coefficient. Their effect on wage change frequency is instead not significant.

As already mentioned, our survey allows to assess to what extent the flexibility of the firm's costs, proxied by the share of labor on total costs, as well as the composition of the workforce, influence the duration of prices and wages. The estimates in Table 7 show that the higher the fraction of firms' costs accounted by labor, the lower the frequency of price changes. As for the composition of the labor force and job-specific characteristics, a longer duration of prices is significantly associated to a higher fraction of permanent workers, of highly skilled personnel and of white-collars, while in the case of wages duration is positively related only to the share of white-collars.

Table 7 – The frequency of price and wage changes and their relationship
(ordered probit estimates)

	Frequency of price change		Frequency of wage change		Relationship between price and wage changes	
Construction	-0.41***	-0.43***	-0.26***	-0.20**	0.14**	0.22***
Trade	-0.80***	-0.79***	0.10**	0.15***	-0.31***	-0.35***
Market services	-0.08*	-0.07*	0.09**	0.05	0.08**	0.04
Financial intermediation	-0.85***	-0.85***	0.38***	0.41***	-0.72***	-0.76***
20-49	-0.01	0.04	-0.06	0.07	0.01	-0.04
50-199	-0.13***	-0.06	-0.19***	-0.06	-0.06	-0.13***
200+	-0.14***	-0.07	-0.29***	-0.12**	-0.11**	-0.21***
AT	0.09		0.14		-0.02	
BE	-0.10		0.22		-0.04	
CZ	0.02		0.77***		-0.13	
ES	-0.01		0.15		-0.61***	
FR	-0.07		-0.08		-0.23***	
GR	0.07		-0.30*		-0.30***	
HU	0.14		0.52***		-0.78***	
IE	-0.15		0.22		-0.38***	
IT	-0.11		1.55***		-0.22**	
LT	-0.46***		-0.20		0.25***	
NL	-0.16		0.33**		-0.25***	
PL	-0.10		0.58***		-0.22***	
PT	-0.08		0.44***		-0.18**	
SI						
labor_cost_share	0.53***	0.49***	-0.08	-0.24***	1.08***	1.12***
white_collar	0.14***	0.15***	0.12**	0.19***	-0.21***	-0.17***
high_skilled	0.07**	0.06*	0.02	0	0.08**	0.15***
share_permanent	0.16**	0.16**	0.01	-0.05	-0.02	-0.03
coll_agr_out	-0.09	-0.10**	0.02	-0.21***	0.11*	0.17***
coll_agr_firm	-0.01	-0.06	-0.05	-0.11**	-0.09**	0.04
Coverage	0.05	0.05	0.06	0.20***	-0.01	-0.04
Indexation	0.01	0.02	-0.38***	-0.49***	0.07**	0.04
perceived competition	-0.31***	-0.32***	-0.02	-0.02	0	0.03
export_share	-0.17***	-0.17***	0	0.03	-0.24***	-0.17***
frequency of wage change	0.20***	0.20***				
frequency of price change			0.13***	0.13***		
Observations	5873	5873	5873	5873	8373	8373
Pseudo R^2	0.06	0.05	0.10	0.04	0.06	0.04
Wald X^2	638.5***	587.6***	672.9***	382.9***	892.6***	575.8***

* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8 - Frequency of price changes and perceived degree of competition
(percentages)

	daily to monthly	quarterly to half yearly	yearly	less frequently than yearly	no pattern
Total	9.2	15.6	39.0	7.5	28.5
Weak	5.0	11.2	42.8	9.1	31.7
Strong	12.3	18.8	36.3	6.3	26.2

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

Finally, we focus the set of covariates that capture the institutional environment underlying wage policies and the functioning of the labor market. The fact that wages are set according to collective agreements, signed at the national/sector level or at the firm level impacts on the relative flexibility of wages only if country dummies are omitted from the regression (column 4 of the table), suggesting that indeed country fixed effects capture most of the variability of the institutional setting, as already emerged from the descriptive analysis presented in section 2. The presence of firm-level policies that adapt wages to (past or expected) inflation induces a higher frequency of wage changes.

It is worth highlighting that there appears to be a significant positive correlation between the duration of prices and that of wages.

The results presented on the last two columns of Table 7 indicate that the intensity of the relationship between price and wage changes at the firm level presents significant cross-sectoral differences: it turns out to be stronger in construction and market services compared to manufacturing, whereas it is weaker for firms in trade and financial intermediation. A higher incidence of labor on total costs significantly affects the probability of a stronger link between price and wage changes, which is also more intense when competitive pressures stemming from foreign exposure are weak and when the share of white collars on total employees is lower. Interestingly, the institutional framework, as captured by the fact that firms are bound to fix and change wages following collective agreements signed at the national or sectoral level, is associated with a stronger link between price and wage change decisions, hence reducing the margins of manoeuvre for independent policies.

3.2 *Disentangling the simultaneous relationship of price and wage durations*

As reported above, about 60 percent of firms (56 percent when weighted adjusting for the number of employees) reported no relationship between price and wage changes in their company; of the remaining ones, the majority acknowledged such a relationship but reported no particular pattern in that. Complementing this direct evidence, below we investigate more formally the link (and its nature) between these two strategic decisions by estimating a system of equations of price and wage change frequencies. The system acknowledges the possible simultaneity of these two variables and allows for effects running in both directions:

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

where $freq_{pi}$ and $freq_{wi}$ are, respectively, the frequency of price and wage changes in firm i, vector x_i contains covariates common to both equations, 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. The vector x_i includes variables on sector and size (see

below about the omission of country dummies). 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 κ and λ: 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 and the share of labour costs on total costs, whereas instruments in the wage equation (z_{wi}) include the presence of collective wage agreements (both at and above the firm level), their coverage, and whether wages are indexed to prices. If the instruments in the wage equation are to reflect institutional differences, they should come to a large extent from cross-country variation. Controlling for country dummies in x_i would therefore take out the most important source of variation in the instruments. We 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 9.

It is important to remark that the evidence provided by the system estimates of κ and λ does not necessarily have to be consistent to the direct evidence from firms' answers on the existence of a link between 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 (changes in which follow changes in the other). The two concepts are related but are not the same. Furthermore, here 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 link 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. The results of the most important parameters are presented in Table 9 (the full set of results is available on request).

The estimates establish a statistically significant relationship from the frequency of wage changes to that of prices; the effect in the opposite direction is only marginally 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). Duration of prices is significantly lower in firms that face stronger product market competition, those that export more and those that have a lower incidence of labor costs. Duration of wages is lower for firms that are subject to collective wage agreement (the effects become statistically not significant when country dummies are included), and that apply some form of indexation to inflation.

Table 9 – System estimates on price and wage change frequencies

	Model 1		Model 2	
	depv: $freq_w$	depv: $freq_p$	depv: $freq_w$	depv: $freq_p$
$freq_p$	-0.01		0.04	
$freq_w$		0.16*		0.13**
z_p				
labor_cost_share		0.33***		0.33***
competition		-0.22***		-0.22***
export_share		-0.10***		-0.10***
z_w				
coll_agr_out	-0.09***		0.01	
coll_agr_firm	-0.05***		-0.02	
index	-0.20***		-0.15***	
white_collars	0.08***		0.05***	
coverage	0.09***		0.03	
country dummies	NO		YES	
x_i				
sector, size	YES		YES	
Observations	5936		5936	

4   Summary and conclusions

This paper provides a wide range of new evidence on firms' price and wage setting policies by relying on a dataset of firm-level (mostly) qualitative data collected through harmonised surveys conducted in 17 European countries. The most interesting findings can be summarised as follows.

i) The typical frequency of wage changes in European firms is once a year: around 60 percent of firms report that on average they change base wages once a year; a quarter of them do it less frequently. Prices are adjusted more often: the corresponding percentages are significantly lower at 40 and 7.4 percent, confirming previous IPN results (see Fabiani et al, 2007). 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. A multivariate regression exercise based on individual data shows that the incidence of labour costs on firms' total costs is one of the main factors behind the observed differences in the frequency of price changes across sectors and in particular the higher stickiness in business services. Together with a lower labour cost share, a higher responsiveness of prices is associated with the intensity of competitive pressures and the flexibility of technology. Firms that do not typically follow a time-dependent price adjustment mechanism are also those that change prices more frequently. While no major heterogeneity can be found across countries in the patterns of price changes, large cross-country differences emerge regarding wage setting practices and in particular the frequency of wage changes, where institutional features are found to play a major role. In particular, firms tend to change wages more frequently in presence of mechanisms (formal or informal) linking wages to (past or expected) inflation and of firm-level collective wage negotiations. The application of national or sectoral collective agreements tends to operate in the opposite direction, enhancing the duration of wages.

ii) Another relevant set of findings refers to timing of both wage and price changes. There is strong evidence of time-dependence in wage-setting: 54 percent of firms report that wage changes are concentrated in a particular month. In this regard, there is a notable "January effect": about 30 percent of wage changes take place in January and this regularity is found in all countries. Our results also point to a certain degree of synchronisation at the firm level between the timing of wage and price changes. Around one-third of the firms typically adjust their price in specific months. Firms that follow a time-dependent pattern when changing prices and wages tend to change prices in a synchronised fashion. For example, 50 percent of firms that change prices in January also

change wages in that month. This apparent synchronisation compares to a fraction of around 40 percent of firms that, when asked directly, acknowledge the existence of a relationship between the timing of price and wage changes within their company; such a relationship is recognised as strong by less than half of them.

iii) There is a relationship between wage and price stickiness. On one hand, the frequency of price adjustment is lower in firms with a high labour cost share; these firms also report more frequently a tight link between price and wage changes. On other hand, regression analysis that allows to control for a number of important factors that may affect wage and pricing policies, shows that the link between price and wage changes is weaker in trade and financial intermediation, in large firms, in those with a lower share of labour on total costs, in presence of a more flexible technology and if the degree of competition or the export share is high. Finally, results that acknowledge the possible simultaneity of frequency of price and wage changes, allowing for effects running in both directions, provide evidence of a statistically significant relationship from the frequency of wage changes to that of prices; the effect in the opposite direction is only marginally significant.

Appendix 1 – The survey

The WDN-survey project involved all euro area countries except Cyprus, Finland and Malta, 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 national survey. However, strong coordination within the WDN guaranteed that the national questionnaires, at least with respect to a subset of clearly pre-defined "core questions", were almost fully harmonized.

The paper is based on results for all countries except Luxembourg and Germany. Luxemburg results were not available yet at the time of completing the paper, while German results turned out not to be comparable.

The available 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. 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, business services, construction, energy and financial intermediation; as shown in Table A1, 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.

Table A1 – The main characteristics of the national surveys

Country	Sectoral coverage	Firms' size	Sample size	Number of respondents (reponse rate)	Ad hoc survey?	Geographical breakdown	Who carried out the survey	How was the survey carried out
Austria	Manufacturing Energy Construction Trade Bus. services Fin. intermed.	≥ 5	~ 3,500	557 (16%)	Ad hoc	No	External Company (WIFO)	Traditional mail and Internet
Belgium	Manufacturing Energy Construction Trade Bus. 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 Bus. services	≥ 20	1,591	399 (25%)	Ad hoc	No	CNB branches	Internet
Estonia	Manufacturing Construction Trade Bus. services	≥ 5	~ 1,400	366 (26%)	Ad hoc	Yes (Tallinn–non-Tallinn)	External company	Internet
France	Manufacturing Trade Bus. 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 Bus. services Non-market services	All	4,600	1,832 (40%)	Attached to IFO business survey	East-West	IFO	Traditional mail
Greece	Manufacturing Trade Bus. services Non-market services	All	5,000	429 (9%)	Ad hoc	All regions	External company	Traditional mail
Hungary	Manufacturing Energy Construction Trade Bus. 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 Bus. services Fin. intermed. Non-market services	≥ 5	~ 4,000	985 (25%)	Ad hoc	No	External company	Traditional mail, phone
Italy	Manufacturing Trade Bus. services Fin. intermed.	≥ 5	~ 4,000	953 (24%)	Ad hoc	Yes	External company	Internet
Lithuania	Manufacturing Energy Construction Trade Bus. services Fin. intermed.	All	2,810	343 (12%)	Ad hoc	No	External company	Phone, mail, face-to-face
Luxembourg	Manufacturing Energy Construction Trade Bus. services Fin. intermed	≥1	>7,000	survey not finished yet	Ad hoc	No	BCL	Email
Netherlands	Manufacturing Construction Trade Bus. services Fin. intermed.	≥ 5	2,116	1,068 (50%)	Ad hoc	No	External company	Internet

Country	Sectoral coverage	Firms' size	Sample size	Number of respondents *(reponse rate)*	Ad hoc survey?	Geographical breakdown	Who carried out the survey	How was the survey carried out
Poland	Manufacturing Energy Construction Trade Bus. services 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 Bus. 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 Bus. services Fin. intermed.	≥ 5	~ 3,000	666 *(22%)*	Ad-hoc	No	Banka Slovenije	Traditional mail and internet
Spain	Manufacturing Energy Trade Bus. services	All	3,000	1,835 *(61%)*	Ad-hoc	No	External company	Mail, phone, fax or internet

Appendix 2 – The questions used from the WDN-survey

All countries included in their national questionnaires a subset of almost fully harmonised "core questions". Although the translation in national languages could lead to small differences, the high degree of harmonization of the content of the questions allows a meaningful comparison of results across countries.

As for prices, firms are asked to refer answers to their "main product (or service)", defined as the one that generated the highest turnover in the reference period. Similarly, in most questions on wage setting respondents are asked to focus on the "main occupational group", defined in terms of the highest number of employees with the same characteristics. This paper relies mainly on following core questions:

6 – Does your firm have a policy that adapts changes in base wages to inflation ?	
No	□
Yes	□

7 – If "yes" in question 6, please select the options that best reflects the policy followed:	
Wage changes are <u>automatically linked</u> to:	
- past inflation	□
- expected inflation	□
Although there is no formal rule, wage changes <u>take into account</u>:	
- past inflation	□
- expected inflation	□

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?
Please tick an option for each of the three types of wage changes listed below.

	more than once a year	once a year	once every two years	less frequently than once every two years	never / don't know
Wage changes apart from tenure and/or inflation	□	□	□	□	□
Wage changes due to tenure	□	□	□	□	□
Wage changes due to inflation	□	□	□	□	□

10 – Under normal circumstances, are base wage changes concentrated in any particular month / months?

No   □
Yes: Jan. □   Feb. □   Mar. □   Apr. □   May □   June □   July □   Aug. □   Sept. □   Oct. □   Nov. □   Dec. □

31 – Under normal circumstances, how often is the price of the firm's main product typically changed?
Please choose a single option, the one that best describes the situation in your firm

More than once a year:	
- daily	□
- weekly	□
- 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	□

32 – Under normal circumstances, are these price changes concentrated in any particular month / months?

No   □
Yes: Jan. □   Feb. □   Mar. □   Apr. □   May □   June □   July □   Aug. □   Sept. □   Oct. □   Nov. □   Dec. □

33 – How does the timing of these price changes relate to that of wage changes?
Please choose a single option

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	□

Additionally, the following core questions were used to construct control variables:

1 – How were your firm's employees distributed across the following occupational groups at the end of the reference period ?	
Low skilled blue collar/Production	____%
High skilled blue collar/Technical	____%
Low skilled white collar/Clerical	____%
High skilled white collar/Professional	____%
Other	____%
TOTAL (= 100%)	100 %
2 – Does your firm apply a collective pay agreement bargained and signed outside the firm (at the national, regional, sectoral or occupational level) ?	
No, such an agreement does not exist	□
No, we opt out	□
Yes, we apply such an agreement	□
3 – Notwithstanding your answer to question 2, does your firm apply a collective pay agreement signed at the firm level ?	
Yes	□
No	□
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) ?	
_____ %	

27 – What share of the revenue generated by your firm's main product in the reference period was due to sales in:	
Domestic market	____%
Foreign markets	____%
Total (= 100%)	100 %
28 – How is the price of your firm's main product set in its main market ? *Please choose a single option.*	
There is no autonomous price setting policy because:	
- the price is regulated, or is set by a parent company / group	□
- the price is set by the main customer(s)	□
The price is set following the main competitors	□
The price is set fully according to costs and a completely self-determined profit margin	□
Other (please specify) _____	□
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? *Please choose a single option.*	
Very likely	□
Likely	□
Not likely	□
Not at all	□
It doesn't apply	□

34 – How many workers (including employees and other types of workers) did your firm have at the end of the reference period?

	Percentages	Number
Number of employees:		_____
of which:		
(fill in one of the two columns, as you prefer: levels or %)		
permanent full-time	_____ %	_____
permanent part-time	_____ %	_____
temporary	_____ %	_____
TOTAL (= 100%)	100 %	
Number of other types of workers (e.g. people employed by agencies, freelance, consultants, apprenticeships, students, other casual workers, etc.)		Number _____

40 – What percentage of your firm's total costs were due to labour costs in the reference period ?
_____ %

A second piece of information is based on an additional survey on wage bargaining institutions at the country level (Du Caju et al., 2008). In particular, within the WDN information on national institutions was collected using a standardised questionnaire answered by national experts from the central banks of each of the countries considered, namely 22 countries of the European Union, plus the US and Japan. The information refers to two data points (1995 and 2006), four

sectors (agriculture, industry, market services and non-market services) and the total economy. More specifically, this information is collected through the following questions:

4. Coordination of wage bargaining Please indicate with an X in the grid below the level(s) at which wage bargaining coordination takes place in your country. *Please respond for each column in turn.*					
Most recent information	Agriculture etc. (NACE A-B)	Industry (NACE C-F)	Market Services (NACE G-K)	Non-Market Services (NACE L-P)	Total (NACE A-P)
State imposed 1 pay indexation (also see qs. 5)					
State imposed 2 statutory minimum wage (also see qs. 6)					
Inter-associational by national or cross-sectoral agreements					
Intra-associational within peak employers' and trade union organisations					
Pattern bargaining coordination by a sectoral trend-setter					
Other (please specify)					
Which one (or more) of the above levels is (are) the dominant?					

9. Indexation mechanisms (also see/use information/updated information in Annex 1 to this questionnaire) For the questions requiring percentages please provide figures as percentages in numbers or, if not available, by choosing from the following ranges: Very Low <0-25%> Low <26-50%> Moderate <51-75%> High <76-100%> *Please respond for each column in turn, underlining Yes or No where indicated.*					
Most recent information	Agriculture etc. (NACE A-B)	Industry (NACE C-F)	Market Services (NACE G-K)	Nonmark. Serv. (NACE L-P)	Total (NACE A-P)
Percentage of workers covered by automatic/direct indexation mechanisms					
Type of indexation none/automatic/only in minimum wages/part of negotiations/combination (please provide details)					
Which price index is used for reference?					
Does indexation refer to its past, expected or targeted annual rate of increase?					
Average duration of agreements					
If relevant, under what circumstances does renegotiation take place?					
If there is a retroactive element to wage indexation in your country, please provide details of the relevant process.					

Appendix 3 – The variables used in the regression analysis

Variable name	Description	Computation
sectoral dummies	Control variables for the economic sector. Dummy variables (=1 if the sector is the one indicated, 0 otherwise).	Based on sampling information: manufacturing construction trade business services financial services
country dummies	Control variables for the country. Dummy variables (=1 if the country is the one indicated, 0 otherwise).	AT BE CZ EE ES FR GR HU IE IT LT NL PL PT SI
size dummies	Control variables for the firm size. Dummy variables (=1 if the size is the one indicated, 0 otherwise).	5_19 = between 5 and 19 employees 20_49 = between 20 and 49 employees 50_199 = between 50 and 199 employees >200 = more than 199 employees
price_follows_competitors	Variable capturing competitive pressures.	Based on answers to question 28. It takes values: 1 = if selected in question 28 option "The price is set following the main competitors" 0 = otherwise
export_share	Variable capturing competitive pressures.	Based on answers to question 27. Percentage of the revenue generated by the firm's main product in the reference period due to sales in the foreign market
perceived_competition	Variable capturing competitive pressures.	Based on answers to question 30, which asks the firm to report how likely it is to decrease its own price if its main competitor did the same. It takes values 1 if "very likely" or "likely", and 0 otherwise.
indexation	Variable capturing the degree of indexation of wages to inflation.	Based on answers to question 6. It takes values: 1 = if respondents selected in question 6 the option "yes, the firm has a policy that adapts changes in base wages to inflation" 0 = otherwise
white_collar	Variable capturing features of the firm's labour force.	Based on answers to question 1 regarding the distribution of employees across occupational groups at the end of the reference period. The variable is the sum of "1_c" (low-skilled, white collar) and "1_d" (high-skilled, white collar).
share_permanent	Variable capturing features of the firm's labour force.	Based on answers to question 34 regarding the distribution of workers at the end of the reference period. The variable is the sum of "34_b" (percentage of permanent full-time) and "34_c" (percentage of permanent part-time)
high_skill	Variable capturing features of the firm's labour force.	Based on answers to question 1 regarding the distribution of employees across occupational groups at the end of the reference period. The variable is the sum of "1_b" (high-skilled, blue collar) and "1_d" (high-skilled, white collar).
coverage	Variable capturing institutional framework and	Based on answers to question 4. If the firm applies a

	industrial relationships.	collective pay agreement signed either outside the firm (question 2) or at the firm level (question 3), percentage of firms' employees covered by this type of contract.
coll_agr_firm	Variable capturing institutional framework and industrial relationships.	Whether the firm applies a collective agreement bargained and signed at the firm level Based on answers to question 3. It takes values: 1 = if yes 0 = if no.
coll_agr_out	Variable capturing institutional framework and industrial relationships.	Whether the firm applies a collective agreement bargained and signed outside the firm (at the national, regional, sectoral or occupational level). Based on answers to question 2. It takes values: 1 = if yes 0 = if no.
labor_cost_share	Incidence of labour on the firm's cost structure.	Based on answers to question 40. Percentage of total costs that were due to labour costs in reference period.
wfr_year	Frequency of wage adjustment.	Based on answers 9_a, 9_b, 9_c. More specifically: a) first we take min(9_a, 9_b, 9_c) b) then we define "more" if wages change more frequent than yearly; "yearly" if wages are adjusted once a year; "less" if wages are adjusted less than once a year. wfr_year takes value 1 if "more" or "yearly" and 0 otherwise.
link	Ordered variable indicating the Intensity of the link between price and wage changes.	Based on answers to question 33. It takes values: 1=no link (question 33, option 1) 2=some link (question 33, option 2) 3= strong link between price and wages (question 33, options 3-4-5)

Appendix 4 – Computing expected durations

The frequencies reported in Section 2 allow to identify the duration of prices (for the firm's main product) and wages (for the firm's typical worker) with the help of 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. Possible answers are categories, which identify points 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 data for the computation of expected wage duration are those related to the point answers. The various points (which will serve as thresholds in the exercise) are denoted by τ_{wj}:

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

These thresholds imply the following probabilities of duration intervals:

$P(d_w\leq 11) = P(\tau_{w1})$

$P(d_w\leq 12) = P(\tau_{w1})+ P(\tau_{w2})$

$P(d_w\leq 24) = P(\tau_{w1})+ P(\tau_{w2})+P(\tau_{w3})$

$P(d_w>24) = P(\tau_{w4})$ (this last one is redundant)

The analogous data for price duration with thresholds τ_{pi} are the following:[13]

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[13] 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. Not that it is only for the imputation exercise that we collapsed the shorter-duration categories $E[dp|dp>12]$, and no information was discarded for the eventual translation of frequencies into durations.

τ_{p1}=daily, weekly, monthly, or quarterly

τ_{p2}=half-yearly/twice a year,

τ_{p3}=once a year,

τ_{p4}= less frequently than once a year

Implied probabilities of duration intervals (d_p)

$\quad$ P($d_p \leq 4$) = P(τ_{p1})

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

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

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

$\quad$ 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:

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

Then

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

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

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

$\quad$ For prices, we have four such equations, for wages, three. Both are overidentified: two equations would identify μ_j, σ_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:

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

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

and therefore

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

so that

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

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

$\quad$ for price duration: μ=2.0, σ=0.6
$\quad$ for wage duration: μ=2.4, σ=0.4

$\quad$ Given the unconditional parameters of the lognormal distribution, we computed the conditional expectations by simulation. The conditional expectations to be imputed are therefore

5 $\quad$ E[$d_w | d_w < 12$] = $\quad$ 8.3
6 $\quad$ E[$d_w | d_w > 24$] = 27.4
7 $\quad$ E[$d_p | d_p > 12$] = 17.7

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