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Evidence of Nominal Wage Rigidity and Wage Setting from Icelandic Microdata*

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Abstract

This paper presents new evidence about wage stickiness and the nature of wage setting. We use a unique micro dataset on monthly frequency, covering wages in the Icelandic private sector for the period from 1998-2010, and draw the following conclusions. First, the mean frequency of wage change is 10.8% per month. When weighted for heterogeneity across industries and occupations the result is almost identical; the frequency of change is 10.5% per month. Second, only 0.5% of monthly wage changes are decreases. Third, the mean duration of wage spells is 8.9 months. One-fifth of wage spells last longer than a year while other spells last for one year or shorter. Fourth, wage setting displays strong features of time-dependence: half of all wage changes are synchronised in January, but other adjustments are staggered through the year. Fifth, there is limited evidence of state-dependence: frequency of wage increases, size of increases, frequency of wage decreases and size of decreases do not correlate with inflation. However, both frequency and size of wage decreases have significant correlation with unemployment. Sixth, the hazard function for wages is mostly flat during the first months but has a large twelve-month spike. These facts align with a model of time-dependent wage contracts of fixed duration.

Keywords: Wage rigidity, wage setting, microdata evidence

JEL Classification: E24, J31

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1 Introduction

In the Keynesian paradigm, nominal rigidities in prices and wages play a central role in explaining variations in output and employment. Because of sluggish adjustment of nominal wages and prices to shocks, changes in money supply can have a real effect on the economy by affecting aggregate output through the real interest rate. A corollary of this notion of short-run monetary non-neutrality is a role for active monetary policy.

Following Erceg, Henderson and Levin (2000), a large number of models have been constructed to incorporate New Keynesian features, both imperfect competition and nominal wage rigidities. The theoretical literature has emphasised that introduction of nominal wage rigidity in macroeconomic models is at least as important a component as price stickiness. In their influential paper, Christiano, Eichenbaum and Evans (2005) construct a New Keynesian model and follow Erceg *et al.* (2000) in modelling staggering of price and wage setting with a Calvo (1983) wage setting mechanism. They conclude that:

> A key finding of the analysis is that stickiness in nominal wages is crucial for the model's performance.

Furthermore, recent research has emphasised that even though inclusion of nominal wage rigidity is essential, the choice of *how* wage rigidity is modelled can have quantitative effects. Dixon and Kara (2011) show that variation in wage contract length, even with only a small proportion of long-term contracts, can significantly increase the degree of output persistence. According to Olivei and Tenreyro (2007), the timing of wage setting is also important. If wage contracts are not uniformly distributed, monetary policy will generate different output effects depending on when monetary policy shock takes place. Specifically, monetary policy actions will have more effect in periods when wages are more rigid. Even though a deep understanding of wage rigidity is of high importance, both for monetary policy and for macroeconomic modelling, limited micro evidence exist on the extent of nominal wage rigidity and the nature of wage setting.

Recently, following Bils and Klenow (2004), an expanding literature – notably Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008) – has used extensive high-frequency micro datasets on prices to evaluate nominal price rigidity and estimate how frequently prices change.[1] Following this path, a very recent but growing literature has used micro datasets on wages to estimate rigidity of

[1] For a survey of this literature, see Klenow and Malin (2010).

nominal wages. Barattieri, Basu and Gottschalk (2010) present evidence for the US. They use survey data, based on interviews with workers that take place every four months for a period of two to four years. Other papers have presented evidence based on data collected directly from firms with higher frequency; Heckel, LeBihan and Montornés (2008) for France and Lünnenmann and Wintr (2009) for Luxembourg. Druant *et al.* (2009) survey the evidence on nominal wage rigidity in Europe collected by Eurosystem Wage Dynamic Network.

The aim of the current paper is to shed light on nominal wage rigidity and wage setting in Iceland and further contribute to the growing literature on nominal wage rigidity.[2] We use a unique monthly frequency database that covers wages for 80% of the Icelandic private sector over a period of 13 years, between 1998 and 2010. Our comprehensive dataset has the rare potential of giving a clear view of nominal wage rigidity. The data allow us to evaluate different wage setting theories, especially as there are phases with low, intermediate and high inflation and unemployment over the sample period.

Our principal measure of nominal wage rigidity is the frequency of wages adjustments. We find that, in general, wages are adjusted infrequently; the mean frequency of change in a month is 10.8% for all workers in our sample. As expected, since wage changes are infrequent, the size of adjustments, both increases and decreases, is large. The mean monthly size of increases is 6.3%, and the mean absolute size of decreases is 4.8% per month. We find wage adjustment to be asymmetric around zero, as only 5% of wage changes are decreases. The economic literature has identified this asymmetry in wage changes as downward nominal wage rigidity: wage changes are more likely to be positive than negative. This property is further explored in Section 6, where we find that, even though the distribution of wage change displays some of the characteristics predicted under downward nominal wage rigidity, it does not seem to be binding. In particular, in the recession beginning in 2008, nominal wage cuts appear to have been one of the channels for adjustment in the labour market.

The estimates of the mean frequency of wage change can be inverted to give a measure of the mean duration of wage spells. We find that the mean implied duration of wage spells is 8.7 months, close to three quarters. Next we deviate from the assumption of constant probability of wage change and look at the distribution of wage spell durations in our sample. The mean duration of wage spells is 8.9 months, similar to the inverse of the mean frequency, and the median length is 7 months. Furthermore,

[2]The relevant papers using Icelandic wage data are Agnarsson *et al.* (1999), Jonsson and Johannesson (2002), and Andrason (2007), who study changes in nominal and real wages in relation to the general flexibility of the Icelandic labour market. Zoega and Karlsson (2006) use Icelandic survey data to study the microfoundations of downward nominal wage rigidity.

we find that there is a wide range of contracts of different lengths and roughly 20% of spells last beyond one year.

The theoretical literature modelling price and wage setting can broadly be separated into time-dependent and state-dependent duration models. We investigate whether wage adjustment is time-dependent and, specifically, if wage setting is synchronised at certain dates or staggered over time. Wage setting is found to be considerably synchronised, as 48% of wage change take place in January. Other adjustments are staggered over the year, however. Our results indicate a regular timing pattern in wage setting. We then explore the existence of state-dependency. We argue that our long sample period, characterised by substantial variation in both inflation and unemployment, provides an ideal testing ground for different wage setting theories. In short, we find very limited evidence of significant state-dependent factors, only a positive relation between the frequency of wage decreases and unemployment.

If wage setting varies across sectors and occupations, simple models, where wage contracts are identical but staggered over time, may miss important dynamics. Moreover, the mean frequency of change will not be an appropriate summary statistic to describe the aggregate wage flexibility in an economy. We find limited heterogeneity in wage setting among different industries and occupations. There is clear evidence of heterogeneity, however, when firms are categorised by size; smaller firms change wages less frequently than large firms. When weighted across both industries and occupations, the monthly frequency of wage change is 10.5%, or almost identical to the overall frequency.

Finally, we estimate a hazard function of wage change. The hazard function is flat during the first year with the hazard of change ranging from 10% to 15%. At 12 months, there is a substantial spike. We conclude that, in line with previous evidence reported in the paper, wage setting is consistent with the Taylor (1980) fixed duration contract model, but there exist contracts with both shorter and longer duration than precisely one year.

The remainder of the paper is organised as follows. Section 2 describes the key elements of the Icelandic labour market. Section 3 sets the stage and briefly reviews the main models of staggered wage setting. Section 4 describes the dataset used. In Section 5, we present evidence on the frequency and size of wage changes, the duration of wage spells, the time- and state-dependency in wage setting and the heterogeneity in wage changes. Section 6 explores the distribution of wage change over time. In Section 7, we estimate the hazard of wage change. Section 8 concludes.

2 Wage setting in the Icelandic labour market

Iceland has the highest union density among OECD countries, at 86% in 2007 (stats. OECD), and bargaining coverage is even higher. In the private sector, unions are organised on an occupational basis and are affiliated with five national federations that are in turn affiliated with the Icelandic Confederation of Labour (ASI). Employers are highly organised as well.

This gives rise to wage setting that is characterised by high centralisation and co-ordinated bargaining, most frequently by the national federations. This leads to more or less nationwide settlements that provide for the minimum wage increases. In addition, the tailoring of national framework pay agreements in sectoral and firm-level negotiations makes it possible to take specific local conditions into account. As a rule, the contracts include Government-sponsored tripartite agreements and/or social pacts.

The duration of contracts has increased over the past two decades. During our sample period (1998-2010), the duration of contracts has been 3-4 years (see Table 1). As a rule, the contracts contain some kind of trigger clauses according to which settlements can be revoked if the premises on which they are based – usually some kind of CPI threshold – fail to hold. If assumptions do not hold (which has been the case more often than not), the contracting parties can either review the wage package within the settlement or revoke the settlement *en bloc*. Reviews generally result in wage increases that nonetheless are far smaller than those that would have been necessary to maintain the purchasing power originally intended when the agreements were signed.

Table 1: Wage Index and Union Wage Contracts

	Private Sector	
	Wage Index	Negotiated Wage Increases
1997-2000	6.1	4.2
2000-2004	8.4	3.2
2004-2008	9.1	2.9
2008-2011	3.3	3.4

Notes: Numbers are average changes per year.
Source: Statistics Iceland, Central Bank of Iceland.

The structure of the wage bargains is usually the same: wage increases take effect upon signing and then on 1 January each year. This is clearly manifested in Figure 3. As most contracts expire at the end of the last year of the settlement period and it takes some time to work out a new contract, the initial wage increases included in the new contract (2000, 2004 and 2008) are usually spread out over a few months (usually Q2), whereas in intervening years we see spikes in January, when between 60% and 80% of the sample experiences a wage increase. During the recession, 2009-2010, there was no January spike, as the wage increases implied in the contract were postponed during those years. We also observe two small spikes in June and in November, which coincide with the payment of special holiday bonus payments.

3 Economic theory of staggered wage setting

In the macroeconomic literature, several paths have been taken in modelling wage setting and nominal wage rigidity. The general notion is that nominal rigidities lead to long-lasting effects on real activity because of staggering of contracts; not all wage rates are reset at the same time. Even for the collective notion of staggering, wage setting has been modelled as to be triggered by several factors, leading to various time profiles of wage adjustment and different results for the transmission of monetary shocks. Before we begin our empirical investigation, we therefore present an overview of wage setting models and highlight their characteristics, which can be detected in the data.

In our brief overview, we distinguish between two classes of wage and price duration models: time-dependent and state-dependent duration models.[3] In time-dependent duration models, wage changes are a function of time, either fixed or random, and as time passes, the shorter it becomes until wages are reset. Conversely, state-dependent duration models describe wage setting as dependent on the state of the economy.

3.1 Time-dependent duration models

Within the class of time-dependent duration models, it is important to distinguish further among various models with different implications about monetary neutrality. First, consider wage rules, where nominal wages are *predetermined* for some number of periods in discrete order. The first introduction of a theoretical model of predetermined wage setting is in Fisher (1977). The model explicitly assumes that wages are set in order to maintain constant real wages and, equivalently,

[3]For discussion about different price- and wage setting models see *e.g.* Blanchard and Fisher (1989) and Taylor (1999).

constancy of employment.[4] Based on complete knowledge of history and rational expectations about the future state of the economy – evolution of the money stock – the wage path is set today for one or more future periods. In a two-period version of the model, those workers who reset wages now can choose different wages for this period and the next, but the path is predetermined. Staggering in wage-setting therefore results from different time intervals between wage setting for different groups. In the Fisher (1977) model, wages are set in such a manner that markets are expected to clear. This results from the assumption that, when decisions are made, they are built on rational expectations about the price level, and deviations from that level cannot affect the wage path.

Taylor (1980) proposes another model, where wage setting is time-dependent. Unlike Fisher (1977), the Taylor model is a *fixed*-duration model: staggered wage contracts are made at the beginning of a period and kept fixed for one or more periods before being reset. In a two-period version of the model, half of the workers set wages today for two periods and the other half reset wages in the next period.[5] The wage chosen for the two periods is then the weighted average of the desired wages for each period, where the desired wage is a function of the price level and aggregate output. As is discussed in both Taylor (1983) and Cecchetti (1987), the motivation behind such fixed-duration models comes from institutional arrangements like trade unions.

The Fisher (1977) and Taylor (1980) models both formulate very simple wage-setting functions in a setting of overlapping time-dependent contracts. Interestingly, however, the effect of changes in money supply and therefore the role of monetary policy are quite different. In the Fisher (1977) model, although wage adjustment is infrequent, money is neutral. Wage setters choose wages according to a rational expectation of the price level in each period. Wages of other groups are only taken into account as they affect the price level, which is expected to persist during the contract. A much-highlighted corollary is that deviations in employment and aggregate output due to a shock in money supply do not persist for a longer time than the longest lasting wage contract. In an economy where wage contracts are characterised by Fisher-like contracts, nominal rigidity will only have a long-lasting effect on output if contracts have a very long duration. Conversely, Taylor-like wage contracts can generate output effects that last long beyond the contract length. This results from the assumption that under fixed wage setting, as in the Taylor (1980) model, wage setters are concerned with relative

[4]The model builds on observations about the institutional nature of the labour market since, as Fisher (1977) emphasises, "wages are usually set in advance of employment".

[5]In the original model, each period is assumed to be 6 months, so in a two-period formulation it implies that every 6 months half of the wages in the economy are reset and kept fixed for a year.

wages. Each group that sets wages is not willing to raise its wage much above the wage of the other groups' fixed wage because doing so would make them less competitive. Because of the importance of relative wages, wage adjustment will be slow and money supply shocks will cause a long-lasting deviation in output and employment from equilibrium.

A third and widespread model of time-dependent duration is the Calvo (1983) random duration model.[6] In the model, there is a constant probability of wage adjustment at any instant. When large numbers of wage-setters is assumed, wage setting becomes highly staggered, as only a constant fraction of wages is adjusted at any point in time. Assuming a continuum of wage-setters, each changing its wage with the constant probability λ, the *time until the next change* follows a Poisson density function. As time passes, it becomes more likely that the wage has been reset. Even though the Calvo model does not have a microeconomic foundation, it has been widely used to introduce rigidity in both nominal prices and wages in New Keynesian models, at least to some extent because of convenience.

3.2 State-dependent duration models

In time-dependent duration models, the probability that wages will be reset increases with time. Another obvious trigger for wage-setting is the evolution of the state of the economy. Models where adjustment of prices is state-dependent include Caplin and Spulber (1987), Dotsey, King and Wolman (1999) and Golosov and Lucas (2007). In those models, price setting is costly because price-setters are subject to menu costs. We are not aware of state-dependent models of wage setting with micro-foundations. However, by intuition from the state-dependent pricing models, one can draw inference about how wage setting under state-dependency will differ from wage setting under time-dependency. In general, under state-dependent duration of wage spells, wages move towards a trigger point as the state of the economy evolves. At this trigger point, wages are reset. In an economy where shocks are relatively infrequent and the state of the economy evolves somewhat smoothly, a state-dependent duration model would predict wage setting of lower frequency than time-dependent models, but the average size of change would be large. In contrast, an unstable economy, where relatively frequent shocks move wages quickly towards a trigger point, would feature more frequent wage setting under state-dependent contracts than if contracts were renegotiated at certain time intervals.

For research into wage setting in the Icelandic labour market, all the above models seem relevant.

[6]Interestingly, another model of staggered price setting, Rotemberg (1982), where price-setters face quadratic costs for adjusting prices, has dynamics similar to those in the Calvo (1983) model. Petursson (1998) estimates the Rotemberg (1982) model using Icelandic price data.

A large share of workers are members of labour unions and union wage setting is the microeconomic foundation built on in Taylor (1980). Triggerclauses in the wage agreements made by Icelandic unions indicate that wage setting is in part predetermined for several periods, as in Fisher (1977). Furthermore, these clauses allow for a review of the wage package if there is a considerable fall in real wages, indicating some state-dependent factors. A close look at our comprehensive dataset provides the opportunity to distinguish between the empirical relevance of various wage setting models.

4 The data

In the paper, we use unpublished confidential micro data from Statistics Iceland. The data are collected by Statistics Iceland through the *Icelandic Survey on Wages, Earnings and Labour costs* (ISWEL), which covers a large share of wages in the private sector and the entire public sector. However, the inclusion process in the ISWEL survey is not fully completed for the public sector, which is therefore not included in our dataset. The monthly Wage Index published by Statistics Iceland is based on the same data. The target population are all Icelandic firms or activity units with 10 or more employees. Every month, each firm in the survey submits electronically standardised and detailed information on wages, labour costs, working hours, and necessary background factors on both the firm and workers. In collaboration with leading Icelandic software firms, wage software has been modified to enable firms to submit the required detailed information directly from the wage software they are using. This methodology minimises firms' effort and cost related to data collection and affects quality because direct access minimises the bias caused by recording and reduces individual estimation in managing the data. A crucial part of the data collection process is the low effort on behalf of the firm after the necessary amendments have been made to the wage software when firms enter the sample. Because of this, firms agree to give information on a monthly basis and remain in the sample for long time.[7]

Our sample period is from January 1998 to September 2010, the longest available period.[8] The dataset includes wage information covering over 80% of the private sector. Wage data are sampled for all workers aged 16 to 74 in a given firm, excluding firm owners and apprentices. For each worker, we have information about his or her date of birth, gender, residence, nationality, country of birth,

[7]To maintain high quality of data, Statistics Iceland performs an extensive data quality check when receiving the data from the firms. In addition, strong emphasis is placed on giving feedback to both the firms and the software companies. Because of constant feedback, data problems are addressed and solved immediately.

[8]Data for workers in financial services are only available from January 2004 to September 2010.

occupation, and length of work experience, both with the current employer and in the labour market.[9] Firms are separated into groups by industry. Wages and working hours are reported at monthly frequency. Hours are divided into daytime and overtime hours.

We have five different measures of wages, where the wider definitions include payments such as overtime pay, overhead compensation, allowances, bonuses, and other forms of compensation. As a measure of wages – *base wages* – we use wages for daytime work divided by number of daytime hours. We do not have information on whether workers are salaried or paid by the hour. However, for those who are paid by the hour, our measure of the hourly base wage should equal their hourly wage. For salaried workers, the number of hours in a month is a fixed number. Thus base wages for salaried workers should not change unless their salary is changed. Wider definitions of wages, which are included in our data, are much more volatile, both in size of change and frequency. Measurements of frequency and size of change in base wages are more relevant for macroeconomic interpretation and therefore the focus of this study.[10]

In all, our dataset contains 2.6 million observations over the sample period of 13 years. The dataset contains 85,534 individual workers with a mean age of 45.[11] In our analysis, we look at wages for workers in continuing jobs and therefore match employers and employees into employer-employee pairs or relationships. In total, we have 116,709 employer-employee relationships, including 62,918 are for male workers and 53,791 for female workers. Firms are categorised into five different industries: industrial production, construction industry, trade and repair service, transport, and financial services. Workers are separated into seven different occupations: managers; specialists, technicians, office personnel, craftsmen and production, blue-collar workers, and service, sales and support. Table 2 illustrates the industrial and occupational composition of the dataset.

The dataset we use has various unique advantages for researching nominal wage rigidity. First, the data are collected directly from firms' wage software but not through interviews with workers or postal surveys. This should result in minimal measurement errors for both wages and working hours. Second, the data are of monthly frequency, the same frequency as most wage payments. Except for Lünnemann and Wintr (2009), who use micro data on monthly frequency for Luxembourg to assess

[9]The variable for residence takes the value 1 for those who live in the capital area and 0 for regional Iceland. Information on education and years of education are included in the database but is incomplete and cannot be used in the analysis.

[10]Evaluation of theories such as the Efficiency wage theory might be conducted using data on more wider definitions of wages and compensation; however, this is beyond the scope of the current paper.

[11]To put the size of our sample into context, the Icelandic labour force was 152,100 in 1998 and 181,000 in 2010.

Table 2: Industry and Occupational Composition of the Dataset and Employment per Subgroup

Industry	Total	Empl.[a]	Occupation	Total	Empl.[a]
Industrial production	35.259	13%	Managers	3.699	8%
Construction industry	9.941	7%	Specialists	6.021	16%
Trade and repair services	36.082	13%	Technicians	8.304	15%
Transport	24.413	7%	Office personnel	13.114	7%
Financial services,	11.566	5%	Service, sales and support	37.032	19%
pension funds and insurances			Craftsmen and production	6.077	19%
			Blue-collar workers	48.580	7%

Notes: The number of employer-employee relationships for the period from January 1998 to September 2010, except workers and firms in Financial services, pension funds and insurances where the period is from January 2004 to September 2010.

[a] Number of employed workers in each subgroup as percentage of the labour force, including the farm industry and public sector. Numbers are averages for the whole sample period. In total, the sample represents over 80% of the private sector. *Source:* Statistics Iceland.

nominal wage rigidity, other studies have used data with quarterly frequency, as in Heckel *et al.* (2008) or, for four month intervals, as in Barattieri *et al.* (2010). Third, our dataset covers a long continuous period of time, 153 months, with great variation in macroeconomic conditions, both in inflation and in unemployment.

We make four amendments to the dataset in order to prevent possible biases or errors in our estimates. First we round the hourly base wage to the next 10 Icelandic krónur (ISK).[12] This prevents the occurrence of variation at that very low margin as a result of rounding in worked hours or monthly wages. For some subset of workers, we find wage changes that take the form of a V-shape or an inverted V-shape, *i.e.* wage increases that are reversed by wage decreases in the subsequent month, or vice versa. Such variation is likely caused by misreporting, either in hours or in wages. If wage changes are reversed in the following month, we regard the wage change as non-permanent, based on the assumption that changes in wages are costly and therefore are not implemented frequently. We use a simple algorithm that detects such non-permanent changes, and we report them as though there were no change in wages in that month. With the same argument, wage changes in three consecutive months are treated in the same way. Last, wage changes of extreme size are omitted in order to limit the effect of such outliers on the measure of the mean wage adjustment size, as we consider them as measurement errors. This excludes about 1% of observations from each tail of the distribution.

[12]ISK 10 equalled EUR 0.06 or USD 0.09 at the time this paper was written.

5 Frequency and size of wage changes

We match employees, i, and their employers, j, in employer-employee relationships. We denote $w_{ij,t}$ as the hourly base wage paid to employee i working for employer j in month t. The employer-employee relationships are assumed to be created in month t, when wage payments $w_{ij,t}$ are first observed, and destroyed in the month $t+n$ when the last wage payment is observed. For each employer-employee relationship we therefore have an n-long wage trajectory. Each wage trajectory can be divided into wage spells, where a wage spell is defined as a continuous period without a wage change. Wage trajectories can therefore be divided into one or more wage spells, depending on the length of the employer-employee relationships and how often wages are changed. For all relationships, ij, that have lasted for two consecutive months we create monthly indicators, $I_{ij,t}$, indicating whether wages have increased, decreased or remained unchanged in month t. More precisely, we define the indicator for wage increase as:

$$I^{+}_{ij,t} = \begin{cases} 1 & \text{if} \quad w_{ij,t} > w_{ij,t-1} \\ 0 & \text{otherwise} \end{cases}$$

the indicator for a wage decrease as:

$$I^{-}_{ij,t} = \begin{cases} 1 & \text{if} \quad w_{ij,t} < w_{ij,t-1} \\ 0 & \text{otherwise} \end{cases}$$

and finally the indicator for constant wages between two consecutive months as:

$$I^{=}_{ij,t} = \begin{cases} 1 & \text{if} \quad w_{ij,t} = w_{ij,t-1} \\ 0 & \text{otherwise} \end{cases}$$

One of the main measures of the degree of wage rigidity is the frequency of wage change. In our notation, the monthly frequency of wage change in the labour market, summing over all employer-employee relationships, ij, can be defined as:

$$f_t = \frac{\sum_{ij}(I^{+}_{ij,t} + I^{-}_{ij,t})}{\sum_{ij}(I^{+}_{ij,t} + I^{-}_{ij,t} + I^{=}_{ij,t})} \tag{1}$$

i.e. the average frequency of change in a given month, t. Analogously, the mean frequency of wage increases and wage decreases can be constructed using each of the two components in the numerator:

$$f_t^+ = \frac{\sum_{ij} I_{ij,t}^+}{\sum_{ij}(I_{ij,t}^+ + I_{ij,t}^- + I_{ij,t}^=)}, \quad f_t^- = \frac{\sum_{ij} I_{ij,t}^-}{\sum_{ij}(I_{ij,t}^+ + I_{ij,t}^- + I_{ij,t}^=)} \tag{2}$$

Corresponding to the mean monthly frequency of wage change, we define the mean duration of wage spells. If we assume a constant probability λ of wage change, as in the Calvo model, the frequency of wage change is $f = 1 - e^{-\lambda}$. This implies that the mean duration of a wage spell is:

$$d = \frac{-1}{\ln(1-f)} = \frac{1}{\lambda} \tag{3}$$

Another important measure of wage adjustment is the size of wage changes. We use the indicators to define formulas for the size of wage increases and wage decreases as:

$$s_t^+ = \frac{\sum_{ij}(I_{ij,t}^+ * (\frac{w_{ij,t} - w_{ij,t-1}}{w_{ij,t-1}}))}{\sum_{ij} I_{ij,t}^+}, \quad s_t^- = \frac{\sum_{ij}(I_{ij,t}^- * (\frac{w_{ij,t} - w_{ij,t-1}}{w_{ij,t-1}}))}{\sum_{ij} I_{ij,t}^-} \tag{4}$$

where s_t^+ and s_t^- are, respectively, the average percentage increases and decreases of wages in a given month, t.

5.1 Wage adjustment and duration of wage spells

Our principal measure of the degree of nominal wage rigidity is the frequency of wage adjustments. Following Bils and Klenow (2004), the frequency of price change has been the reference point for the degree of nominal price rigidity. Our measures of wage rigidity are therefore comparable to the evidence of price rigidity estimated using monthly microdata. The first column in Table 3 reports the mean frequency of wage change, whereas the second and third columns report the frequency of wage increase and wage decrease, respectively. The mean monthly frequency of change for all workers in our sample is 10.8%, and the mean frequency of wage increases is 10.3%. We find evidence of nominal wage cuts; the mean frequency of wage decreases is 0.5% per month.

Assuming a constant hazard of change – a standard assumption applied in much of the price and wage rigidity literature – we can invert our measure of mean frequency of change, giving a measure of the average duration of wage spells. Corresponding to the mean frequency of wage change, the implied duration of a wage spell is 8.7 months, or almost three quarters. The frequency of change and the average duration of wage spells are the statistics that are essential for calibration of macroeconomic

Table 3: Frequency of Wage Change, Size of Changes and Duration of Wage Spells

	Mean Frequency			Mean Size		Wage Spell
	Change (%)	Increase (%)	Decrease (%)	Increase (%)	Decrease (%)	Implied Duration (months)
All workers	10.8	10.3	0.5	6.3	4.8	8.7
Male workers	10.6	10.1	0.5	6.1	5.1	8.9
Female workers	11.1	10.6	0.5	6.5	4.4	8.5
Excluding union settlements	4.7	4.3	0.4	6.1	4.5	20.8
Low Unemployment[a]	12.0	11.6	0.4	6.9	3.7	7.8
Intermediate Unemployment[b]	10.6	10.1	0.5	5.7	4.5	8.9
High Unemployment[c]	11.2	10.6	0.6	4.5	4.5	8.4

Notes: All frequencies reported are in percentage per month. The mean size is the mean percentage change per month. The size of decrease is reported in absolute terms. Implied duration is calculated under the assumption that the hazard rate of wage change is the constant λ and the probability of a wage change is $f = 1 - e^{-\lambda}$. The mean implied duration is therefore $d = -1/\ln(1-f)$, where f is the mean frequency of wage change.

[a] 2005, 2006 and 2007.

[b] 2001, 2002 and 2003.

[c] 2009 and 2010.

models that capture staggering of wage adjustment through a setting such as the Calvo mechanism.

Although wages for male workers are slightly more rigid than those for female workers, with a 10.6% monthly frequency of change for males compared to an 11.1% frequency for females, there does not seem to be a substantial gender difference in wage setting. We also estimate the frequency of wage changes by workers' residense, and find little difference in the frequency of wage change between workers living in the capital area and those living in regional Iceland.

We find that adjustment of wages is generally infrequent. This is expected because the adjustment process is costly; both the bargaining process and adjustment of wage payments require time and resources. However, because wage adjustment is costly, we would not only expect wage adjustment to be infrequent; we would also expect them to be large when wages are changed, even though adjustment to shocks is sluggish. Columns four and five in Table 3 report the mean size of wage increases and the mean absolute size of wage decreases, both in levels.[13] The mean size of increase for all workers is 6.3%, and the mean absolute size of wage decrease is 4.8%. We also estimate a median increase of 3.9% and a median absolute decrease of 3.1%. In Figure 1 we plot a histogram of all non-zero wage changes, excluding extreme values. The histogram is constructed using a bar for each percentage point of size change. This means that the height of a certain bar, *e.g.* the bar at 1%, shows the fraction of wage changes of the size from 1% up to 2%. There is a substantial variation in the size of adjustment; increases range from 1% to 30% and decreases from -1% to -15%. However, as Figure 1 illustrates, only a small fraction, or 5%, of wage changes are decreases. We also observe a great variation in the size of increases and decreases over time. On a yearly basis, the mean size of increases ranges from 4.6% to 7.5%, and 3.1% to 6.1% for decreases. In this context we should emphasise the great variation in inflation and unemployment over the sample period, when inflation ranged from 0.8% to 18.6% and monthly unemployment from 0.8% to 9.3%. In Section 5.4, we explore the relationship of inflation and unemployment with the frequency and size of wage adjustment.

In the fourth row of Table 3, we report the frequency and size of wage change, excluding changes according to union settlements. This is an *ad hoc* method where we have historically identified dates of wage changes related to union settlements and should give a rough estimate of wage adjustments that are at the discretion of firms only. After controlling for wage changes due to union settlements,

[13]We choose to report wage changes as percentage change in levels rather than log differences since changes in levels are more intuitive and log differences may in some cases underestimate wage changes. Another reason to use levels rather than logs is for comparability between sections where we report sizes and where we plot histograms and distributions of wage changes.

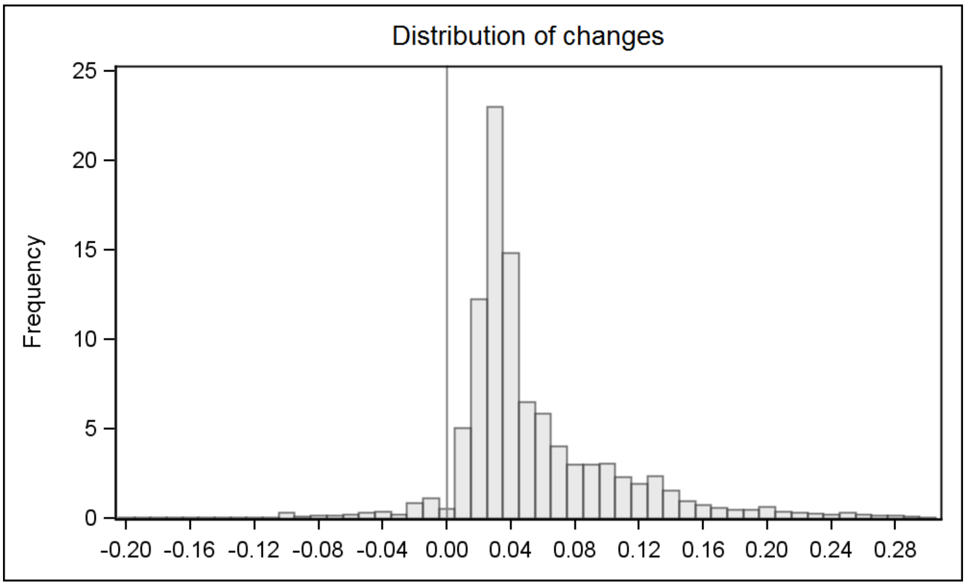


Figure 1: Size of Nominal Wage Changes

the frequency of wage changes decreases to 4.7% and the mean size of increases drops to 6.1%.

As is noted in the Introduction, the number of studies that estimate the frequency of wage change and duration of wage spells is limited, especially those using monthly data. However, most research on nominal price rigidity uses monthly microdata and reports results on monthly frequency.[14] Our results on wage behaviour are therefore comparable to the literature on price behaviour using monthly microdata. To compare our results to previous studies of wage rigidity that use lower-frequency data, we can transform our monthly frequency of change to a mean quarterly frequency of 37% and a mean yearly frequency of 75%.[15] Lünnemann and Wintr (2009), the only other paper known to the authors that reports frequency using monthly micro data, reports monthly frequency of wage change in Luxembourg between 9% and 14%. Using quarterly data collected from firms through a postal survey, Heckel *et al.* (2008) report a 38% quarterly frequency of wage change. Barattieri *et al.* (2010) estimate the frequency of wage change in the US using data from a survey of workers conducted every four months. They report a 17.8% quarterly frequency of wage change after having adjusted for possible measurement errors. Druant *et al.* (2009) report an average duration of wage spells of 15 months, using data collected through a firm survey among European firms. In another survey of European firms, Fabiani, Kwapil, Rõõm, Galuscak and Lamo (2010) find that around 60% of firms

[14] See Bils and Klenow (2004), Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008) for frequency of price change in the US. See Gudmundsson *et al.* (2011) for frequency of price change in Iceland.

[15] These are approximations made under the assumption of constant monthly frequency of change. A constant monthly frequency of 10.8% transforms into 37% quarterly frequency $(1-(1-0.108)^3 = 0.37)$ and 75% yearly frequency of wage change $(1-(1-0.108)^{12} = 0.75)$.

adjust wages once a year and 12% more frequently.

To summariase, we find that wages are adjusted infrequently and by a relatively large amount when adjusted. Furthermore, our measures are broadly in line with the limited micro evidence available for European countries, but wages are adjusted more frequently than Barattieri *et al.* (2010) report for the US.

5.2 Duration of wage spells

In the previous section, we extrapolated the mean duration of wage spells from our estimates of the mean frequency of wage change. This inference was made under the assumption of a constant monthly probability of change. However, direct evidence on the distribution of wage spell durations can provide important and valuable evidence on how monetary shocks are transmitted to the real economy and, more precisely, information on the timing of the transmission process. We devote Section 7 to estimation of the hazard function, *i.e.* the discrete-time probability of a change in nominal wages conditional on the wage spell reaching that age, which gives deeper information about the duration of wage spells and allows us to distinguish between the empirical relevance of different wage setting models.

Figure 2 plots the distribution of wage spell durations. Before plotting the distribution, we have taken account of several factors. First, we drop all wage trajectories that are only one wage spell, *i.e.* employer-employee relationships where wages are never reset during the period observed. Second, we focus only on completed wage spells and therefore exclude both right-censored spells, where the end of the spell is not observed, and left-censored spells where the beginning of the spell is not observed. Figure 2 shows that there is a substantial variation in the duration of spells. Most of the spells last one year or less. The mean wage spell duration is 8.9 months, similar to the duration implied by the mean monthly frequency, and the median duration is 7 months. Spells that last precisely one year are most frequent, or 13.5% of spells.[16] However, as is shown on the right portion of the figure, there is a significant fraction of long-lasting wage spells. About one-fifth of spells last longer than a year, and some spells last up to three years.

Dixon and Kara (2011) show that in an economy with various lengths of wage contracts, the existence of only a small proportion of long contracts can significantly increase the output persistence following a monetary shock. They develop a DSGE model where wage setting is modelled as a

[16]The distribution of spells is similar when we exclude union settlement changes.

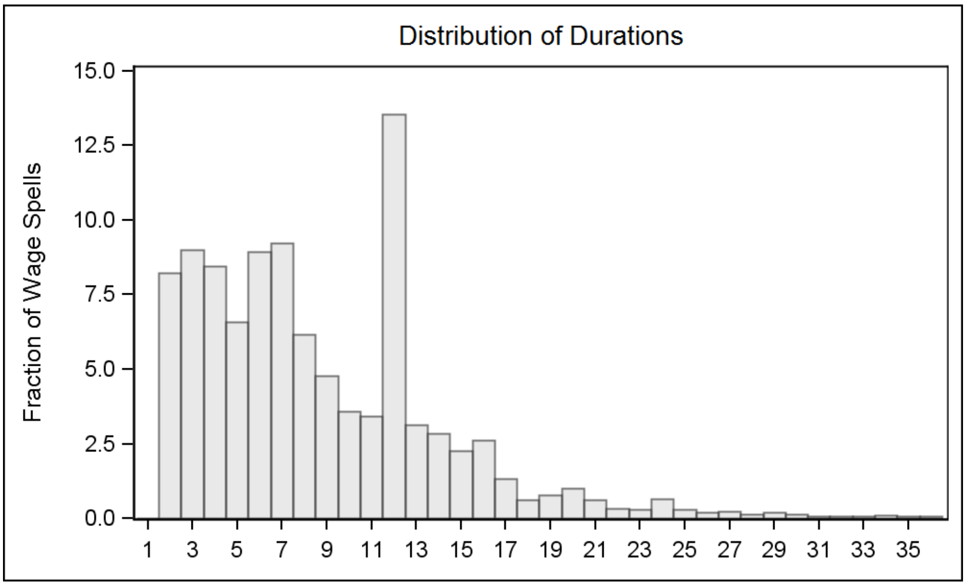


Figure 2: Distribution of Wage Spell Durations

Notes: Durations are in months. All left-censored and right-censored wages spells have been excluded.

generalisation of the staggered wage contract setting of Taylor (1980), and they allow for wage contracts of different lengths. The reason why even a small number of long contracts can generate an increase in persistence is that long contracts create a spillover effect. Since longer contracts adjust slowly to monetary shocks, shorter contracts will also adjust slowly, as the desired wage depends on the price level, which further depends on the wages of those with longer contracts. The spillover from longer to shorter contracts is therefore through the slow and more persistent effect of long contracts on the price level. In light of the results in Dixon and Kara (2011), our findings of a significant number of long wage spells provide an empirical explanation for output persistence.

5.3 Time dependence: staggering or synchronisation

In Section 3, we reviewed some models in which wages are not directly adjusted following a shock but adjusted at fixed or random time intervals, *i.e.* wage setting is time-dependent. If wage adjustment is dependent on time, the degree of synchronisation (how large a fraction of wages are adjusted at the same time) and the degree of staggering (how wage adjustment is distributed over time) becomes an important factor determining how aggregate shocks and monetary policy affect the real economy.

Figure 3 plots the frequency of wage change, separated into increases and decreases, per month over the sample period. In a typical month, the frequency of change is relatively low and stable. However, the plot of monthly frequency displays distinct spikes, especially in January. For further identification

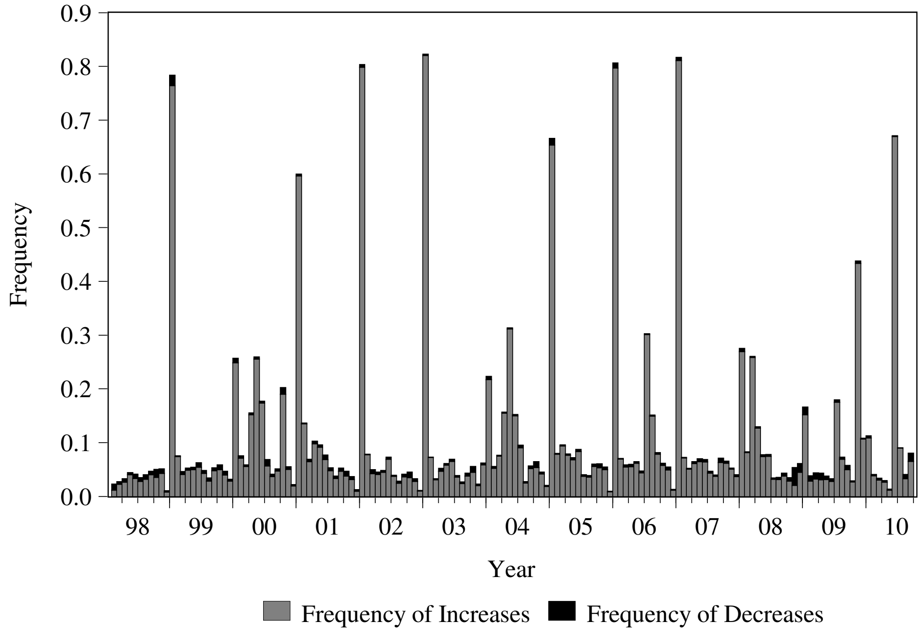


Figure 3: Frequency of Nominal Wage Changes, January 1998 - September 2010

of this pattern, Figure 4 plots the frequency by months for a typical year. While a substantial share of wage adjustments are distributed over the course of the year, a clear pattern is revealed; 48% of wages change in January and, additionally, we see two small peaks in June and November. Those three peaks correspond in general to implementation of wage increases negotiated by unions. The timing of wage changes is therefore characterised by a combination of synchronisation of changes in January but also a substantial staggering over other months, with positive frequency in every month. Similar clustering of wage changes in January has been identified in other European countries (see *e.g* Lünnemann and Wintr, 2009 and Druant *et al.*, 2009). However, Barattieri *et al.* (2010) do not find evidence of seasonality in wage changes in the US labour market.

Evidence of time-dependent wage setting is mirrored in evidence of firms' price setting strategies. In a recent study of price setting, Olafsson, Vignisdottir and Petursdottir (2011) find that Icelandic firms' price review strategies depend on the nature of their cost structure. Specifically, they find that the share of firms that use a pure time-dependent price review strategy increases as the share of labour cost of the total production cost increases, reflecting time-dependency in labour costs.

The fact that wage changes are not uniform has important implications for transmission of monetary shocks. Olivei and Tenreyro (2007) show that, if wage contracts are not uniformly staggered,

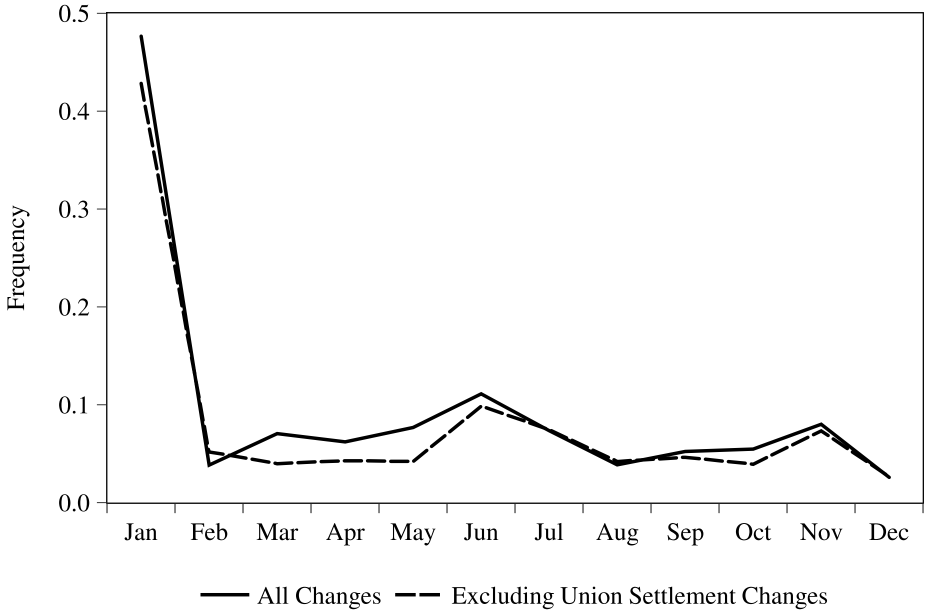


Figure 4: Frequency of Wage Changes by Month

monetary policy can have different effects on the real economy at different points in time. More precisely, monetary policy makers are able to create larger responses in economic activity for a given interest rate change if interest rates are changed when wages are more rigid. The results of Olivei and Tenreyro (2007) and our findings concerning synchronisation of changes in January imply that monetary shocks taking place in the months after a large share of wages has been reset will generate more output effect than monetary shocks taking place when wages are relatively more flexible.

5.4 State-dependence and cyclicality

Over the period from January 1998 to September 2010, economic conditions in the Icelandic economy varied greatly. The inflation rate was both high and volatile, ranging from 0.8% to 18.6% *per annum*. Rapid increases in the price level have generally followed depreciation of the local currency. Furthermore, our sample includes periods of wide fluctuations in the labour market: sudden shifts from excess demand to excess supply of labour. After the financial collapse in the autumn of 2008, registered unemployment rose from 1.3% in September 2008 to 9% in April 2009. Our dataset provides a rare opportunity to evaluate state-dependency in wage setting – a comparison to the analysis of time-dependency – and therefore the potential to distinguish among different strands of wage setting models. In this Section, we explore how wage setting correlates with the business cycle.

In Table 3, we report the frequency of change for three periods with different labour market conditions: first, a period of low unemployment (2005-2007) when registered unemployment averaged 1.5%; second, a period of intermediate level of unemployment (2001-2003) when unemployment averaged 2.4%; and last, a period of exceptionally high unemployment (2009-2010) when unemployment averaged 8.1%. The frequency of wage change, especially increases, does not show a strong relation with unemployment. Even though increases are most frequent when unemployment is low, wages are not found to be very upwardly rigid in times of severe labour market conditions. The frequency of wage decreases is somewhat more frequent when unemployment is high (0.6% per month), however, than when unemployment is low (0.4% per month). As regards magnitude, mean increases are greater when unemployment is low.

Table 4: Correlation with Macroeconomic Variables

	Correlation	
	Unemployment	Inflation
Frequency of increase	-0.13	-0.24
Frequency of decrease	0.40*	-0.07
Size of increase	-0.17	0.16
Size of decrease	0.37*	0.07

Note: * denotes statistical significance of correlation at 5%.

Exploring further the extent of cyclical variation in wage setting, we estimate the correlation between the frequency and size of wage adjustment with unemployment and inflation. We generate quarterly series of the frequency and size of wage changes, both increases and decreases, by taking quarterly averages of our monthly series. The quarterly series are then seasonally adjusted using the X-12 ARIMA procedure provided by the US Census Bureau. We then extract the cyclical component from the seasonally adjusted series using the Hodrick-Prescott (HP) filter with a smoothing parameter of 1600. A quarterly series for unemployment is generated by taking quarterly averages of monthly unemployment as it is registered at the Directorate of Labour.[17] In the same way, we generate quarterly averages of monthly observed headline CPI. Inflation is then calculated as the percentage change in the quarterly series for the CPI. We seasonally adjust both unemployment and inflation

[17]We choose to use averages of the monthly registered unemployment from the Directorate of Labour rather than the quarterly unemployment rate based on the Labour Force Survey (LFS) because the LFS survey was conducted only on a semi-annual basis before 2003.

using the X-12 ARIMA procedure and detrend using the HP filter. Table 4 reports the correlation between the two macroeconomic series and the four nominal wage series, lagged one period. We do not find much evidence of state-dependency in wage setting. Frequency and size of wage increases are weakly correlated with unemployment, but frequency of wage decreases and size of decreases have positive and statistically significant correlation with unemployment of 0.40 and 0.37 respectively.

None of the wage series has a strong correlation with inflation. The weak correlation between nominal wage changes and inflation can be traced, at least to some extent, to the factors driving the variation in the inflation rate and nominal wage increases. As upswings often turn into overheating with a tight labour market, nominal wage increases drive real wage growth, whereas during downswings the depreciation of the Icelandic króna drives inflation.

The fact that neither frequency nor size of wage changes reflects a high degree of state dependency and the strong evidence of time dependent wage contracts we have found lead us to conclude that models with time-dependent wage setting have more empirical relevance, at least in the Icelandic labour market, than models with wage setting dependent on variation in the state of the economy. However, it should be emphasised in this context that wages, nominal and real, do not provide the only adjustment channel for the labour market. If wages are frictionless, all shocks affecting the labour market are absorbed through changes in the wage level but not through variation in hours and employment. Sigurdsson (2011) finds significant cyclical variation in total hours and that Icelandic firms adjust labour input almost equally along the intensive and extensive margin. In a recession, firms both reduce hours worked per worker and lay workers off, increasing the flow into unemployment, which drives up the unemployment rate.

5.5 Heterogeneity across firms and workers

Generally, nominal wage rigidity is modelled assuming a homogeneous group of agents that have identical wage contracts, but the wage setting is staggered through time. If individual industries or occupations display a substantial degree of heterogeneity in wage setting, *e.g.* differ in the sense that some have time-dependent wage contracts while other contracts are state-dependent, such simple models might omit out important dynamics. In this Section we therefore explore heterogeneity both across workers and firms.

Table 5 reports the monthly frequency and size of wage change, where firms have been divided into five industry subgroups. The frequency of change varies from 9.5% per month for firms in

Table 5: Frequency of Wage Change, Size of Changes and Duration of Wage Spells by Industry

	Mean Frequency			Mean Size		Wage Spell
	Change (%)	Increase (%)	Decrease (%)	Increase (%)	Decrease (%)	Implied Duration (months)
Industrial Production	10.2	9.8	0.4	6.0	4.3	9.3
Construction Industry	10.2	9.7	0.5	5.4	5.1	9.3
Trade and Repair Services	11.1	10.6	0.5	7.0	4.4	8.5
Transport	12.0	11.3	0.7	6.2	5.4	7.8
Financial Services	9.5	9.2	0.3	7.1	4.6	10.0
Weighted average	10.5	10.0	0.5	6.4	4.6	9.0

Notes: All frequencies reported are in percentage per month. The mean size is the mean percentage change per month. The size of decrease is reported in absolute terms. The weighted average is calculated using the industry weights from Statistics' Iceland monthly Wage Index. Implied duration is calculated under the assumption that the hazard rate of wage change is the constant λ and the probability of a wage change is $f = 1 - e^{-\lambda}$. The mean implied duration is therefore $d = -1/\ln(1-f)$, where f is the mean frequency of wage change.

Table 6: Frequency of Wage Change, Size of Changes and Duration of Wage Spells by Occupation

	Mean Frequency			Mean Size		Wage Spell
	Change (%)	Increase (%)	Decrease (%)	Increase (%)	Decrease (%)	Implied Duration (months)
Managers	9.3	8.8	0.5	6.4	6.2	10.2
Specialists	9.6	9.1	0.5	6.9	5.1	9.9
Technicians	10.9	10.4	0.5	6.1	5.3	8.7
Office personnel	10.8	10.3	0.5	6.5	4.5	8.7
Service, sales and support	11.9	11.2	0.7	7.0	4.4	7.9
Craftsmen and production	10.0	9.7	0.3	5.1	4.7	9.5
Blue-collar workers	10.8	10.3	0.5	6.2	4.7	8.7
Weighted average	10.5	10.0	0.5	6.3	5.0	9.0

Notes: All frequencies reported are in percentage per month. The mean size is the mean percentage change per month. The size of decrease is reported in absolute terms. The weighted average is calculated using the occupation weights from Statistics' Iceland monthly Wage Index. The size of decrease is reported in absolute terms. Implied duration is calculated under the assumption that the hazard rate of wage change is the constant λ and the probability of a wage change is $f = 1 - e^{-\lambda}$. The mean implied duration is therefore $d = -1/\ln(1-f)$, where f is the mean frequency of wage change.

financial services to 12.0% in the transport industry. Both increases and decreases are most frequent in transport, where the probability of a wage decrease in a given month is 0.7%, compared to 0.3% in financial services.[18] Furthermore, we find more seasonality in wage changes in the transportation industry, partially explaining the higher frequency of change than is found in other sectors. We calculate the weighted average frequency of change using the weights used by Statistics Iceland to compute the Wage Index, finding a mean weighted frequency of 10.5%. As regards the mean size of change, the size of increase in financial services stands out in magnitude. The recession that began in 2008 hit the financial and construction sectors especially hard. In our data, we find evidence of substantial nominal wage decreases in both construction and financial services in late 2008 and early 2009.

In Table 6, we report the frequency and size of wage change for workers in seven different occupational subgroups. We find relatively limited heterogeneity across occupations. We would expect that salaried workers have more rigid wages than those paid by the hour and that the change is larger when their wages are adjusted. This inference is supported by evidence from our data. The most frequent wage changes are for workers in services with monthly frequency of change of 11.9%, but the most rigid wages are among managers, for whom the probability of wage change in a given month is 9.3%. Wages for workers in service, sales and support are also relatively more flexible downwards, with the monthly frequency of decrease at 0.7%. Specialists are similar to managers in that they are likely to be salaried, have also relatively rigid wages, with a probability of change in a given month of 9.6%. When weighted across occupations, the monthly frequency of change for the sample is 10.5%.

5.6 Wage adjustment by firm size

Is the flexibility in wages variable between firms of different size? Larger firms may have greater ability to apply firm-level wage contracts rather than contracts such as those negotiated by unions. This may result in a higher degree of wage flexibility in large firms, as they can apply more discretionary wage determination processes. Furthermore, the wage structure is often more complicated in larger firms, characterised by various compensation payments and bonuses. Such a wage structure may have a general firm-level effect on base wages where overall wage payments may follow a similar path within the firm. The cost of changing wages may also be *relatively* higher in small firms than in large firms,

[18] It should be noted that the sample period for financial services is January 2004 throughout September 2010, as opposed to January 1998 throughout September 2010 for other industry groups.

as the action of changing wages may involve some fixed cost. As a result, wages will adjust more frequently in large firms than small firms.

Table 7: Frequency and Size of Wage Change by Firm Size

	Mean Frequency			Mean Size		Wage Spell
Number of employees[a]	Change (%)	Increase (%)	Decrease (%)	Increase (%)	Decrease (%)	Implied Duration (months)
10-19	9.0	8.5	0.5	5.9	4.2	10.6
20-49	9.9	9.3	0.6	5.8	4.9	9.5
50-149	10.2	9.6	0.6	6.4	5.4	9.3
$\geq$ 150	10.8	10.3	0.5	6.3	4.7	8.7

Notes: All frequencies reported are in percentage per month. The mean size is the mean percentage change per month. The size of decrease is reported in absolute terms. Implied duration is calculated under the assumption that the hazard rate of wage change is the constant λ and the probability of a wage change is $f = 1 - e^{-\lambda}$. The mean implied duration is therefore $d = -1/\ln(1-f)$, where f is the mean frequency of wage change.

[a] As Statistics Iceland does not include firms in their sample that have less than 10 workers the smallest subgroup strictly includes firms with 10-19 employees.

In an influential study, Bewley (1999) finds that firms are reluctant to cut nominal wages since this is thought to damage workers' morale. He argues as well that productivity hinges on workers' morale. The effect of nominal wage cuts on morale may be thought more important in smaller firms, where the relation between employees and their employers is stronger. This reluctance to cut nominal wages may result in nominal wages being more downwardly rigid, and even more so in smaller firms. This can also lead to wage increases being more compressed, as is emphasised by Elsby (2009), because firms fear costly wage cuts in the future. The argument made in Elsby (2009), together with the fact that workers are more strongly connected to their employers in smaller firms, leads us to expect less frequent wage changes, both increases and decreases, the smaller the firm.

Table 7 reports the frequency of wage change, the size of change, and the implied duration of wage spells for four different size categories. We find strong evidence supporting the hypothesis that wages are more rigid in small firms than large firms.[19] The frequency of change in firms with fewer than 20 employees is 9.0%, compared to 10.8% monthly frequency in firms with 150 employees or more. This evidence is in line with previous research. Both Heckel *et al.* (2008) and Lünnemann and Wintr

[19]Firm size also seems to matter for the frequency of price setting; large firms set prices more often than smaller firms, see Lünnemann and Mathä (2007). Olafsson *et al.* (2011) find that, in Iceland, price reviews are more frequent among larger firms.

(2009) find a substantial difference in the frequency of change between firms of different size, large firms changing wages more frequently. Druant *et al.* (2009) present similar evidence using survey data.

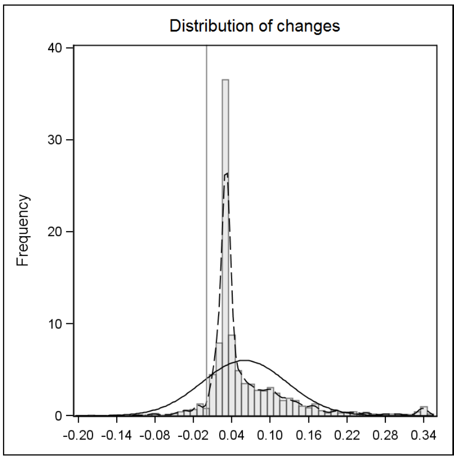
6 Distribution of wage changes

The notion in economics that prices and wages are sticky dates at least back to Keynes (1936). A further notion about this inertia is that nominal wage rigidity is asymmetric; wages are more rigid downwards than upwards. If this is the case, it has important macroeconomic implications, especially for inflation targeting monetary policy, but also for membership in monetary unions. As is argued by Tobin (1972), downward nominal wage rigidity causes unemployment because shocks that lead to a decrease in demand or increased supply raise real wages above marginal product. Tobin (1972) further argued that, because of this property monetary policy makers can "grease the wheels" of the labour market by targeting inflation above zero.

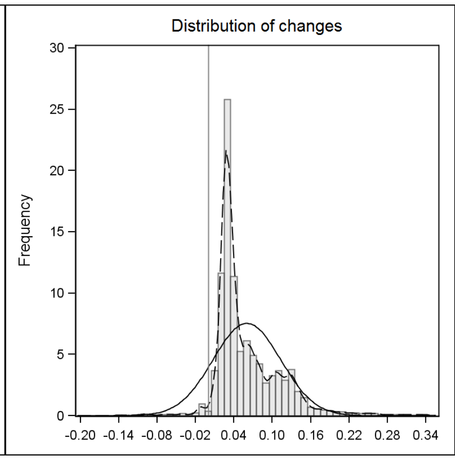
Until recently most of the literature on wage rigidity focused on downward wage rigidity rather than generally on how frequently wages are adjusted.[20] There is however limited agreement in the literature on if and how extensively nominal wages are downwardly rigid. Recently, researchers have used micro data to study distributions of wage changes to provide an empirical answer to these questions (see, for example, Dickens *et al.*, 2007; Holden and Wulfsberg, 2007). Even though the current paper does not intend to answer this question *per se*, we direct our focus at the properties of the distribution of changes in our data. Presumably, nominal wage cuts should be less likely when inflation is high and unemployment low than in periods with low inflation or adverse labour market conditions. Our dataset enables us both to shed light on the asymmetry in the distribution of changes and to make a more general inference about downward nominal wage rigidity at times of different economic conditions.

Figure 5 plots the yearly distribution of the size of wage changes for nine years. Each histogram is constructed using a bin for each percentage point of size change, meaning that the height of each bin shows the fraction of workers with wage changes in that range. We omit both extreme values at either end of the distribution and all zero changes so as to enable a clearer view of the centre of the distribution, but we include a zero spike to give a reference point. In Figure 5, we have also included a fitted normal distribution for the size of wage changes (solid line) and an estimated Kernel density

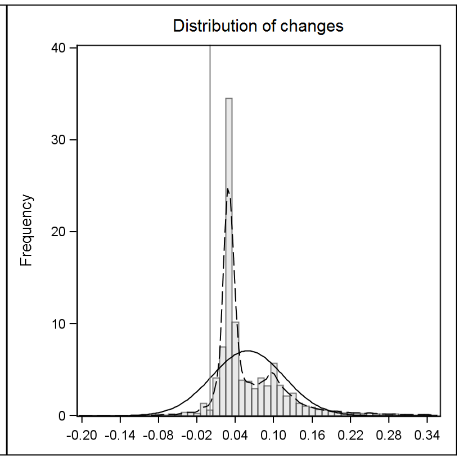
[20]See, for example, McLaughlin (1994), Card and Hyslop (1996), Kahn (1997), Smith (2000), and Nickell and Quintini (2003). See Gottschalk (2005) for a review of the literature.



(a) 2005, mean 6.4%, meadian 3.4%

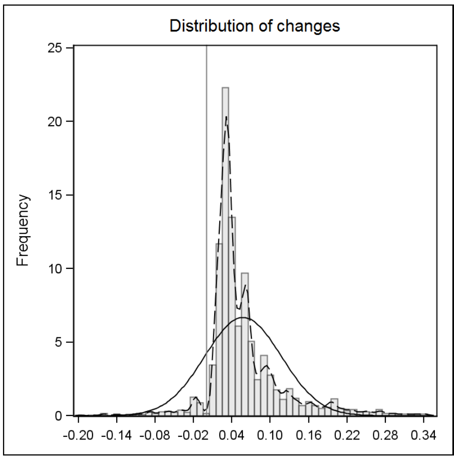


(b) 2006, mean 6.2%, meadian 4.0%

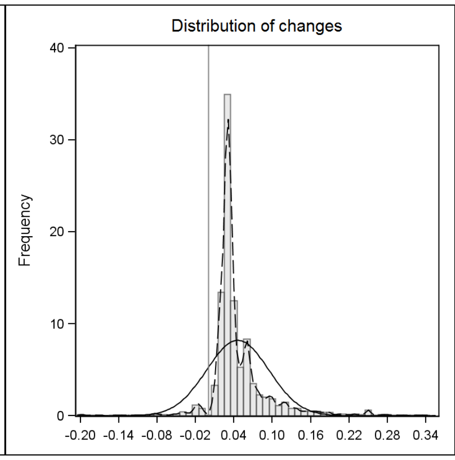


(c) 2007, mean 6.2%, meadian 3.5%

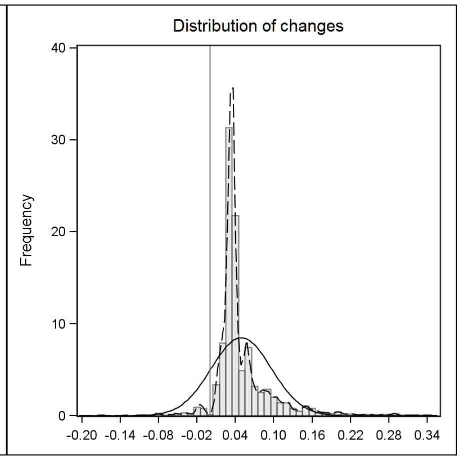
Low Unemployment



(d) 2001, mean 5.9%, meadian 4.0%

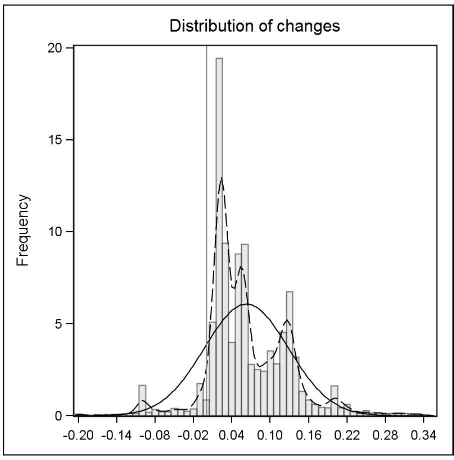


(e) 2002, mean 4.7%, meadian 3.3%

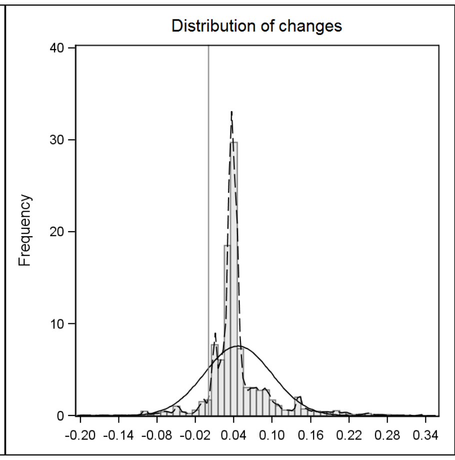


(f) 2003, mean 5.1%, meadian 3.6%

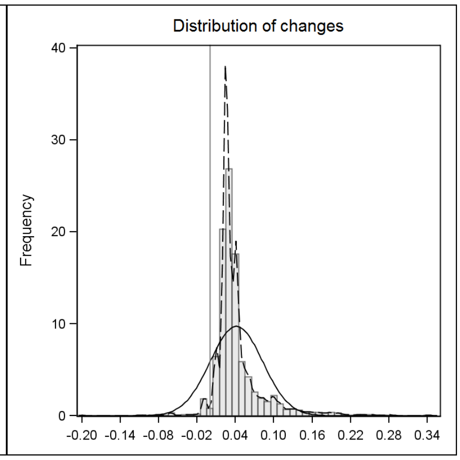
Intermediate Unemployment



(g) 2008, mean 6.4%, meadian 5.2%



(h) 2009, mean 4.7%, meadian 3.7%



(i) 2010, mean 4.2%, meadian 2.9%

High Unemployment

Figure 5: Distributions of Non-Zero Wage Changes

Notes: Histograms of non-zero nominal wage changes, a fitted normal distribution (solid line) and estimated Kernel density (dotted line).

(dotted line). Each row in Figure 5 represents a period of different labour market conditions: low, intermediate and high unemployment.

If downward nominal wage rigidity is present, what properties would characterise the distribution of wage changes? The distribution would be non-normal and highly asymmetric, with only very low or even no density below zero and a large zero-spike. We look for these features in the distributions we plot. What we see first is that there is great variation in the size of changes, even in years with adverse labour market conditions. Secondly, wage changes are not normally distributed and have much more clustering around the median compared to the normal distribution. Third, a considerable share of wages is unchanged over a whole year (a zero spike). And finally, even though wage increases are much more frequent than decreases, there is a positive density below zero in all years plotted. Specifically, wage cuts appear to have been one channel of adjustment in the recession starting in 2008. Illustrated in the histogram for 2008 there is a clear distinct spike at -10% and relatively high density below zero. To summarise, we find that the distributions display some of the features we expect to find under downward nominal rigidity but do not seem to be strictly binding.

7 The hazard of wage change

The economic theory on staggered wage setting implies various different duration profiles of wage spells that depend on whether wage setting is contingent on time, either fixed or random, or the state of the economy. By estimating the conditional probability of wage change – the *hazard rate* – we are able to test the empirical relevance of different theoretical wage setting models, such as those proposed by Taylor (1980) and Calvo (1983). Furthermore, by estimating the hazard function we can evaluate how well different theoretical wage setting models can simulate wage setting in the Icelandic labour market.

In previous sections, we have explicitly assumed a constant hazard of wage change, λ, which is true for the Calvo model. Under this assumption, we were able to report the average duration of wage spells implied by the mean frequency of wage change. We have also reported the distribution of wage spells, finding both that a large share of spells have a lifetime under a year and that a substantial fraction last longer than a year.

A general way of describing wage spells is to express the hazard rate as a function of time, $\lambda(t)$. In discrete time where T is a random variable denoting the duration of a generic wage spell, the hazard function is explicitly defined as:

$$\lambda(t) = Pr[T = t | T \geq t] = \frac{f(t)}{S(t-1)} \tag{5}$$

where $f(.)$ is the probability density function and $S(.)$ is the survival function, describing the lifetime of wage spells. The hazard function therefore describes the probability of a wage change in period t, conditional on survival of a wage spell until the start of period t.

What do wage setting models imply about the shape of the hazard function? If the probability of a wage change increases directly with the duration of a wage spell, the hazard function takes an upward sloping shape. This would indicate that a state-dependent duration model, where the hazard of change increases as wages move farther from a desired level, is an appropriate theoretical description. On the other hand, the Taylor (1980) model gives rise to a hazard function with spikes at the duration of contracts. Specifically, if the labour market is characterised by one-year wage contracts, the hazard function would display a large spike at 12 months. If the timing between wage adjustments is random, as is assumed in the Calvo (1983) model, the hazard of change will not vary and the hazard function is flat. By estimating the hazard function, we can distinguish empirically between these models and the nature of wage setting.

New wage spells begin either at the start of a new employer-employee relationship or directly after a wage change. A common problem in survival analysis is censoring, *i.e.* the length of spells is not known exactly. This can take the form of either right- or left-censoring. In the case of right-censoring, the end of a wage spell has not yet occurred at the end date, while for left-censored spells the start date of spell is not observed. We choose to drop all left- and right-censored spells and estimate the hazard function only for the subset of completed wage spells.

Figure 6 plots the estimated hazard function, described by equation (5), for changes in nominal wages. The hazard function is mostly flat during the first year, with the monthly hazard of change ranging from 10% to 15%. At 12 months, however, a large spike is observed. After the first year the hazard function has smaller spikes at 16, 20, and 24 months. However, after 12 months, the survival probability of a generic wage spell has dropped down to 15%. In light of economic theory, the shape of the estimated hazard function is highly intuitive; the hazard function represents a pattern consistent with fixed-time wage contracts as predicted by the Taylor model. Along with Figure 4, our results indicate that there is a high degree of synchronisation in wage contracts that have a one-year duration

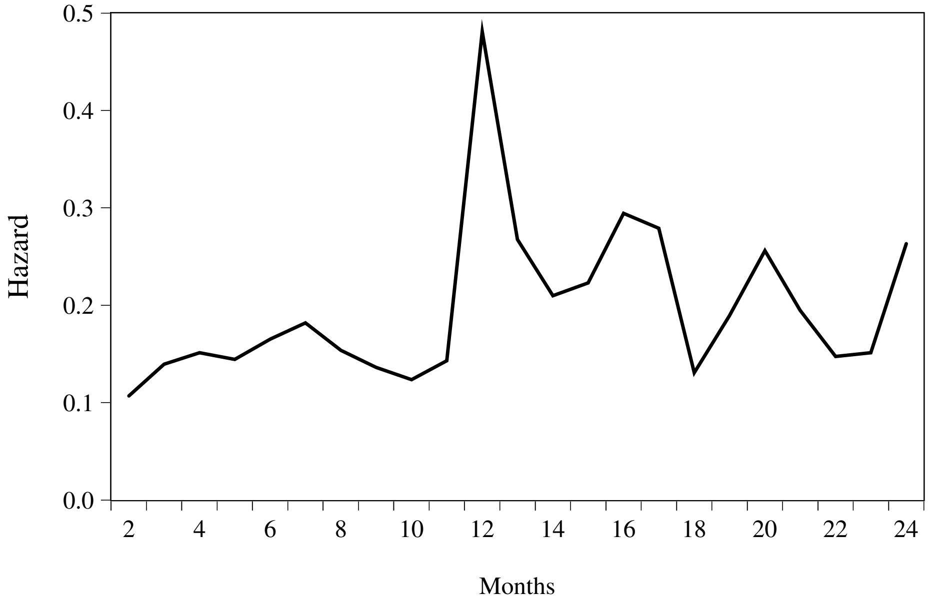


Figure 6: Hazard Function for Wages

and are reset in January. Shorter and longer spells are staggered over the course of the year.

The literature estimating nominal price rigidity, *e.g.* Nakamura and Steinsson (2008), has emphasised that heterogeneity across products must be accounted for. In section 5.5, we found that there is limited heterogeneity in the labour market, across both firms and workers. We estimate separate hazard functions for all industries and occupational subgroups. We find great homogeneity in the shape of all hazard functions estimated, all flat over the first year and displaying a significant twelve-month spike. Furthermore, we find no evidence of upward-sloping hazard functions. One plausible explanation for this homogeneity is the centralisation in wage setting that characterises the Icelandic labour market.

8 Conclusion

In this paper, we present a number of facts about wages and wage adjustment at the microeconomic level. We use a unique dataset at monthly frequency covering wages in the Icelandic labour market over the period from 1998 through 2010. This dataset provides valuable evidence on wage rigidity because of both the quality of the data and the period covered.

The facts we establish are consistent with a model of time-dependent wage contracts of fixed duration. Wage adjustments are infrequent, and most of them are increases. Wage setting is partially synchronised at the beginning of the year but is also staggered over the course of the year. Inflation does not affect wage adjustment, but adverse labour conditions seem to trigger wage decreases. The hazard of wage change illustrates a high concentration of fixed-period wage contracts with yearly wage changes.

Our results may prove helpful both for monetary policy and macroeconomic modelling. New Keynesian models that incorporate both imperfect competition and nominal rigidities in wages and prices must rely on empirical evidence about wages and wage setting. Until recently, information on how frequently wages are adjusted and what factors are important when modelling wage setting has been scarce. The evidence presented here will therefore provide necessary information for distinguishing between alternative wage setting mechanisms for macroeconomic models.

References

[1] Agnarsson, S., A. Hall, T.T. Herbertsson, S. Ingolfsson, G. Magnusson and G. Zoega (1999), "EMU and the Icelandic labour market", Working Paper, Central Bank of Iceland.

[2] Andrason, O.D. (2007), "Sveigjanleiki launa á íslenskum vinnumarkadi ", M.Sc. Dissertation, University of Iceland.

[3] Barattieri, A., S. Basu and P. Gottschalk (2010), "Some Evidence on the Importance of Sticky Wages", NBER Working paper w16130.

[4] Bewley, T.F. (1999), "*Why Wages Dont Fall During a Recession*", Harvard University Press, Cambridge and London.

[5] Bils, M. and P.J. Klenow (2004), "Some Evidence on the Importance of Sticky Prices", *Journal of Political Economy,* vol. 112(5), pp. 947-985.

[6] Blanchard, O.J. and S. Fischer (1989), "*Lectures on Macroeconomics*", The MIT Press, Cambridge and London.

[7] Calvo, G. (1983), "Staggered Prices in a Utility Maximising Framework", *Journal of Monetary Economics,* vol. 12(3), pp. 383-398.

[8] Caplin, A. and D. Spulber (1987), "Menu Costs and the Neutrality of Money", *Quarterly Journal of Economics,* vol. 102(4), pp. 703-725.

[9] Card, D. and Hyslop, D. (1996), "Does inflation "Grease the Wheels of the Labor Market"?", NBER Working Paper No.5538.

[10] Cecchetti, S. (1987), "Indexation and Incomes Policy: A Study of Wage Adjustment in Unionized Manufacturing", *Journal of Labor Economics,* vol. 5(3), pp. 391-412.

[11] Christiano, L. J., M. Eichenbaum and C.L. Evans (2005), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy", *Journal of Political Economy,* vol. 113(1), pp. 1-45.

[12] De Walque, G., M. Krause, S. Millard, J. Jimeno, H. Le Bihan and F. Smets (2010), "Some Macroeconomic and Monetary Policy Implications of New Micro Evidence on Wage Dynamics", *Journal of the European Economic Association*, vol. 8(2-3), pp. 506-513.

[13] Dickens, W., L. Goette, E. Groshen, S. Holden, J. Messina, M. Schweitzer, J. Turunen, and M. Ward-Warmedinger (2008), "How Wages Change: Micro Evidence from the International Wage Flexibility Project", *Journal of Economic Perspectives,* vol. 21(2), pp. 195-214.

[14] Dixon, H. and E. Kara (2011), "Contracts Length Heterogeneity and the Persistence of Monetary Shocks in a Dynamic Generalized Taylor Economy", *European Economic Review,* vol. 55(2), pp. 280-292.

[15] Dotsey, M., R. King and A. Woolman (1999), "State-Dependent Pricing and the General Equilibrium Dynamics of Money and Output", *Quarterly Journal of Economics,* vol. 114(2), pp. 655-690.

[16] Druant, M., S. Fabiani, G. Kezdi, A. Lamo, F. Martins and R. Sabbatini (2009), "How are Firms' Wages and Prices Linked: Survey Evidence in Europe", ECB Working Paper No. 1084.

[17] Elsby, M. (2009), "Evaluating the Economic Significance of Downward Nominal Wage Rigidity", *Journal of Monetary Economics,* vol. 56(2), pp. 154-169.

[18] Erceg, C.J., D.W. Henderson and A.T. Levin (2000), "Optimal Monetary Policy with Staggered Wage and Price Contracts", *Journal of Monetary Economics,* vol. 46(2), pp. 281-313.

[19] Fabiani, S., C. Kwapil, T. Rõõm, K. Galuscak and A. Lamo (2010), "Wage Rigidities and Labour Market Adjustment in Europe", *Journal of the European Economic Association*, vol. 8(2-3), pp. 497-505.

[20] Fisher, S. (1977), "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule", *Journal of Political Economy,* vol. 85(1), pp. 191-205.

[21] Golosov, M. and R.E. Lucas (2007), "Menu Costs and Phillip Curves", *Journal of Political Economy,* vol. 115(2), pp. 171-199.

[22] Gottschalk, P. (2005), "Downward Nominal Wage Flexibility: Real or Measurment Error?", *Review of Economics and Statistics,* vol. 87(3), pp. 556-568.

[23] Gudmundsson, T., T.T. Olafsson, E. Nakamura , J. Steinsson and K. Vignisdottir (2011), "Price Adjustment and Inflation: Micro Evidence from Iceland", Working Paper, Central Bank of Iceland, Forthcoming.

[24] Heckel, T., H. Le Bihan and J. Montornés (2008), "Sticky Wages: Evidence from Quarterly Microeconomic Data", ECB Working Paper No. 893

[25] Holden, S. and F. Wulfsberg (2008), "Downward Nominal Wage Rigidity in the OECD", *The B.E. Journal of Macroeconomics*, vol. 8(1) (Advances), Article 15.

[26] Jonsson, A. and S. Johannesson (2002), "Sveigjanleiki á vinnumarkadi og upptaka evrunnar", Report, Confederation of Icelandic Employers.

[27] Kahn, S. (1997), "Evidence of Nominal Wage Stickyness from Microdata", *American Economic Review,* vol. 87(5), pp. 993-1008.

[28] Keynes, J.M. (1936), *The General Theory of Employment, Interest and Money,* MacMillan, London.

[29] Klenow, P.J. and B.A. Malin (2010), "Microeconomic Evidence on Price-Setting", in Friedman, B. and M. Woodford (ed.) *Handbook of Monetary Economics*, vol. 3, pp. 231-284.

[30] Klenow, P.J. and O. Kryvtsov (2008), "State-Dependent or Time-Dependent Pricing: Does it Matter for Recent U.S. Inflation", *Quarterly Journal of Economics,* vol. 123(3), pp. 863-904.

[31] Lünnemann, P. and T. Mathä (2007), "A Comparison Based on International Survey Evidence", in Fabiani, S., C. Loupias, F. Martins and R. Sabbatini (ed.) "*Pricing Decisions in the Euro Area,*" Oxford University Press, Oxford.

[32] Lünnemann, P. and L. Wintr (2009), "Wages are Flexible, Arent't They? Evidence from Monthly Mirco Wage Data", ECB Working Paper No. 1074.

[33] McLaughlin, K.J. (1994), "Rigid Wages?", *Journal of Monetary Economics,* vol. 34(3), pp. 383-414.

[34] Nakamura, E., and J. Steinsson (2008), "Five Facts about Prices: A Reevaluation of Menu Cost Models", *Quarterly Journal of Economics,* vol. 123(4), pp. 1415-1464.

[35] Nickell, S. and G. Quintini (2003), "Nominal Wage Rigidity and the Rate of Inflation", *The Economic Journal,* vol. 113, pp. 762-781.

[36] Olafsson, T.T, Vignisdottir, K.A. and Petursdottir, A.O. (2011), "Price Setting in Turbulent Times: Survey Evidence from Icelandic Firms", Central Bank of Iceland *Working Paper* No. 54.

[37] Olivei, G. and S. Tenreyro (2007), "The Timing of Monetary Policy Shocks", *American Economic Review,* vol. 97(3), pp. 636-663.

[38] Petursson, T.G. (1998), "Price Determination and Rational Expectations", *International Journal of Finance and Economics,* vol. 3, pp. 157-167.

[39] Rotemberg, J.J. (1982), "Sticky Prices in the United States", *Journal of Political Economy,* vol. 90(6), pp. 1187-1211.

[40] Sigurdsson, J. (2011), "Unemployment Dynamics and Cyclical Fluctuations in the Icelandic Labour Market", Central Bank of Iceland *Working Paper*, Forthcoming.

[41] Smith, J.C. (2000), "Nominal Wage Rigidity in the United Kingdom", *The Economic Journal,* vol. 116, pp. 176-195.

[42] Taylor, J. (1980), "Aggregate Dynamics and Staggered Contracts", *Journal of Political Economy,* vol. 88, pp. 1-22.

[43] Taylor, J. (1983), "Union Wage Settlements During Disinflation", *American Economic Review,* vol. 73(5), pp. 981-993.

[44] Taylor, J. (1999), "Staggered Price and Wage Setting in Macroeconomics" in J. Taylor and M. Woodfords (eds), *Handbook of Macroeconomics,* vol. I.

[45] Tobin, J. (1972), "Inflation and Unemployment", *American Economic Review,* vol. 62(1), pp. 1-18.

[46] Zoega, G. and T. Karlsson (2006), "Does Wage Compression Explain Rigid Money Wages?", *Economic Letters,* vol. 93(1), pp. 111-115.