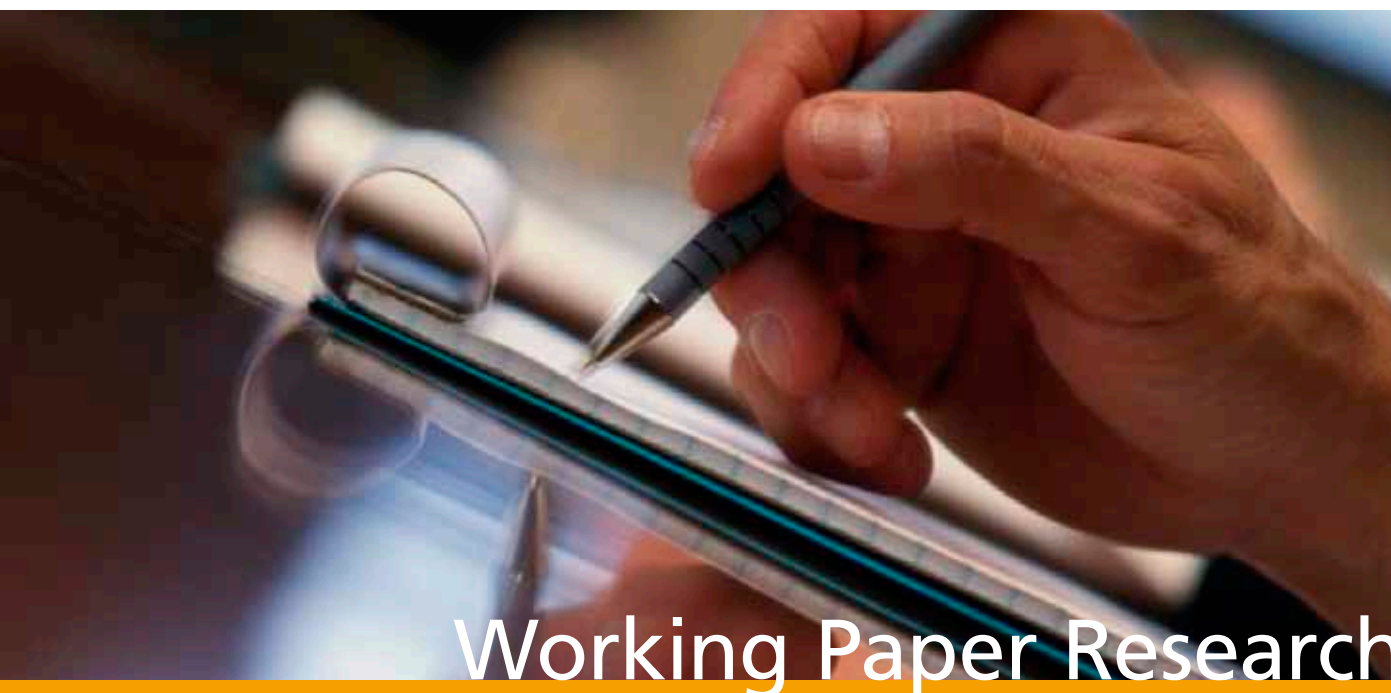# A global assessment of the degree of price stickiness – results from the NBB business survey

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by Emmanuel Dhyne

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Abstract

In this paper, we estimate the degree of price stickiness in Belgium using the NBB business survey. Compared to similar empirical exercises based on consumer or producer price data, the micro data set used allows us to cover most of the Belgian economy in one exercise and therefore provides a better estimate of the overall degree of price stickiness. Based on our estimates, 19.2% of prices are changed each month. In the manufacturing sector and the trade sectors, the frequency of price changes is close to 24.5%. In the construction sector the frequency of price changes is close to 20.5% and in the B2B service sectors it is almost 9%. Econometric analyses of the determinants of the sectoral frequency of price changes indicate, on the one hand, that the cost structure is the main explanatory variable of the sectoral discrepancies. On the other hand, we find that domestic competition does not seem to explain an excess or shortage of price changes at the sectoral level.

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1   Introduction

In modern macroeconomics, an important body of the literature has focused on the importance of the degree of nominal rigidity, which is one of the determinants of the slope of the so-called New-Keynesian Philips Curve (NKPC), and its implications on inflation dynamics and the conduct of monetary policy. In the last twenty years, several empirical investigations have been conducted in order to evaluate the actual importance of these nominal rigidities, using individual price quotes. In this literature, one may distinguish between seminal works by Cecchetti (1986), Lach and Tsiddon (1992, 1996) and Kashyap (1995) and a new strand of results including the work by Bils and Klenow (2004), Klenow and Kryvstov (2008), Nakamura and Steinsson (2008) for the US, Dhyne *et al.* (2006), Vermeulen *et al.* (2007) and the research conducted within the Eurosystem Inflation Persistence Network for the euro area countries, Baharad and Eden (2004) for Israel, Gagnon (2009) for Mexico, Coricelli and Horváth (2006) for Slovakia. The first wave of empirical works has been conducted on a limited number of products: magazine prices (Cecchetti, 1986), fresh meat and wine (Lach and Tsiddon, 1992, 1996) or on specific markets (catalogue prices (Kashyap, 1995). The second wave of empirical works is based on large micro data sets that are used by statistical offices to compute either consumer (Bils and Klenow, 2004, Nakamura and Steinsson, 2008, Dhyne *et al.*, 2006) or producer (Nakamura and Steinsson, 2008, Vermeulen *et al.*, 2007) price indices. Each data set, which commonly represents several millions of price quotes, covers a large range of either goods and services sold directly to the final consumer or intermediate goods. If these studies provide useful insights about how frequently consumer or producer prices are changed, the picture is however incomplete. If some services are included in the CPI basket, most of the service sector, and especially the business to business service sector, is not included in those analysis. Because in most countries there are no such thing as a (corporate) Service Price Index[1], there are no quantitative micro data available on corporate service prices. Therefore, in order to obtain estimates of the frequency of price changes in this sector and a more complete picture of the situation at the aggregate level, one has to use other types of data.

A potential source of interesting data on price setting is the individual records of business surveys. In this type of survey, one may find information about the frequency of price changes for almost all the sectors of the economy. In this paper, we analyze the individual answers to the National Bank of Belgium Business surveys for the manufacturing, construction, trade and service sectors. For each of these sectors, the business survey questionnaires include a question about the evolution of individual prices.

For instance, in the questionnaire of the manufacturing sector, the firm has to answer the following question :

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[1]A Service Producer Price index and a Corporate Service Price Index are available respectively for the UK and Japan. Other service price indices are available in some countries but they focus on very narrowly defined services (architectural, legal or telecommunications...).

Between period t and $t - 1$, the selling price of your product
a) increased b) remained unchanged c) decreased.

Similar questions are also included in the questionnaire of the other sectors.

Compared to studies based on micro price reports, this qualitative information only allows us to analyze the frequency of price changes but not their magnitude. However, as the Business surveys cover almost all the Belgian economy, this analysis may provide us with a unique estimate of the overall degree of price stickiness, an important parameter for macro modelling based for instance on Calvo (1983) pricing rules.

Considering that cross-country differences in the frequency of price changes are not extremely large in the euro area (see Dhyne *et al.*, 2006) in comparison to sectoral discrepancies, the estimates obtained for the Belgian economy and especially for the Belgian service sectors may also be considered as informative of the situation characterizing the euro area, which increases the interest for our results.

The purpose of this paper is therefore to present a new set of estimates of frequency of price changes for the Belgian economy at the NACE 2 digit level and to compare it with the existing evidence available for the Belgian economy (Aucremanne and Dhyne, 2004, Aucremanne and Druant, 2005, and Cornille and Dossche, 2008). Then, we use the information available in the 2000 Belgian Input - Output table to address the question of the determinants of the frequency of price changes. More precisely, we look at the relation between the frequency of price changes and some variables capturing the cost structure or the degree of both domestic and international competition of the different sectors. In so doing, we extend the analysis conducted in Cornille and Dossche (2008). Based on our estimates, we find that the cost structure is the major determinant of the sectoral frequencies of price changes. The import content of a product is also positively affecting the frequency of price changes. The import contents is the only channel through which the degree of openness to international trade positively affects the frequency of price changes. Finally, other factors related to the degree of competition do not seem to play an important role. If bivariate analysis tend to indicate a positive link between the degree of competition, approximated by the sectoral Lerner index or sectoral markups, and the frequency of price changes, this link is not significant and becomes negative when other factors are taken into account.

2   The National Bank of Belgium Business Surveys

Since the mid 50', the National Bank of Belgium conducts surveys to evaluate the sentiment of business confidence. Initially, this survey was conducted only for the manufacturing sector. However, with the growing importance of the service sector, a specific survey for services has been introduced in the early 90's.

2

Each month, a panel of around 6,000 business leaders are contacted. They are asked about their assessment of the current economic situation and their expectations for the next three months.

More precisely, they must evaluate in period t how their situation, in terms of output, orders, sales, prices has evolved between $t-2$ and $t-1$, and how some key variables (employment, demand, prices) are expected to evolve between t and $t+3$. They typically have to choose between 3 different answers to each question:

(a) *has increased*

(b) *has not changed*

(c) *has decreased*

   or

(a) *will increase*

(b) *will not change*

(c) *will decrease*

These surveys are conducted on the basis of a panel. The same representative sample of businesses that are active in manufacturing industry, construction, trade and Business to Business (B2B) services is sent a written survey at the start of each month.

For this article, we use the individual replies to the question relative to the evolution of prices between t-2 and t-1. For the manufacturing sector, we have access to individual information covering the period starting in January 1990 (the survey conducted in February 1990) and ending in December 2007 (the survey conducted in January 2008). For the business to business (B2B) service sector, the observation period is shorter, as data is commonly available only afterJanuary 1995. During this observation period, the structure of the sample naturally evolved over time to maintain its representativeness of the Belgian economy. Therefore, some firms disappeared and had to be replaced. If the occurrence of entries and exits is a concern for the analysis of quantitative price data, this is less the case for qualitative data. With qualitative data, the occurrence or not of a price change is directly identified at the first observation, while the observation of the same product during two consecutive months is needed in order to identify a quantitative price change. Globally, we observe 1,101,995 individual price setting decisions[2] (do I keep my price unchanged ? do I increase it ? do I decrease it ?), out of which 90,275 leaded to a price rise and 114,505 to a price cut. This data refers to 299 NACE 4 digit sub-sectors and 36 NACE 2 digit sectors (out of 59).

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[2] We simply consider that each observation represents a price-setting decision. However, based on the results for an ad-hoc survey on price-setting practices in Belgium (Aucremanne, Druant, 2005), Belgian firms review their pricing policy only once every 10 months on average.

In order to increase the coverage of our analysis, we completed our estimates using existing empirical evidence available in Cornille and Dossche (2008) (hereafter, CD) or Aucremanne and Dhyne (2004) (hereafter, AD). Estimates of the frequency of price changes in the following sectors were taken out of these two articles : NACE 13 "Mining of metal ores" (CD), NACE 14 "Other mining and quarrying" (CD), NACE 16 "Manufacturing of tobacco products" (CD), NACE 23 "Manufactures of coke, refined petroleum products, nuclear fuel" (CD), NACE 40 "Electricity, gas, steam and hot water supply" (CD), NACE 41 "Collection, purification, distribution of water" (CD), NACE 55 "Hotels and Restaurants" (AD) and NACE 85 "Health care" (AD). Taking into account these additional sources of information allows us to cover 44 NACE 2 digit sectors which represent 84% of the Belgian GDP (according to the 2000 Belgian input - output table).

3   New estimates of the frequency of price changes in Belgium

As mentioned above, the micro data available allows to identify 299 NACE 4 digit sub-sectors. The basic estimation of the frequency of price changes is therefore conducted at that very disaggregated level. Then, the results are aggregated to higher level of aggregations using weights computed on the basis of the 2000 annual accounts of Belgian firms. Using the annual turnover of the Belgian firms coming from the annual accounts, we compute the weight of each NACE 4 digit sub-sector and we use these weights to aggregate our results up to NACE 2 digit level. For additional aggregation, we then use the weights coming from the 2000 Belgian Input Output tables (Eurostat).

Based on our estimates, we find that the aggregate monthly frequency of price changes for the Belgian economy is equal to 19.2%, which decomposes itself in a 9.9% frequency of price increases and a 9.3% frequency of price decreases. This aggregate frequency of price changes lies between the CPI frequency of price changes of 17% computed in Aucremanne and Dhyne (2004) and the PPI frequency of price changes of 24% computed in Cornille and Dossche (2008). Considering very broad sectors of activity, we find a frequency of price changes of 24.4% (increases: 13.0 % / decreases: 11.4%) in the manufacturing sector, 20.3% (8.0% / 12.3%) in the building sector, 24.7% (11.8% / 12.8%) in the trade sector, 3.3% (2.9% / 0.4%) in hotels and restaurants and 8.8% (4.5% / 4.4%) in the service sector. An interesting result is that our estimates do not indicate any evidence in favour of additional downward price stickiness as we find that in almost every broad sector of activity price changes distribute almost equally between price increases and price decreases, even in the service sector[3]. This result contrasts particularly with the results presented in Aucremanne and Dhyne (2004) for services.

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[3]The only exception is associated to hotels and restaurants, for which almost all price changes are price increases. However, this result is not based on qualitative survey data but on CPI quantitative data.

TABLE 1 - MONTHLY FREQUENCY OF PRICE CHANGES BY NACE 2 DIGIT
SECTOR

NACE code	Freq	Freq(+)	Freq(-)	NACE code	Freq	Freq(+)	Freq(-)
13[1]	10.0	7.0	2.0	35	12.6	5.4	7.2
14[1]	10.4	7.0	3.5	36	9.2	6.8	2.4
15	23.3	12.7	10.6	40[1]	63.5	42.2	21.5
16[1]	12.0	11.0	1.0	41[1]	14.0	10.0	5.0
17	18.9	7.8	11.1	45	20.3	8.0	12.3
18	13.3	5.5	7.8	50	14.5	8.6	5.8
19	12.4	8.0	4.4	51	27.3	12.9	14.3
20	22.8	9.5	13.3	52	23.9	10.7	13.2
21	26.6	12.1	14.4	55[2]	3.3	2.9	0.4
22	18.1	7.8	10.3	60	12.4	7.9	4.5
23[1]	89.0	51.0	38.0	63	10.1	4.1	5.9
24	22.2	12.8	9.4	64	9.2	2.2	7.0
25	18.2	11.6	6.6	65	18.6	7.2	11.4
26	17.8	8.9	8.9	67	10.5	3.9	6.6
27	45.3	21.7	23.5	70	6.0	3.3	2.6
28	16.8	7.9	9.0	71	10.9	5.6	5.3
29	12.0	6.5	5.6	72	10.6	3.4	7.2
30	31.6	6.2	25.4	73	8.3	3.9	4.4
31	14.8	6.0	8.8	74	6.8	3.6	3.2
32	14.8	2.9	11.9	85[2]	6.4	5.8	0.6
33	8.6	6.2	2.4	90	12.8	10.1	2.7
34	6.5	3.6	2.9	93	3.3	0	3.3

[1] Cornille, Dossche (2008) : Estimation period : 02/01- 01/05
[2] Aucremanne, Dhyne (2004) : Estimation period : 02/89 - 01/01

If our estimate of the frequency of price changes in the manufacturing sector is close to the one obtained in Cornille and Dossche (2008), our estimate of the frequency of price changes in the trade sector, which may be considered as a proxy for the frequency of price changes for final consumer prices is above the estimate obtained by Aucremanne and Dhyne (2004) but is very close to those obtained by Bils and Klenow (2004) and Klenow and Kryvstov (2008) for the US CPI. We may also compare our estimates to those obtained through the ad-hoc survey on price setting practices conducted in 2004 by the NBB. If our estimates for manufacturing and trade are above the frequencies derived from Aucremanne and Druant (2005), our estimates for construction and services are in line with their results. Our estimate of the frequency of price changes in services is also close to the corresponding frequency of price changes of 7% computed by Gautier (2008) for France.

TABLE 2 - FREQUENCY OF PRICE CHANGES - COMPARISON WITH OTHER STUDIES

Sector	Frequency	Other estimates
Manufacturing	24.4	Cornille, Dossche (2008) : 24
		Aucremanne, Druant (2005) : 16.4
		Vermeulen *et al.* (2007) : $15^1/25^2$
		Nakamura, Steinsson (2008) : $10.8^3/13.3^4$
Construction	20.3	Aucremanne, Druant (2005) : 22.7
Trade	24.7	Aucremanne, Dhyne (2004) : 17
		Aucremanne, Druant (2005) : 13.5
		Dhyne et. al (2006) : 15.1
		Bils, Klenow (2004) : 23.6
		Nakamura, Steinsson (2008) : $11.9^5/20.3^6$
Services	8.8	Aucremanne, Druant (2005) : 10.2
		Gautier (2008) : 7

[1] Italy   [2] France
[3] finished goods   [4] intermediate goods
[5] excluding sales   [6] including sales

4 The determinants of the frequency of price changes

4.1 Frequency of price changes and input prices

As presented in Section 3, our results are very similar to the results obtained from previous studies. However, as our data set allows to analyze the frequency of price changes in 44 NACE 2 digit sectors, we are able to conduct a number of econometric exercises that address the question of the structural determinants of the frequency of price changes.

The first element that we want to investigate is the link between the frequency of input price changes and the observed frequency of price changes.

As argued in Dhyne *et al.* (2008), a low frequency of price changes is not necesseraly symptomatic of strong price rigidity. Indeed, firms keep their price constant for two reasons: (i) because it is costly to reset price or (ii) because the price determinants are stable and there is no reason to reset prices. In Dhyne *et al.* (2008), the first cause is refered to as intrinsic price rigidity, the second as extrinsic price rigidity. Therefore, in order to assess the degree of sectoral degree of price rigidity, one has to analyse the link between the frequency of price changes and the volatility of input prices.

Such an exercise has been conducted for instance by Hoffmann and Kurz-Kim (2006) using German micro CPI data. For a sample of 60 product categories included in the German CPI basket, the authors identify the price index of

what they consider to be the main input of each product[4]. Then, they relate the observed frequency of price changes for these 60 product categories to the variability of the price index for their main input. They find that the more volatile the price of the main input, the more frequent are price changes.

Using the information about the sectoral cost structure embodied in the input-output tables, several authors (Álvarez, Burriel and Hernando, 2008, Cornille and Dossche, 2008, Vermeulen *et al.*, 2007) have looked at the link between the frequency of price changes and the energy and labour content of a good. Using sectoral estimates of the frequency of price changes at the NACE 3 digit level for the manufacturing sector, they relate this frequency to the shares of energy or wages in total costs that come from the NACE 2 digit decomposition of the input-output tables. In this study, we follow the same path, but as we consider also the construction, trade and service sectors we have enough observations to conduct our econometric exercise at the NACE 2 digit level for both the explained and the explanatory variables.

Moreover, as we cover most of the Belgian economy, we can use our sectoral estimates of the frequency of price changes to compute the expected frequency of price changes that is inherited from the frequency of changes in either input prices or wages. More precisely, we use the share of each NACE 2 digit sector in the cost structure of a given product and our estimates of the frequency of price changes to infer the frequency of price changes that would be the reflect of the frequency of price changes of all input prices (material inputs or labour inputs). We refer to this frequency as the input derived frequency of price changes, which is given by

$$InputFreq_j = \sum_{i=1}^{n} s_{ij}Freq_i + s_{wj}Freq_w \tag{1}$$

with

$$s_{ij} = \frac{Input_{ij}}{\sum_{i=1}^{n} Input_{ij} + WB_j}$$

$$s_{wj} = \frac{WB_j}{\sum_{i=1}^{n} Input_{ij} + WB_j}$$

where $Freq_i$, $Freq_w$, $Input_{ij}$ and WB_j are respectively the estimated frequency of price changes in sector i, an estimate of the monthly frequency of wage changes[5], the demand for CPA product[6] i consumed by sector j and the total

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[4] For instance, the consumer price of bananas has to reflect the variation of the import price of bananas, the price of heating oil has to mainly relate to the price of oil on the international market, the hourly rate of a plumber has to relate to the evolution of wages, ... Ratfai (2006) does a similar exercise for meat prices in Hungary which the author relates to the producer price index of meat. Dhyne *et al.* (2008) follow a close path but they use the micro CPI data to extract the common driving variable instead of imposing the use of an ad-hoc input price.

[5] We assume that wages are typically changed once a year, so that the monthly frequency of wage changes is 1/12.

[6] The CPA classification is the EU official classification of products by activity. In the

wage bill of sector j.

NACE code	Freq	Input Freq	NACE code	Freq	Input Freq
13	**10.0**	**29.4**	35	12.6	14.2
14	**10.4**	**19.6**	**36**	**9.2**	**16.3**
15	23.3	19.3	*40*	*63.5*	*32.1*[2]
16	**12.0**	**18.6**	41	14.0	14.1
17	18.9	18.8	45	20.3	18.1
18	13.3	16.8	50	14.5	13.1
19	12.4	16.6	*51*	*27.3*	*12.8*
20	22.8	20.2	*52*	*23.9*	*13.9*
21	26.6	21.8	**55**	**3.3**	**16.8**
22	18.1	17.8	**60**	**12.4**	**17.8**
23	*89.0*	*80.5*[2]	63	10.1	13.9
24	22.2	24.6	64	9.2	11.1
25	18.2	19.2	*65*	*18.6*	*10.3*
26	17.8	18.2	67	10.5	10.0
27	*45.3*	*32.4*	**70**	**6.0**	**17.1**
28	**16.8**	**22.7**	**71**	**10.9**	**17.7**
29	12.0	14.7	72	10.6	11.2
30	*31.6*	*13.6*	73	8.3	10.8
31	14.8	16.4	74	6.8	11.1
32	14.8	14.2	**85**	**6.4**	**11.7**
33	**8.6**	**14.2**	**90**	**12.8**	**19.1**
34	6.5	11.2	**93**	**3.3**	**18.3**

[1] In bold (italic): sectors for which the observed frequency of price changes is 5 percentage point below (above) the input derived frequency of price changes. The threshold of 5% is derived from a clustering exercise.

[2] The input derived frequency for NACE 23 and NACE 40 also takes into account the contribution of CPA 10 "Mining of coal and lignite; extraction of peat" and CPA 11 "Crude petroleum and natural gas; services incidental to oil and gas extraction, excluding surveying" which represent 59.8% and 4.7% of the inputs consumed respectively by the NACE 23 and NACE 40 industries, assuming a frequency of price changes of 100%.for those two CPA products.

This frequency gives us a benchmark to which one may compare the observed frequency of price changes. If the observed frequency of price changes in one sector lies below its input derived frequency, this means that the prices in that sector are changed less frequently than what would be implied by the input

input-output tables, the NACE sectors are found in columns while the CPA products are found in rows. A single entry (A_{ij}) in the input-output table gives the amount of product i consumed by sector j.

price volatility and therefore that additional sources of price stickiness might be at work in that sector.

Based on our estimates, 13 sectors out of 44 seem to be characterized by a much lower frequency of price changes than what it should be. However the prices are changed more frequently than expected in 7 sectors. Among the 13 "too sticky" sectors, 7 are services. However, this does not mean that all services are characterized by excessive price stickiness. Indeed, as many other NACE 2 digit service sectors are characterized by a frequency of price changes in line or above the input derived frequency.

From a statistical point of view and considering the sample of 44 sectors, a Wilcoxon Sign Rank test does not reject the assumption that the observed frequency of price changes is equal to the input derived frequency.[7]

4.2 Definition of other explanatory variables

4.2.1 Production complexity

A potential determinant of the frequency of price changes is the production complexity of a product. If the production process mixes many different inputs, the price of which going in various direction (some are increasing, some are decreasing), this may lead to a lower frequency of price changes than what is implied by the underlying frequencies of input price changes. Therefore, it might be important to control for the degree of production complexity when analyzing the degree of price rigidity of a given sector. To do so, we use the following indicator[8]

$$Complexity_j = 1 - \sum_{i=1}^{n} \omega_{ij}^2 \tag{2}$$

with

$$\omega_{ij} = \frac{Input_{ij}}{\sum_{i=1}^{n} Input_{ij}}$$

This indicator is equal to 1 minus an Herfindhal index computed using the production cost structure of each sector. If a sector uses only one input, the complexity index is equal to 0. However, if it equally uses inputs from all the 66 CPA 2 digit products (which describes the most complex production process), the complexity indicator will be close to unity (0.985). It is worth mentioning that the computation of the complexity index uses the contribution of all 66

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[7] The Wilcoxon Sign Rank test statistics associated to our sample is equal to -1.447, larger than the critical value of -1.96. Therefore, the test does not reject the null hypothesis of equality between the two paired series.

[8] This index takes the value 0, if the production in sector j uses only one type of input. The higher the index, the more complex is the production of one unit of product j. Note that this indicator does not reflect the importance of the labour share and has been computed considering the contribution of all the 59 CPA 2 digit categories (not the 44 for which we have an estimate of the frequency of price change).

CPA 2 digit products and not only the contribution of inputs produced by the 44 NACE sectors for which we have estimated the frequency of price changes.

4.2.2 Labour share

A traditional candidate to explain sectoral discrepancies in the frequency of price changes is the share of labour costs in total costs or value added (see Álvarez, Burriel and Hernando, 2008, Cornille and Dossche, 2008). If we assume that wages are reset less frequently than the price of other inputs, we expect that the frequency of price changes will be lower in the more labor-intensive sectors[9]. Using the 2000 Belgian input-out tables, we have address this question using the following indicator :

$$Labour_j = \frac{WB_j}{VA_j}$$

where VA_j and WB_j represent respectively the value added and the wage bill of sector j.[10]

4.2.3 Import content

In terms of costs structure, a final explanatory variable of the frequency of price changes is the share of imported inputs. Following Álvarez, Burriel and Hernando (2008) , we investigate the link between the frequency of price change and the share of imported inputs using:

$$Import_j = \frac{\sum\limits_{i=1}^{n} MInput_{ij}}{\sum\limits_{i=1}^{n} Input_{ij}}$$

where $MInput_{ij}$ represents the amount of CPA product i that is imported by sector j to be used as inputs in its production process. This indicator is also computed using the 2000 Belgian input-output tables.

4.2.4 Product market competition

Several authors also address the issue of the relation between the frequency of price changes and the degree of market competition (Álvarez and Hernando, 2007, Cornille and Dossche, 2008, among others). In this paper, we use the information included in the Belgian 2000 input-output table to estimate a sectoral Lerner index at the NACE 2 digit level and we relate this measure with our estimates of the frequency of price changes.

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[9] Note that this effect of wage stickiness on price stickiness is also captured in our input derived frequency of price changes.

[10] A similar picture would be observed if we used the alternative measure of labour intensity, s_{wj}, as defined in Sub-section 4.1.

To proxy the degree of market competition for each sector, we compute

$$Lerner_j = \frac{VA_j - WB_j}{Prod_j} \tag{3}$$

where VA_j, WB_j and $Prod_j$ represent respectively the value added, the wage bill and the total production of sector j.

Alternatively, we also measured competition by using the sectoral markups estimated for Belgium in Christopoulou and Vermeulen (2008). Considering their estimates, the average level of the relative markup in the Belgian economy is equal to 1.22, which is lower to the euro area average (1.37).[11]. Both competition indicators are positively correlated as their linear correlation is equal to 0.63 and their Spearman Rank correlation is equal to 0.76.

4.2.5 International trade openness

Another way to tackle the relation between the frequency of price changes and the degree of market competition would be to look at the sectoral exposure to international trade. Sectors protected from international competition might change less frequently their prices than exposed sectors. Using the information include in the Belgian 2000 input-output table, we estimate an indicator of the sectoral openness to international trade at the NACE 2 digit level and we relate this measure with our estimates of the frequency of price changes.

To proxy the degree of sectoral openness for each sector, we compute a sectoral indicator of trade openness given by

$$Openness_j = \frac{M_j + X_j}{Prod_j} \tag{4}$$

where M_j, X_j and $Prod_j$ represent respectively the imports, exports and total production of sector j.

4.3 What are the main determinants of the frequency of price changes

The variables defined above, including the input derived frequency of price changes, are used in a simple econometric equation to identify the main determinants of the frequency of price changes. As the frequency of price changes is a variable that takes its value between 0 and 1, we also estimate a non linear regression using the QML estimation procedure proposed in Papke and Wooldridge (1996). The results associated to the OLS and QML regressions are respectively summarized in Tables 4. and 5.

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[11]Globally, product markets in Belgium should be considered more competitive than in other euro area countries. Indeed, using a Wilcoxon Sign Rank Test which compares the sectoral mark-ups is Belgium and in the Euro Area, we find that sectoral markups in Belgium are in general below their Euro area estimates.

TABLE 4 - OLS LINEAR REGRESSION - EXPLAINED VARIABLE : $Freq_j$

					Number of obs = 44	
					$F(6, 37) = 23.45$	
					$Prob > F = 0.0000$	
					$R^2 = 0.7458$	
					$BIC = -74.467$	
		Robust				
	Coef.	Std. Err	t	P>|t|	[95 % Conf. Interval]	
$Const$	−0.317	0.200	−1.58	0.122	−0.723	0.088
$InputFreq_j$	1.199	0.155	7.72	0.000	0.884	1.514
$Lerner_j$	0.109	0.110	0.98	0.331	−0.115	0.333
$Complexity_j$	0.251	0.246	1.02	0.315	−0.248	0.749
$Labour_j$	−0.037	0.115	−0.32	0.750	−0.270	0.196
$Import_j$	0.178	0.112	1.58	0.122	−0.050	0.406
$Openness_j$	−0.006	0.002	−3.33	0.002	−0.009	−0.002

Based on the OLS regression, it seems that two explanatory variables affect significantly the observed sectoral frequency of price changes. Firstly, the most important factor is the input derived frequency of price changes. An increase in the input derived frequency naturally translates into an increase in the observed frequency and the coefficient associated to this variable is not statistically different from unity. The other significant variable is the degree of sectoral openness to international trade, which seems to affect negatively the frequency of price changes. This result is quite difficult to understand but seems to be highly significant. We expected a positive relation between the two variables as a larger exposure to international trade implies stronger competition and therefore stronger pressure on prices that should therefore react more rapidly to changes in costs, but this assumption is not supported by the data.

TABLE 5 - QML NON LINEAR REGRESSION - EXPLAINED VARIABLE : $Freq_j$

						Number of obs = 44	
						$BIC = -138.367$	
		Robust					
	Coef.	Std. Err	z	P>|z|	Marg. effect	[95 % Conf. Interval]	
$Const$	−4.835	1.277	−3.79	0.000	−	−	−
$InputFreq_j$	7.009	1.740	4.03	0.000	0.973	0.478	1.468
$Lerner_j$	0.482	0.686	0.70	0.482	0.067	−0.121	0.255
$Complexity_j$	2.009	1.555	1.29	0.196	0.279	−0.153	0.710
$Labour_j$	−0.423	0.757	−0.56	0.576	−0.059	−0.267	0.149
$Import_j$	1.249	0.745	1.68	0.094	0.173	−0.032	0.379
$Openness_j$	−0.035	0.014	−2.42	0.016	−0.005	−0.009	−0.001

The second variable associated to international trade is almost significant at the 10% level and indicates that the larger the share of imported inputs in the cost structure, the larger is the frequency of price changes. Based on results obtained in Dhyne *et al.* (2009), the low significance of that variable may be due to a composition effect. As shown in Chapter 5 of Dhyne *et al.* (2009), a larger share of imported inputs affects differently the occurrence of price increases and price decreases. Price increases are less frequent, while price decreases might be more frequent. If a net negative impact on the total frequency of price changes is found in Dhyne *et al.* (2009) using cross-country data, the results presented above seem to indicate that the reverse is true when the sample is restricted to the Belgian economy.

Finally, the other variables have no statistically significant impacts on the frequency of price changes. If we find that large share of labour inputs decreases the frequency of price changes, the positive sign associated to the Lerner index and the Complexity index are more difficult to understand.[12]

In terms of the sign associated to the different coefficients, the QML estimation confirms our OLS results. The share of imported inputs is now significant at the 10% level. The marginal effect computed at the sample mean confirms that an increase in the input derived frequency of price changes translates almost one to one to the observed frequency of price changes. Comparing both equations, the non linear estimates seem to provide better results than the OLS, based on the Bayesian Information Criteria (BIC).

As it seems that both specifications indicate that the marginal effect of the input derived frequency of price changes on the observed frequency is equal to one, we also estimate an equation relating the difference between the observed frequency and the input derived frequency with the other explanatory variables. What are the factors explaining the excess or the shortage of frequency of price changes compared to the level implied by the sectoral cost structure ? The results associated to this constrained equation are presented in Table 6.[13]

Based on these results, we observe that the variables that seem to explain the discrepancy between the observed frequency of price changes and the input derived frequency of price changes are the share of imported inputs (almost significant at the 5% level) and the degree of openness to international trade. As mentioned above, the price of imported inputs might be more volatile than the price of domestic inputs because of exchange rate fluctuations. Therefore, a larger share of imported inputs increases the frequency of price changes of domestic goods through a faster pass-through of international prices in domestic prices. Considering the other variables, the coefficient associated to the labour share is the only coefficient which has the expected sign. Using an alternative measure of market competition does not improves our results.

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[12] Considering the impact of competition, we have also estimate our OLS and QML equations using the sectoral mark-ups computed by Christopoulou and Vermeulen (2008) instead of the Lerner index. Using this alternative measure of product market competition do not alter the conclusions drawn from Table 4 and 5.

[13] A Wald test supports the assumption that the coefficient associated to the input derived frequency is equal to one. Therefore, the restricted model can be considered as valid.

TABLE 6 - OLS LINEAR REGRESSION - EXPLAINED VARIABLE :
$Freq_j - InputFreq_j$

	Coef.	Robust Std. Err	t	P>|t|	[95 % Conf. Interval]	
				Number of obs = 44		
				$F(5, 38) = 4.86$		
				$Prob > F = 0.0015$		
				$R^2 = 0.1943$		
$Const$	−0.239	0.190	−1.26	0.215	−0.623	0.145
$Lerner_j$	0.091	0.111	0.82	0.417	−0.134	0.316
$Complexity_j$	0.219	0.246	0.89	0.379	−0.280	0.718
$Labour_j$	−0.089	0.112	−0.80	0.430	−0.316	0.137
$Import_j$	0.232	0.120	1.93	0.061	−0.011	0.476
$Openness_j$	−0.005	0.001	−3.68	0.001	−0.008	-0.002

5 Conclusions

This paper examines how frequently prices change in Belgium, by exploiting the information available in the firms replies to the NBB Business surveys conducted in the manufacturing, construction, trade and service sectors, for the period starting from January 1990 to December 2007. In so doing, it tries to obtain a quantitative measure of the unconditional degree of price stickiness for the Belgian economy. Compared to existing evidence for Belgium, this study adds the important sector of B2B services. If Aucremanne and Dhyne (2004) and Cornille and Dossche (2008) provide evidence of the frequency of price changes in Belgium respectively for consumer and producer prices, the behavior of price setting in the service sector is almost not covered by these two papers (a few services are included in the CPI basket but the coverage of the service sector is very limited). Combining the evidence obtained through the use of the NBB business surveys with existing empirical evidence allows us to cover 44 NACE 2 digit sectors out of 59, which represent 84% of the Belgian GDP

Based on our estimates, we find that, each month, almost one fifth (19.2%) of the Belgian prices are changed. This estimates lies between the 17% frequency of consumer price changes computed in Aucremanne and Dhyne (2004) and the 24% frequency of producer price changes computed in Cornille and Dossche (2008). This frequency of price changes of 19.2% decomposes itself in a 9.9% frequency of price increases and a 9.3% frequency of price decreases, indicating that at the aggregate level, there are no strong indications in favor of additional downward price stickiness.

The frequency of price changes at the aggregate level hides large sectoral variations in the frequency of price changes. The manufacturing sector and the trade sectors are characterized by a frequency of price changes close to 24.5%. The construction sector is characterized by a frequency of price changes close to 20.5%. B2B service sectors are characterized by a frequency of price changes

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of almost 9% and finally the sector of hotels and restaurants are characterized by the lowest frequency of price changes (3.3%).[14] If Aucremanne and Dhyne (2004) indicate that the services are characterized by a strong asymmetry in the direction of price changes, our estimates refute their results, as there seems to be no excessive asymmetry in the direction of price changes in the B2B services sector.

In addition to this evaluation of the global degree of price stickiness of the Belgian economy, this paper also takes advantages of the large number of sectors covered to analyze the determinants of the frequency of price changes at the sectoral level, using the statistical information available in the 2000 input-output table of the Belgian economy.

We investigate the link between the frequency of price changes with either the cost structure, the degree of production complexity, the labour share, the share of imported inputs, the degree of competition measured by the sectoral Lerner index and the degree of sectoral openness to international trade.

Based on our estimates, two main conclusions may be drawn.

Firstly, the main determinant of sectoral frequency of price changes seems to be the cost structure, captured by the input derived frequency of price changes, and to a minor extent by the share of imported inputs.

This is an extremelly important result that stresses the fact that the frequency of price changes is a very bad proxy of price rigidities. A frequency of price changes of 9% is per se not symptomatic of strong difficulties associated to price adjustment in the service sector. If services were produced out of crude oil, their price would change as frequently as energy prices. But their main input is labour. Therefore, the frequency of price changes in services reflects mainly the frequency of wage changes. Increasing the price adjustment process in services would therefore require labour market reforms designed to facilitate wage adjustment.

Secondly, domestic competition measured either by the sectoral Lerner index or the sectoral mark-ups estimated in Christopoulou and Vermeulen (2008) does not seem to explain an excess or shortage of price changes at the sectoral level.

With the computation of the input derived frequency of price changes, our estimates finally allows to adjust the frequency of price changes to the sectoral cost structure in order to use the difference between the observed and the input derived frequency as an indicator of price rigidity.

According to this indicator, the 44 sectors analysed in this paper can be grouped into 3 clusters.

The main cluster is a group of 24 sectors characterized by a frequency of price changes almost equal to the input derived frequency of price changes[15]. These sectors are : NACE 15 Manufacture of food products and beverages, NACE 17 Manufacture of textiles, NACE 18 Manufacture of clothing and dyeing of fur, NACE 19 Leather industry, manufacture of luggage and footwear, NACE

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[14]This estimates comes from Aucremanne and Dhyne (2004)

[15]The difference between the observed and input derived frequency for this group ranges from -4.7 to 4.8.

20 Manufacture of wood, except furniture, NACE 21 Manufacture of pulp, paper and paper products, NACE 22 Publishing, printing and reproduction of recorded media, NACE 24 Manufacture of chemicals and chemical products, NACE 25 Manufacture of rubber and plastic products, NACE 26 Manufacture of other non-metallic mineral products, NACE 29 Manufacture of machinery and equipment n.e.c., NACE 31 Manufacture of electrical machinery and apparatus n.e.c., NACE 32 Manufacture of radio, television and communication equipment and apparatus, NACE 34 Manufacture of motor vehicles, trailers and semi-trailers, NACE 35 Manufacture of other transport equipment, NACE 41 Collection, purification and distribution of water, NACE 45 Construction, NACE 50 Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel, NACE 63 Supporting and auxiliary transport activities; activities of travel agencies, NACE 64 Post and telecommunications, NACE 67 Activities auxiliary to financial intermediation, NACE 72 Computer and related activities, NACE 73 Research and development and NACE 74 Other business activities.

The second cluster is a group of 7 sectors characterized by a frequency of price changes larger than the input derived frequency. These sectors are NACE 23 Manufacture of coke, refined petroleum products and nuclear fuel, NACE 27 Manufacture of basic metals, NACE 30 Manufacture of office machinery and computers, NACE 40 Electricity, gas, steam and hot water supply, NACE 51 Wholesale trade and commission trade, except of motor vehicles and motorcycles, NACE 52 Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods and NACE 65 Financial intermediation, except insurance and pension funding.

Finally, the third cluster is a group of 13 sectors characterized by a frequency of price changes smaller than the input derived frequency. These sectors are NACE 13 Mining of metal ores, NACE 14 Other mining and quarrying, NACE 16 Manufacture of tobacco products, NACE 28 Manufacture of fabricated metal products, except machinery and equipment, NACE 33 Manufacture of medical, precision and optical instruments, watches and clocks, NACE 36 Manufacture of furniture; manufacturing n.e.c., NACE 55 Hotels and restaurants, NACE 60 Land transport; transport via pipelines, NACE 70 Real estate activities, NACE 71 Renting of machinery and equipment without operator and of personal and household goods, NACE 85 Health and social work, NACE 90 Sewage and refuse disposal, sanitation and similar activities and NACE 93 Other service activities.

Comparing the two extrem groups, there is no significant difference in terms of Lerner index or markups among the two groups, which mean that the "rigid" sectors are not different from the "flexible" ones in terms of competition, as indicated by the econometric analysis.

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