Do Minimum Wages Make Wages More Rigid? Evidence from French Micro Data

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Abstract

How do minimum wages (MW) shape the aggregate wage dynamics? In this paper, we document new empirical findings on the effects of MW on wage rigidity using quarterly micro wage data matched with sector- and job-specific bargained MW. First, both national and sectoral MW have a large effect on the timing and on the size of wage adjustments. At the aggregate level, MW contribute to amplify, by a factor of 1.7, the response of wages to past inflation but they also delay by about one year the transmission of shocks to aggregate wages. The aggregate elasticities of wages with respect to past inflation, the national MW and industry-level MW are respectively 0.42, 0.17 and 0.16. Finally, we document significant spillover effects of the NMW on higher wages transiting through industry-level MW.

JEL codes: E24, E52, J31, J50
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1 Introduction

The degree of wage flexibility shapes how economic shocks might generate macroeconomic fluctuations in employment. In standard New-Keynesian macroeconomic models, infrequent wage adjustment is a key assumption to explain why monetary policy shocks might have real effects (Erceg et al. [2000] and Smets and Wouters [2003]). Christiano et al. [2005] show that wage stickiness is even more important than price rigidity to explain the dynamic responses of real macro variables after a monetary policy shock. However, the empirical literature has much more focused on measuring price rigidity than wage rigidity and only a rather small number of recent papers have provided micro evidence on wage rigidity (Taylor [2016]). Besides, contrary to the United States, most workers in Europe are covered by collective wage agreements which define industry- and job-specific wage floors. Wage rigidity might thus come from the way these minimum wages adjust and then affect individual wages.[1] In addition, in many European countries, minimum wages are set at different levels (national, industry, firm) possibly interacting with each other, which might reinforce wage rigidity. However, empirical evidence on how minimum wage policies affect the degree of wage rigidity is very scarce. This paper aims at filling this gap and provides new empirical evidence on how minimum wage policies shape the aggregate wage dynamics.

One important empirical challenge to measure implications of minimum wages for wage rigidity is to link, at the micro level, wage trajectories and sectoral minimum wages. We here use a large data set of micro wages collected by the French Ministry of Labour to compute the official aggregate base wage index. These data are available at a quarterly frequency over the period 2005Q4 - 2015Q4. We match this data set with quarterly data on sectoral wage floors. For that, we have collected a data set on collectively bargained minimum wages for more than 350 industries covering almost all workers in the private

[1] Díez-Catalán and Villanueva [2014], Martins [2014], and Guimaraes et al. [2017] describe how the existence of sectoral wage floors affect employment in Portugal and Spain. See also Magruder [2012] for similar evidence in South Africa.

sector. We also match our sample of data with qualitative information on firm-level wage agreements. Using this data set, we first document new stylised facts on wage and minimum wage adjustments. First, both wages and minimum wages are quite rigid since on average they both adjust once a year. Second, actual wages and minimum wages usually adjust at the beginning of the year and minimum wage policies seem to lead the timetable of wage adjustments. Finally, there is a strong correltation between the average size of actual wage adjustments and the size of minimum wage adjustments.

These observations motivate our quantitative analysis. We first estimate a standard microeconometric wage rigidity model where the timing and the size of wage adjustments depend on inflation or unemployment but also on national or sectoral wage floors. We then show that the aggregate response of wages to a given shock cannot be easily derived from parameter estimates of this micro wage rigidity model for at least two reasons. First, in this set-up, since wages are rigid at the micro level, a shock has long-lasting effects on the aggregate wage dynamics. Second, the transmission of a shock to wages is complicated by the multi-level wage-setting system. In this set-up, the shock can also affect minimum wages which then affect individual wages, leading to potential second round effects of the initial shock on workers' wages. One novelty of this paper is that we here simulations of wages and minimum wages (using parameter estimates of our micro models) and we then aggregate all these simulations to investigate how wages respond to a macro shock. This simulation exercize allows us: (i) to assess the aggregate persistence in wages due to micro wage rigidity; (ii) to investigate how minimum wages shape but also amplify the transmission of a shock to aggregate wages.

We document three new sets of empirical findings. First, we show that micro wage stickiness translates into a delayed aggregate wage response to a shock: for instance, a 1% increase in inflation will take a little less than 4 years to be fully incorporated into wages. Moreover, we find that state-dependent factors modify significantly the aggregate dynamics response to a shock compared to a set-up where the frequency of wage adjustment is assumed to be exogeneous. Second, we estimate long-run direct effects of the main drivers of aggregate wages. A 1% increase in inflation has a long-term direct effect of +0.24 pp on aggregate wage increase whereas unemployment has only a small negative effect. One novelty of the paper is also to estimate the direct effects of minimum wages on the aggregate wage dynamics. We find that 1% increase in NMW or sectoral wage floors have a long-run impact of respectively 0.13 pp and 0.16 pp, more than half the effect of inflation. Finally, we show that minimum wages do amplify the effect of inflation on aggregate wages. Once we allow NMW and sectoral minimum wages to react to shocks, the overall effect of inflation on aggregate wages raises to 0.42 pp and the effect of NMW to 0.17 pp. Besides, we show that the multi-level system of wage setting contributes to slow the adjustment of aggregate wages by about one year.

Our paper is a contribution to the empirical literature documenting patterns of nominal wage rigidity. The very first papers calibrating the degree of wage rigidity used wage agreement data for the United States and Canada (Christofides and Wilton [1983], Taylor [1983], Cecchetti [1987], Christofides and Stengos [2003]), or Sweden (Fregert and Jonung [1998]) (see also Avouyi-Dovi et al. [2013] and Fougère et al. [2018] for recent evidence in France). On the other hand, a recent growing literature has documented new facts on wage rigidity using administrative sources of wage data (Barattieri et al. [2014] or Grigsby et al. [2018] for the United States, Le Bihan et al. [2012] for France, Sigurdsson and Sigurdardottir [2016] for Iceland or Lunneman and Wintr [2015] for Luxemburg). Our first contribution is here to fill the gap between these two types of literature by relating infrequent wage adjustments to the way minimum wages are modified in collective wage agreements. Moreover, the wage rigidity literature usually investigates the main drivers of wage adjustments by estimating wage rigidity microeconometric models (see Le Bihan et al. [2012] for instance). In this paper, we go a step further: we use simulation exercizes to derive implications of micro wage rigidity for the aggregate wage dynamics. To our knowledge, this is the first attempt to derive empirically the aggregate wage response to shocks from estimates of a micro wage rigidity model. Moreover, using these simulation exercizes, we are also able to identify quite precisely how national or sectoral minimum wages contribute to shape the aggregate wage dynamics in response to a shock.

We also contribute to the empirical literature assessing the pass-through of minimum wages to other wages. Several empirical studies find that the NMW affects not only wages close to the NMW but have also spillover effects to higher wages (see for instance Grossman [1983], Card and Krueger [1995], Dickens and Manning [2004], Neumark et al. [2004], and Autor et al. [2016], or Givord et al. [2016] in France). In France, sectoral minimum wages set by industry-level agreements can be a relevant channel through which the NMW can affect higher wages. In France, as in most European countries, every industry defines wage floors for representative occupations and wage floors cannot be set below the NMW. Thus, when the NMW adjusts, industries have to update thousands of industry-level wage floors to keep wage floors above the NMW. In addition, the NMW increase is considered as the fair value for sectoral minimum wage negotiations or the norm and might be transmitted to the whole scale of wage floors.[2] Then, wage floors affect individual wages and are a possible channel of NMW spillover to higher wages (see Dittrich et al. [2014] for experimental evidence). Our contribution is here to quantify the empirical relevance of sectoral wage agreements as a channel for spillover effects of NMW to higher wages. Doing so, we also better identify NMW pass-through to other wages.

The rest of the paper is organized as follows. In Section 2, we set up a wage rigidity model at the micro level where wages depend on minimum wages and derive some implications for the aggregate wage persistence. Section 3 presents our micro data sets and documents some stylised facts on wage rigidity and minimum wages. Section 4 presents our microeconometric model and estimation results. In Section 5, we describe our simulation exercize and document how aggregate wages respond to shocks. Section

[2]For instance, Falk et al. [2006] show that the introduction of a minimum wage can increase reservation wages (even if the minimum wage is not binding) because the minimum wage affects the workers perception of a fair wage offer. Similarly, Knell and Stiglbauer [2012] show that sectoral minimum wages play an important role as norms for individual wages.

6 concludes.

2 A Model of Infrequent Wage Changes with Minimum Wages

In this section, we first set up a quite general model of staggered wage adjustment at the micro level to examine aggregate implications for the wage persistence. Then, we allow the wage adjustment process to depend on minimum wage changes and describe possible consequences for the adjustment of aggregate wages to shocks.

2.1 A Simple Model of Wage Rigidity

Most macro models assume that wages do not adjust at every period, this can be rationalized by different theoretical models. Taylor [1980] and Calvo [1983] assume that wages remain constant for a certain period of time whereas state-dependent models assume that wages can not adjust continuously because wage changes entail some negotiation costs, costs of performance appraisal, or administrative costs of payrolls for instance (Kahn [1997] and Fehr and Goette [2005]). In all these models, when wages do not adjust, there is a gap between the wage that would have been observed in absence of any friction (w_{it}^*) and the actual wage (w_{it}) whereas when wages adjust, the new wage w_{it} is equal to w_{it}^*. Overall, we can write:

$$w_{i,t} = R_{i,t} w_{i,t}^* + (1 - R_{i,t})\, w_{i,t-1} \tag{1}$$

where $R_{i,t}$ is a dummy variable equal to 1 in case of wage update and 0 otherwise. By recurrence, it comes that $w_{it-1} = w_{i,\tau_{it}}^*$, τ_{it} being the last time the wage of worker i was adjusted (i.e. $\tau_{it} = \max_s [s < t, R_{is} = 1]$). Hence, we have:

$$w_{it} - w_{it-1} = R_{it}\left(w_{it}^* - w_{i\tau_{it}}^*\right) \tag{2}$$

The occurrence of a wage update R_{it} is a Bernoulli variable and the probability of wage change P_{it} can then be written as:

$$P_{it} = P\left(R_{it} = 1\right) = P\left(R^*_{it} > 0\right) \tag{3}$$

where R^*_{it} is the propensity to update wages and depends on $\left(w^*_{it} - w^*_{i\tau_{it}}\right)$ the cumulated change in the frictionless wage since the last wage adjustment but also on the elapsed duration since the last wage adjustment. This model allows us to encompass predictions of both time- and state-dependent wage rigidity models. In a typical Taylor model, the probability of wage adjustment will only depend on the elapsed duration whereas in the adjustment cost model, this probability depends on $\left(w^*_{it} - w^*_{i\tau_{it}}\right)$. Finally, in a Calvo model, the probability of wage change is constant.[3]

In this wage rigidity model, a shock on a variable affecting the frictionless wage will not be transmitted instantaneously to individual wages. At the date of the shock t_0, only wages that adjust will incorporate the shock. However, after t_0, wages that have not yet adjusted will keep track of this shock through $\left(w^*_{it} - w^*_{i\tau_{it}}\right)$ (i.e. the cumulative change in frictionless wage since the last wage adjustment). Thus, they will incorporate the shock later, when they can adjust. Similarly, a shock will affect the probability of wage change at the date of the shock but also later as far as this probability depends on w^*_{it}.

2.2 Implications for the Aggregate Wage Dynamics

From this simple micro wage rigidity model, we can now derive implications for the aggregate wage dynamics. Let us denote W_t the aggregate wage at date t, computed as a simple average of all individual wages. The aggregate wage change (between date t and

[3] This set-up is very similar to the one proposed in Le Bihan et al. [2012] or Sigurdsson and Sigurdardottir [2016].

$t-1$) can be written in expectation as:

$$E(\Delta W_t) = E(w_{it} - w_{it-1}) = E(R_{it}(w_{it}^* - w_{i\tau}^*)) \quad (4)$$

$$= \sum_{\tau=-\infty}^{t-1} \pi_{t,\tau} p_{t,\tau} E(w_{it}^* - w_{i\tau}^* | R_{it} = 1, \tau_{it} = \tau) \quad (5)$$

where $p_{t,\tau} = P(R_{it} = 1 | \tau_{it} = \tau)$ is the probability of a wage update at date t given the date of the last wage update equal to τ and $\pi_{t,\tau} = P(\tau_{it} = \tau)$ is the distribution across workers of the dates of last wage changes before date t. This distribution results from the past probability of wage updates and can be derived by recurrence:

$$\pi_{t+1,\tau} = \pi_{t,\tau}(1 - p_{t,\tau}), \; \tau < t$$

$$\pi_{t+1,t} = \sum_{\tau=-\infty}^{t-1} \pi_{t,\tau} p_{t,\tau}$$

How do aggregate wages respond to a macro shock in this set-up? A shock S affecting the frictionless wage at date t_0 will take time to be incorporated to aggregate wages since a proportion of wages cannot adjust immediately to the shock, leading to persistence in aggregate wages. In equation (5), the shock will affect the probability of wage change at t_0 but also later (and so the distribution of dates of last wage adjustments before date t) and the size of wage changes.

We can easily show that if the shock does not affect the probability of wage change (like in a Calvo or a model), the aggregate response to a shock will only come from the response of the size of wage adjustment (third term in equation 5). The duration before a full transmission to aggregate wages will fully depend on the exogenous distribution of dates since the last adjustment and the probability of a wage adjustment. In a menu-cost model, the shock will also modify the probability of adjustment (and so the distribution of dates since the last wage adjustment) (the term $\pi_{t,\tau} p_{t,\tau}$ in equation 5). A shock affecting positively the probability of wage change will make wage changes more frequent, leading to a quicker aggregate wage adjustment. Wage changes will become more frequent but also possibly of smaller size.[4]

2.3 How Do Minimum Wages Affect the Aggregate Wage Dynamics?

In France as in many European countries, workers' wages depend on minimum wages set either at the national level or at the industry level. The existence of minimum wages can modify the response of wages to shocks for at least two reasons. First, minimum wage adjustments might be affected by the same macro shocks as the ones hitting individual wages (like unemployment, inflation...). Thus, minimum wages can be an additional channel through which macro shocks affect individual wages and they might amplify the wage response to a shock. Second, because of negotiation costs, minimum wage adjustments are infrequent, meaning that a shock affecting minimum wages will take some time to be transmitted to minimum wages and much more time to be transmitted to individual wages. This would add some delays in the reaction of wages to a given shock.

However, the overall effect of the shock on the aggregate wage change will be a non-trivial composition of the direct response of individual wages and the indirect responses of individual wages transiting through minimum wages. The aggregate implications of the existence of minimum wages is thus hard to derive analytically. As a simple illustration and to give intuition behind the aggregate dynamics in this case, we here present some calibrations of a simple model where wages and minimum wages adjust infrequently and wages depend on minimum wages, we also assume that a shock can affect both minimum

[4] To illustrate these predictions, we report in the Appendix A some calibrations of a very stylised model of wage rigidity similar to the one presented above. Figure A in this Appendix plots aggregate response to a shock affecting either the probability of wage adjustment or the frictionless wage w^*. When the shock plays a more important role in the probability, the speed of adjustment increases whereas when it does not affect the probability, the speed of adjustment is much slower. When the shock affects the firctionless wage, this only affects the long term effect of the shock and not the speed of adjustment.

wages and actual wages (Appendix A for a full description). Figure 1 plots the impulse response functions of aggregate wages where we allow the shock to affect MW through the probability of MW adjustment (top panel) or through the frictionless MW (bottom panel). When the shock affects the probability of MW adjustment, the aggregate wage response is different from the one obtained from a model where there is no MW (red line): it first accelerates the transmission of the shock but it also takes more time to converge to the long run effect. This long-run effect is a little higher since now the MW enters the frictionless wage. When the importance of the shock in the frictionless MW varies, the long-run effects of the shock will vary accordingly since it increases the role played by second-round effects transiting through MW. However, the dynamics is only little modified.

In the rest of the paper, we will use micro data on wages and minimum wages to first estimate the main determinants of infrequent wage and minimum wage adjustments. Then, using micro estimates from these models, we will aggregate micro simulations of individual wage trajectories to assess the aggregate wage effects of shocks when we allow or not minimum wages to respond to these shocks.

3 Data

In this study, we use three quarterly data sets containing individual wages, sectoral wage floors set in industry-level wage agreements and information on collective wage agreements at the firm level.

3.1 Wages

Our first data set consist of individual wages collected in the ACEMO survey at a quarterly frequency over the period 2005Q1-2015Q4.[5] This survey is carried out by the Min-

[5]Individual data of this survey over the period 1998Q4-2005Q4 have also been used by Le Bihan et al. [2012].

istry of Labour to compute the aggregate growth of base wages for the French economy. Every quarter, data are collected in about 40,000 different firms with at least ten employees (in the private non-farm market sector); firms are sampled to be representative of the French economy. The survey collects individual monthly base wages, excluding bonuses, allowances, performance-related compensations or overtime payments. Base wages represent about 85% of total labour earnings (Sanchez [2014]). In a given firm, wage data are collected for workers who hold representative job positions within the firm: at first, depending on their size, firms define 1 to 12 different representative job positions (3 different occupations in 4 broad job categories: blue-collar workers, white-collar workers, technicians and managers); then, every quarter, firms report individual base wages for all these representative occupations. Using this data set, we are able to track individual wage trajectories for representative occupations within firms and so, we can compute base wage changes at a quarterly frequency for a worker with a given occupation in a given firm. By construction, we focus on wage dynamics of job insiders and we cannot track wage adjustments due to job mobility. However, the effects of collective wage agreements on the wage dynamics might be concentrated on insiders' wages.[6]

Table 1 documents stylised facts on wage changes. First, the average wage change (q-o-q) is about 0.5%. Every quarter, 27% of base wages adjust (which implies an average duration between two wage changes of about one year)[7] and the average non-zero wage change is 1.8%. Figure 2 plots the average wage growth (q-o-q), the frequency of wage changes and the average non-zero size of wage changes over time. The main time variations of the average wage growth come from strong seasonal movements. Quarterly wage growth is much higher on the first quarter (0.9% on average versus less than 0.5% for the other quarters (Table 1)). This strong seasonality comes mainly from the seasonality of

[6]See Appendix B for a discussion on measurement issues and details on data treatment.

[7]By comparison, using the same French survey data, Le Bihan et al. [2012] obtain a much higher frequency of 38% but their data set cover the period of workweek reduction which implied a lot of wage changes. For the US, Barattieri et al. [2014] and Grigsby et al. [2018] find quarterly frequencies of wage change between 20 and 25% whereas for Iceland, Sigurdsson and Sigurdardottir [2016] document a monthly frequency of 13% and a typical wage duration of 7 months.

the frequency of wage adjustments: 45% of all wages adjust in the first quarter versus only 20% on average in the other quarters. Moreover, the distribution of durations between two wage changes shows a large peak at durations exactly equal to one year (Figure D in Appendix C). The seasonality in the size of non-zero wage changes is much weaker and is mainly due to the fact that wage changes in the first quarter are associated with longer wage durations.[8] Over a longer horizon, we also find that wage growth was much weaker in 2010 and during the low inflation period (2013-2015). When looking at the cross section distribution of wage changes (Figure 3), we first find a very small proportion of negative wage changes (about 2% of all non-zero wage changes and less than 0.5% of all wage changes) but we also find that about two thirds of all non-zero wage changes are between 0 and 2%.[9]

3.2 Collective Bargaining and Minimum Wages

In France, as in many European countries, different levels of wage regulation coexist. At the national level, a binding and uniform National Minimum Wage (NMW, in French SMIC for *Salaire Minimum Interprofessionnel de Croissance*) is set by the Ministry of Labour and its value is updated once a year (in January since 2010) following a legal rule (see below). The NMW is binding for all workers but only 10 to 15% of workers are directly concerned by NMW increases. At the industry level, collective agreements define sector- and job-specific minimum wages which should be higher than the NMW. At the firm level, unions and firms can negotiate on collective wage agreements but wages cannot be set below sectoral minimum wages or the NMW. We match our sample of individual wage data with information on sectoral minimum wages and on firm-level

[8]Tables A and B in Appendix C provide additional results on the heterogeneity of wage adjustments by firm size and wage level. Wage changes are a little more frequent but smaller in large firms compared to small firms whereas wages changes are less frequent but larger at the top of the wage distribution compared to wages close to the NMW.

[9]Figure C in Appendix C plots the distribution of wage changes when inflation is close 2% and when inflation is much below. The distribution shifts to the left and is much less dispersed when inflation is low.

wage agreements (see Appendix B for details on the matching procedure).

Our first data source on collective bargaining consists of industry-level minimum wages over the period 2005-2015.[10] At the industry level, collective wage agreements define wage floors for several representative occupations within the industry. Every industry defines a specific classification of jobs using criteria such as worker skills, job requirements, or experience. All workers within an industry are then assigned to one position of the job classification and their wage cannot be set below the wage floor associated to their job position. A new wage agreement sets updated values for wage floors. By law, industries must open negotiations on wages every year but have no obligation to reach an agreement. In absence of any new agreement, wage floors remain unchanged until the next agreement and there is no explicit contract duration.[11] Besides, industry-level wage agreements are automatically and quickly extended by decision of the Ministry of Labor to all workers covered by the industry and firms cannot opt out from these wage agreements. We have here collected wage floors contained in more than 3,000 wage agreements covering more than 360 bargaining industries (i.e. about 90% of wage observations collected by the ACEMO survey). The main variables are the following: the identifier of the industry, the date at which the agreement comes into force, the scale of wage floors for all representative occupations and a broad category for job occupations (blue-collar workers, employees, technicians, managers). Wage floors can be defined as hourly, monthly, or yearly base wages (in euros), bonuses and other fringe benefits are excluded. Their definition is very close to the one used to define base wages in the ACEMO survey. Using this data set, we track wage floor trajectories for typical job occupations in a given industry and we calculate the growth rate of wage floors between two wage agreements.

Our second data source on collective bargaining is an administrative data set containing comprehensive information on firm-level agreements. At the firm level, employers and

[10]This data set is described in full details in Fougère et al. [2018].

[11]If some wage floors are below the NMW, in particular because of delays in reaching a new agreement in a given industry, the NMW applies.

unions must also open wage negotiation at least once a year[12] but there is no obligation to reach an agreement. In most firm-level wage agreements, unions and employers bargain on wage increases that can be the same for all workers or different from a job category to another. On average, the share of workers covered by firm-level wage agreements is between 15% and 20% of the total labour force and this proportion has been rather stable for several years (Avouyi-Dovi et al. [2013]). By law, French firms must report to the Ministry of Labour all collective agreements. Information contained in these agreements is standardized by the Ministry of Labour to build a longitudinal firm-level research data set. Available variables include for each agreement: a firm identifier, the date and the main topics of the agreement. Firm-level agreements cover a wide range of topics including wages, bonuses, employment, hours, union rights, labour conditions, on-the-job training... We here restrict the data set to firm-level agreements that deal with wage policy.[13] Wages are the most frequent topic of firm-level agreements (about 70% of all firm-level agreements deal with wages and bonuses, Carluccio et al. [2015]). Information on the size of the negotiated wage increase or on categories of workers covered by the agreement is not available. We here use a dummy variable equal to one if a firm-level wage agreement is signed in a given quarter.

Overall, our estimation sample contains about 2 millions of individual wage observations for more than 45,000 different firms. The simple aggregation of all individual wage changes of our sample turns out to be very close to the aggregate growth of base wage published by the Ministry of Labour (Figure B in Appendix C). Some small differences are observed in the beginning of the sample period where the number of observations in our sample is smaller.[14]

Two main stylized facts emerge when relating wage agreements to the wage dynamics.

[12]This obligation is enforced only for firms with a union representative (i.e. firms with at least 50 employees).

[13]We cannot distinguish agreements dealing with annual base wage increase and agreements dealing with bonuses or performance-related compensations.

[14]Besides, our weighting scheme is not exactly the same as the one used by the Ministry of Labour, which can partly explain deviations between the two series.

First, there is a strong common seasonality between NMW updates, increases in sectoral MW, the frequency of firm-level agreements and the aggregate wage growth (Figure 4): they all usually increase in the first quarter of the year (Table 1) and to a lesser extent in the second quarter for firm-level agreements. This might suggest that wage agreements are at least partly driving the timetable of actual wage changes.[15] The second main fact is the strong similarities between the distribution of wage changes and the distribution of sectoral minimum wage changes (Figure 3). Besides, the average wage change is much larger when there is a wage agreement: the average wage change is 0.3% when there is no wage agreement, 0.7% if there is either an industry-level or a firm-level agreement and 1.1% if there are both a firm- and an industry-level agreements (Table 2). Wage changes are both more frequent and larger when there is a wage agreement either at the industry- or firm-level.[16]

4 Empirical Micro Model of Wage Rigidity and the Aggregate Wage Dynamics

In this section, we present our empirical strategy to investigate aggregate wage response to shocks when individual wages are sticky. We first present the estimates of the micro empirical wage rigidity model which then will be used as as data generating processes to simulate micro wage trajectories. These trajectories will then be aggregated to derive the macro wage dynamics.

[15] Moreover, the distribution of durations between two wage changes (Figure D in Appendix C) also shows that wage durations of exactly one year are much more frequent when there is a wage agreement at the same time.

[16] In presence of a sectoral wage agreements or a firm-level wage agreement, the whole distribution of wage changes shifts to the right (Figure E in Appendix C)

4.1 Empirical Model of Wage Rigidity

Our empirical model can be easily derived from the model presented in section 2.1. We estimate determinants of a joint process of wage adjustment: first, the decision to change wages R and second, the size of wage adjustment conditional on observing a wage change ΔW. For a given worker j in firm i at date t, the model can then written as follows:

$$\text{If } R^*_{ijt} \leq 0 \text{ then } R_{ijt} = 0 \text{ and } \Delta_{(t,\tau_{ij})}W = 0$$
$$\text{If } R^*_{ijt} \geq 0 \text{ then } R_{ijt} = 1 \text{ and } \Delta_{(t,\tau_{ij})}W = \Delta_{(t,\tau_{ij})}W^*$$

where $\Delta_{(t,\tau_{ij})}$ is the log difference operator between date t and the date of the last wage change τ_{ij}, R^*_{ijt} is the propensity to adjust wages and ΔW^*_{ijt} the frictionless wage adjustment. The use of cumulative variables can be justified by predictions of state-dependent models of wage rigidity (see for instance Le Bihan et al. [2012] or Sigurdsson and Sigurdardottir [2016]). Our empirical model is a type II Tobit model. The first equation of the model is a Probit model for the decision of wage adjustment R where R^* depends on the cumulative change in explanatory variables between date t and the date of the last wage adjustment τ_{ij}, as follows:

$$R^*_{ijt} = \beta\Delta_{(t,\tau_{ij})}X + \sum_{d=1}^{\infty}\gamma_d d_{ijt} + \mu_{ij} + \lambda_t + \epsilon_{ijt}$$

where X include the French headline CPI, the nominal NMW, the industry- and job-specific wage floor, a dummy variable equal to one if a firm-level wage agreement has been signed in a firm j since the last wage change, and the local unemployment rate. $d_{ijt} = t - \tau_{ij}$ are duration dummies controlling for Taylor contracts and λ_t are quarter dummies capturing the seasonality of wage adjustments.[17] We also include firm and worker controls μ_{ij} like dummy variables for the size class and sector of the firm, and dummy variables for the wage position in the wage distribution (by deciles). Our second

[17]We also run different robustness specifications where λ_t are date dummies or quarter dummies in interaction with a post 2010 dummy (since the usual quarter of NMW adjustment was modified in 2010 (from Q3 to Q1)). We also run a specification where we do not include any quarter dummies

equation relates non-zero wage adjustment to some similar determinants:

$$\Delta_{(t,\tau_{ij})}W = b\Delta_{(t,\tau_{ij})}X + cMR_{ijt} + v_{ij} + u_{ijt}$$

where MR_{ijt} is the Mills ratio, X are the same variables as in the Probit equation and v_{ij} are the same worker and firm controls. We here assume that duration and quarter-specific dummies do not affect the size of wage adjustment but only the wage change decision.[18]

The Tobit model is estimated using a two-step Heckman estimation procedure. Standard errors are obtained using pair cluster (firm) bootstrap simulations.[19] Two identification issues should be addressed. First, we here use macro variables like CPI or NMW that might lack of individual variability. By using cumulated changes in macro variables since the last wage adjustment, we here expand the support of the distribution of changes in macro variables. Cumulated variations are now specific to each individual, which should help us to identify the effect of macro variables.[20] Second, the identification of the Tobit parameters comes from the assumption that the duration and quarter dummies have no direct effect on the size of the wage changes besides the impact of cumulated macro variables introduced in the model. We argue that these two sets of variables correspond to calendar or seasonal effects (related to negotiation costs or legal constraints), independent of the decision about the size of wage adjustments. These variables would capture predictions of the Taylor wage contracts model.

[18]We still control for elapsed duration by introducing duration as a linear trend (and interacting with size, decile or sector), doing so we capture all other potential unobserved determinants of the size of wage changes. Besides, there is no constant term in this equation, which is consistent with the prediction of the model that only cumulative shocks since the last wage adjustment will affect the size of wage changes.

[19]Maximum likelihood estimation would require to specify a rather complex covariance matrix for residuals. Resorting to bootstrap simulations allows us to have a very flexible covariance matrix without specifying it explicitly.

[20]A similar identification method has been used by Fougère et al. [2010] or Le Bihan et al. [2012].

4.2 Estimation Results

In Table 3, columns (1a) and (1b) report results of the Tobit model without any variables related to wage bargaining (NMW, industry or firm-level agreements). One first finding is the strong degree of time-dependence of wage changes: the probability of a wage change increases by about 40 pp if the duration since the last wage change is exactly one year. In addition, the probability of a wage change is much smaller (by about 10 pp or more) in other quarters than Q1. Inflation and local unemployment have also a significant effect on the probability of a wage change: their marginal effects are respectively +4.6 and −0.1 pp. The size of wage changes is also positively correlated with inflation and negatively with unemployment. Overall, Taylor-type time-dependence seems to play a key role on the probability of wage changes but macro variables like inflation or unemployment have still a significant contribution. These results are very in line with the ones provided by Le Bihan et al. [2012] in France or Sigurdsson and Sigurdardottir [2016] in Iceland.

When we include the NMW, sectoral MW and firm-level agreements in our regression (columns (2a) and (2b) and columns (3a) and (3b)), results are somewhat modified: inflation has now a smaller effect on both the probability and on the size of a wage adjustment whereas the effect of unemployment is larger; second, duration effects are now weaker, marginal effects of duration dummies decrease by about 2 pp when including the NMW and by 6 to 10 pp when we include wage bargaining variables; finally, the strong firm size effects on the probability of wage change almost disappear (Figure F in Appendix C). Besides, wage-setting institutions have a significant direct effect on both the probability and the size of wage changes. First, a 1%-increase in the NMW or in sectoral wage floors raises the probability of a wage adjustment by about 2 pp whereas a firm-level agreement raises this probability by 11 pp. NMW and sectoral MW have also a direct effect on the size of wage changes, respectively +0.11 and +0.14 and a firm-level wage agreement increases the average wage change by 0.33 pp.[21]

[21] In Appendix, we report several robustness exercizes including or not quarter dummies, date dummies

4.3 Minimum Wage Adjustments

In our simulation exercize, we will allow minimum wages and firm-level agreements to respond to the same shocks as the ones considered for wages. For that, we define data generating process for these variables.

First, the data generating process of the NMW is given by the legal formula and the legal calendar: the NMW adjusts automatically every year (in July until 2009, then in January since 2010) according to an explicit formula linking NMW increase to the past inflation rate and the past real wage increase of blue-collar workers:

$$\Delta NMW_t = Max\left(0, \Delta CPI_{t-1}\right) + \frac{1}{2} Max\left(0, \Delta W_{t-1} - \Delta CPI_{t-1}\right) + \epsilon_t \tag{6}$$

where ΔNMW_t is the NMW increase in year t, ΔCPI_{t-1} is the inflation rate since the last NMW update, ΔW_{t-1} is the increase of the blue-collar hourly base wage since the last NMW update and ϵ_t is a possible discretionary governmental increase.[22]

At the industry level, we assume that sectoral minimum wages follow a similar two-stage process as the one assumed for individual wages (Fougère et al. [2018]). Results are reported in Appendix Table E. Like for individual wages, we find large time-dependence effects on the probability of a minimum wage adjustment (for instance, the probability of a wage change is 33 pp higher when a sectoral MW has not adjusted for exactly one year) and small but significant effects of state-dependent variables (inflation, NMW or past aggregate wage change) on the probability of wage floor adjustments. Moreover, we find that a 1% increase in inflation, NMW or past aggregate wage growth has a significant positive effect on the size of wage adjustment (respectively 0.25, 0.24 and 0.31).

Finally, we also estimate a model for the occurrence of a wage agreement at the firm

(see Table C in Appendix D), results are quite robust. We also run a type 1 Tobit on annual wage growth to be able to control for annual productivity growth (Appendix D for more detail on this model). We find only a small effect of productivity on individual wage changes whereas the impact of wage floors or firm-level wage agreements remain unchanged (Table D in Appendix D).

[22] If between two NMW adjustments, the cumulated inflation is larger than 2%, the NMW is automatically and immediately adjusted (it was the case in May 2008 and in Dec. 2011).

level (Table F in Appendix). Firm size and duration effects are the main drivers of the probability of a wage agreement whereas minimum wages have only small negative effects. The negative effects of minimum wages might suggest the presence of crowding-out effects.[23]

4.4 Simulation Exercize

As shown in Section 2.2, if wages are sticky at the micro level, the transmission of a shock to aggregate wages can take several quarters. To investigate the transmission of shocks to aggregate wages, we resort to simulation exercizes using estimates of micro models as data generating processes (DGP). Our simulation exercize is the following.[24] We simulate four variables: the NMW trajectory using as DGP the legal formula; individual wage floors and base wages using as DGP our Tobit model estimates; and occurrence of firm-level agreements using as DGP our Probit estimates. We use as inputs for all simulations: parameter estimates, initial values of simulated variables, exogenous variables (like inflation, unemployment,...) and simulated variables when they enter as inputs in micro-econometric models (for instance, wage floors for base wages). We run simulations of wage trajectories only for individuals observed at the date of the shock and we keep the sample composition fixed for the rest of the simulation period (i.e. there is no entry/exit during the simulations).[25] Using the simulated base wage trajectories, we then compute the average wage change at every period, defined as: $\Delta W_t^0 = \frac{1}{N_t}\sum_i \Delta W_{it}^0$ where N_t is the number of individuals at t. This average aggregate wage change computed without any exogenous shock will be used as a benchmark.

Then, we redo the same simulation exercize but introducing a shock at a given date

[23] Like for wage floors, it is likely that inflation and NMW may play a role on the size of wage changes set in the firm-level agreements. Indirect effects of NMW or inflation might however come mainly through the size of negotiated wages, affecting mostly large firms. This is left for further research since information on the size of wage change in firm-level agreements is not available.

[24] Appendix G for a full description.

[25] We run several simulations using bootstrapped values of our parameter estimates to provide standard errors of aggregate simulated responses to shocks.

(Q12010 in our baseline simulations). For instance, we consider that the CPI is now 1% higher after Q12010 (compared to its actual value). All our simulated variables will respond to this shock since they all depend on inflation. Besides, since some simulated variables are used as inputs of others (like wage floors for base wages), it leads to possible additional indirect effects of shocks on base wages (see below for a description of the different cases). At the end, we compute the average wage change for this new set of simulations ($\Delta W_t^1 = \frac{1}{N_t}\sum_i \Delta W_{it}^1$).

Overall, the average aggregate response to a shock is given by the difference between average wage change with the shock and the same average without the shock ($\Delta W_t^1 - \Delta W_t^0$). We will report the cumulative response to a shock as the cumulative sum of this difference over time. We will consider different simulation exercizes to decompose the impact of a shock on aggregate base wages in several channels.

In the first exercize, the shock can only affect base wages (and not the NMW, wage floors and firm-level agreements). Simulated trajectories of NMW, wage floors and firm-level agreements do not include the shock but are still used as inputs for simulations of base wages. In the rest of the paper, the cumulative aggregate response obtained in this exercize will be called the direct effect of a shock on base wages. In a second exercize, we allow base wages but also wage floors and firm-level agreements to respond to the shock. For instance, an exogenous increase in CPI will lead wage floors to adjust, which would in turn affect workers' wages. We are then able to estimate the indirect effect of a given shock on base wages coming through wage floor adjustment process. This effect will be referred as the indirect effect of the shock (Figure K in Appendix for a diagram). In a third exercize, we assume that base wages, sectoral MW and firm-level agreements but also the NMW can respond to the shock. NMW adjustment depends on two factors: past inflation and past aggregate wage change. In our set-up, a positive shock is going to raise individual wages (due to direct or indirect effects), translating into increases in aggregate wages. Since past aggregate wage change is one input of the NMW legal formula, this increase in aggregate wage will lead to raise NMW (with some delays), which might increase again individual wages and wage floors.[26] In our simulation exercize, we will allow such feedback loop effects from past increase of actual wages (calculated as the sum of all simulated changes in micro wage trajectories) on NMW or industry-level wage floors. In the rest of the paper, feedback loop effects refer to this channel (Figure L in Appendix for a diagram). The sum of indirect and feedback loop effects is referred as second-round effects of a shock on base wages.

5 Aggregate Wage Response to Shocks

In this section, we report results of the different simulation and aggregation exercizes.

5.1 Aggregate Direct Effects

We first describe how aggregate wages directly respond to different shocks (introduced separately): a 1%-shock in CPI inflation, NMW, sectoral MW and unemployment. Figure 5 plots the aggregate response of base wages to different shocks. The red line is the aggregate response when the shock affects both the probability and the size of wage changes (our baseline model) whereas the dashed black line is the aggregate response when the shock only affects the size of wages changes (i.e. the probability of wage changes remains unchanged (exogenous to the shock) like in a time-dependent model). First, in our baseline model, it takes about 4 years for aggregate wages to fully adjust to the shock versus 3 years in a time-dependent model (see Table 4 for statistics on the duration before full adjustment). In our baseline model allowing state-dependence, aggregate adjustment is first a little quicker than in the model without state-dependence (75% of the long term effect after 2 quarters versus 58% in the model with exogenous frequency) since wage changes are much more frequent with the shock. However, after

[26] We do not consider possible feedback loop effects coming from the response of inflation and unemployment to a shock. They are however all other potential channels for feedback loop effects.

some quarters, wage adjustments are less frequent in our baseline model since firms which have already incorporated the shock are now less likely (compared to the case without shock) to update their wages again.

In Table 5, we have reported long-term effects of shocks.[27] The first column reports direct effects, we find that the long run effect of a 1% shock in inflation on aggregate base wages is 0.24 pp. The long-run effects of minimum wages on base wages are substantial: a 1% increase in sectoral minimum wages leads to a increase of base wages of 0.16 pp whereas the same increase in the NMW leads to an increase of 0.13 pp in aggregate base wages. Each of this effect represents more than half the overall effect of inflation. We can also note that in our baseline model, these long-term effects of shocks are a little larger than the estimates of the second equation in the Tobit model since they include the effects on both the size and the frequency of wage adjustments.

5.2 Minimum Wages and Aggregate Wage Dynamics

To which extent do minimum wage adjustments modify the aggregate wage response to shocks? We here present results of simulations where we allow minimum wages to react to changes in macro variables (i.e. CPI inflation, NMW and past agregate wages for sectoral MW and inflation and past aggregate wages for the NMW).

Figure 6 plots the overall effect of CPI and NMW shocks on aggregate wages. The solid blue line corresponds to the overall cumulative response of aggregate wages including second-round effects whereas the red dashed line represents the direct effect of the shock. The maximum cumulative effect of a shock is obtained after two years (more than 0.5% for CPI and a little more than 0.2% for the NMW) but the convergence to the long-run effect is also longer than the one observed for the direct effect (Table 4). Overall, it takes about 5 years for a shock to be completely transmitted to aggregate wages (versus 4 years for the direct effect). This higher degree of persistence in the reaction of aggregate wages

[27] We measure long term effects at the end of the sample period Q4 2015. Standard errors are obtained using bootstrap simulations.

to shocks can be explained by the fact that the reaction of minimum wages to shocks is also persistent (Figure G in Appendix for the aggregate response of wage floors to a 1% increase in the NMW and inflation).[28]

The second and third columns of Table 5 report long-term effects of inflation and NMW shocks when we account for indirect effects (through wage floor adjustments) and also second-round effects (feedback loop effects). First, effects of shocks are much larger when taking into account second-round effects. A 1%-increase in NMW now raises base wages by 0.17 pp (versus 0.13 pp only for direct effects).[29] The amplification effect is mainly driven by the response of wage floors to NMW (about +0.03 pp) whereas the feedback loop effects are much smaller (0.01 pp). Overall, the response of sectoral minimum wages amplifies the wage response to NMW increases by a factor of 1.3. The degree of inflation indexation of base wages is also amplified by minimum wages. A 1%-increase in inflation now raises wages by 0.42 pp when we allow minimum wages to respond to the inflation shock (versus 0.22 when we do not allow this possibility). The indirect effect of inflation coming from sectoral wage floors is estimated close to 0.05 pp whereas the feedback loop due in particular to the reaction of NMW to the inflation shock is 0.16 pp. This strong reaction of NMW to inflation can be explained by the legal formula for NMW where NMW adjusts fully to past inflation. Overall, wage indexation to past inflation is augmented by a factor 1.7 when we take into account interactions with wage-setting institutions.

What do we miss if we do not include minimum wages as possible determinants of wage adjustments? In Table 5, we report long-run effects obtained in models with only NMW or without any wage bargaining variable. In those models, CPI inflation effects are a little lower and might capture part of the minimum wage effect. Figure 7 plots the cumulative response function to a 1%-increase in inflation and NMW with the different

[28]The contribution of the response of firm-level agreements to the shock is close to zero since the probability of a firm-level agreement depends only weakly on macro variables.

[29]The NMW shock should be interpreted as a discretionary increase decided by the government.

specifications. Excluding all bargaining variables, we find a quicker response of wages to inflation (by about 2 to 3 quarters, Table G in Appendix for further statistics on duration before full adjustment). When we include the NMW, the cumulative impulse response function is much closer to the aggregate response obtained with NMW and sectoral minimum wages.

We also test the robustness of aggregate responses to shocks according to the quarter and the year of the shock. First, some papers argue that seasonality of wage changes may affect the effects of monetary policy (see Olivei and Teynrero [2010], Juillard et al. [2013], and Bjorklund et al. [2018]). We here run simulations where the shock is introduced either in Q1, Q2, Q3 or Q4. We find that the duration before full adjustment to a CPI shock is a little longer when the shock is introduced in Q1 whereas a shock has less persistent effect when introduced in Q4 (Figure 8 and also Table I in Appendix). This is due to the strong seasonality of minimum wages: if the shock is introduced in Q1, it takes more time for wages and minimum wages to adjust since they usually adjust in Q1. However, long-run effects are of similar magnitude. For a NMW shock, the overall effect is stronger in Q1 where the marginal effects of NMW increase is larger leading to more frequent wage changes (direct effect) whereas a NMW shock introduced in Q2 has a smaller effect (Table H in Appendix reports results of long-term effect of CPI and NMW shock according to the quarter of the shock).

Finally, we have run robustness exercizes with respect to the year of the introduction of the shock. Long-run effects of shocks vary only a little.[30]

5.3 Heterogeneity Along the Wage Distribution

We now investigate to which extent long-run effects of shocks are heterogeneous along the wage distribution. Following the empirical literature on minimum wage spillover effects,

[30] We also provide results of robustness exercizes where we modify the specification of the Probit model in the Tobit regression (including or not time/quarter controls). We find that long-run effects are quite robust to changes in the specification (see Table J in Appendix).

we might expect in particular some heterogeneity in the transmission of NMW increases along the wage distribution. Moreover, our simulation exercizes allow us to investigate whether spillover effects can come from second round effects. In this exercize, we have first estimated Tobit model on base wages where our main exogenous variables interact with 10 different positions of wages in the wage distribution (these positions correspond to deciles of base wages).[31] We have run the same estimation for industry-level wage floor process including interactions with positions along the wage distribution. Finally, we have run the same simulation exercize as previously described.

Figure 9 plots the long-run effects of 1%-shock on NMW along the wage distribution. First, looking at overall effects of a 1%-NMW shock (black line), we find a decreasing effect of the NMW along the wage distribution. The overall effect is about 0.4 pp for wages close to the NMW (decile 1) and then falls to about 0.2 for wages between 1.04 and 1.2 $\times$ the NMW (deciles 2 and 3). For wages higher than 1.3 $\times$ the NMW (deciles 4 to 10), the overall effect of NMW is still positive and significant (about 0.1 pp) and increases for wages higher 2$\times$NMW.[32] This overall effect can be broken down into three components: direct effects from NMW to wages, indirect effects coming from the reaction of wage floors and feedback loop effects coming from the response of aggregate wages. For wages close to the NMW we find a large contribution of direct effects but this direct effects decreases quickly along the wage distribution. Indirect effects of NMW transiting through wage floors contribute mostly to the overall effects on the highest wages (last 4 deciles) and represent half of the overall effects at the top of the wage distribution. Sectoral minimum wages do contribute to NMW spillovers to wages higher than the NMW.[33] Finally, feedback loop effects are positive and concentrated on wages below

[31] The deciles of the distribution are the following: 1.04*NMW, 1.12*NMW, 1.2*NMW, 1.3 NMW, 1.5*NMW, 1.6*NMW, 1.9*NMW, 2.2*NMW, 2.9*NMW. We have dropped wage observations when base wage is below 0.97*NMW and above 8*NMW.

[32] Figure I in Appendix plots robustness analysis with models including different time effects. When we include time dummies in the model, the overall effect of NMW is close to 0 for wages higher than the median wage (above 1.5*NMW) since time dummies might capture part of the common seasonality in NMW.

[33] Metalworking, Construction and Public Works industries covering managers at the national level

1.6*NMW (on this part of the distribution, these feedback effects are about 0.04 pp). By comparison, using different administrative French data sources at annual frequency, Givord et al. [2016] find that spillover effects affect wages until $2 \times NMW$ (see also Koubi and Lhommeau [2006]).

If we consider the impact of indexation to past inflation along the wage distribution (Figure 10), we find that the impact of CPI inflation is rather homogenous along the wage distribution. This small degree of heterogeneity in the overall effect is the result of two opposite effects: first, direct effects of CPI inflation are increasing along the wage distribution, their contribution is rather small for NMW earners whereas they are about 0.25 pp for wages higher than 1.1 times the NMW; second, feedback loop effects are very large for wages close to the NMW (about +0.2 pp) but decrease along the wage distribution and are close to 0.1 pp for higher wages. After a CPI inflation shock, the NMW adjusts accordingly, leading to wage increases concentrated on low wages. Finally, indirect effects coming from wage floor adjustments after the CPI inflation shock are significant over the whole wage distribution but larger for the highest deciles. Overall, the dynamics of minimum wages contribute to increase the degree of indexation to past inflation for the whole distribution of wages.

6 Conclusion

In this paper, we have documented how a multi-level system of minimum wages can shape the aggregate wage dynamics in France. For that, we have matched comprehensive data sets consisting of millions of quarterly base wages, industry-level wage floors for more than 350 different industries and thousands of firm-level wage agreements over the period 2005Q4-2015Q4.

First, we have provided new stylised facts on how wage bargaining institutions has

(total of 500,000 employees) contribute a lot to explain this increase. In Appendix, Figure J plots the same estimates but excluding these industries from our sample. The overall effect of NMW is much lower for the highest deciles.

an impact on the degree of micro wage rigidity. Time schedules of wage agreements and actual wage changes are highly synchronized: most wages changes are observed during the first quarter of the year when a vast majority of both industry- and firm-wage agreements are signed. Moreover, the typical duration between two wage changes is one year which corresponds to the usual duration of wage agreement. This last observation is quite consistent with predictions of Taylor [1980] model. We also show that the size of wage adjustments depends not only on inflation and unemployment but also on NMW and sectoral wage floors increases.

Second, using simulation exercizes, we have investigated how micro wage stickiness translates into delayed aggregate wage response to a shock. We find that a typical 1% increase in inflation would take between 4 and 5 years to be fully incorporated to aggregate wages. We also provide new evidence on the emprical relevance of state-dependent factors for the micro wage dynamics but also for the aggregate wage response to shocks. We have also documented that minimum wages contribute to delay by about one year the transmission of a given shock to wages.

Third, we have also estimated long-run direct effects of the main drivers of aggregate wages. Minimum wages have a large effect on the aggregate wage dynamics: a 1% increase in NMW or sectoral wage floors have a long-run impact of respectively 0.13 pp and 0.16 pp, more than half the effect of inflation. Finally, we show that minimum wages do amplify the effect of inflation on aggregate wages. Once we allow NMW and sectoral minimum wages to react to shocks, the overall effect of inflation on aggregate wages raises to 0.42 pp and the effect of NMW to 0.17 pp. This amplification effect is not homogeneous along the wage distribution. In particular, the NMW pass-through to higher wages is mainly due to sectoral minimum wages for the highest deciles of the wage distribution whereas feedback loop effects play a major role for the lowest deciles of the wage distribution.

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Tables

Table 1: Aggregate Moments of Wage Changes

	Base Wage changes			Collective wage agreements			
				Industry			Firm
	Average (%)	Freq.	Size (%)	Average (%)	Freq.	Size (%)	Freq.
Overall	0.47	0.27	1.75	0.38	0.21	1.91	0.15
Overall (unw.)	0.45	0.24	1.90	0.37	0.21	1.91	0.11
Q1	0.84	0.45	1.87	0.90	0.47	1.93	0.21
Q2	0.49	0.27	1.82	0.31	0.17	1.92	0.20
Q3	0.37	0.23	1.62	0.24	0.14	1.71	0.10
Q4	0.21	0.14	1.50	0.15	0.08	1.93	0.09
2006	0.47	0.27	1.75	0.43	0.21	1.95	0.14
2007	0.59	0.30	1.97	0.53	0.22	2.43	0.14
2008	0.70	0.35	2.05	0.60	0.27	2.32	0.15
2009	0.43	0.25	1.75	0.44	0.21	1.99	0.13
2010	0.39	0.25	1.55	0.23	0.16	1.61	0.14
2011	0.53	0.28	1.86	0.50	0.25	1.95	0.15
2012	0.52	0.30	1.78	0.47	0.22	2.09	0.15
2013	0.38	0.24	1.59	0.40	0.23	1.79	0.15
2014	0.33	0.22	1.50	0.19	0.15	1.16	0.19
2015	0.30	0.21	1.41	0.14	0.15	1.02	0.15

Note: Moments are calculated using the data set matching ACEMO individual data, firm-level and industry-level wage agreements data sets. The first column contains the average quarterly wage changes for all workers of our data set. The second column is the proportion of workers whose wage is modified in a given quarter compare to the previous quarter. The third column is the average wage change conditional on observing a wage change. Columns 4-5-6 are the same statistics but calculated for sectoral minimum wage changes in industry-level agreements. The last column is the proportion of workers covered in a given quarter by a firm-level wage agreement. Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

Table 2: Aggregate Moments of Wage Changes and Wage Agreements

Level of wage agreement	Wage changes		
	Average (%)	Freq.	Size (%)
All			
No Agreement	0.34	0.20	1.70
Firm OR Industry	0.70	0.40	1.77
Firm AND Industry	1.08	0.54	1.98
Wage Inflation Close to 2%			
No Agreement	0.40	0.22	1.80
Firm OR Industry	0.78	0.41	1.91
Firm AND Industry	1.27	0.59	2.15
Wage Inflation Below 2%			
No Agreement	0.25	0.17	1.52
Firm OR Industry	0.56	0.37	1.50
Firm AND Industry	0.76	0.47	1.63

Note: Moments are calculated using the data set matching ACEMO individual data, firm-level and industry-level wage agreements data sets. Moments are calculated according to the coverage in a given quarter by a firm- or an industry-level wage agreement. About 70% of observations are not concerned by any wage agreement in a given quarter, 25% by a firm- OR an industry-level agreement and about 5% by at the same quarter an industry and a firm-level agreements. Column (2) contains the average quarterly wage changes in a given bargaining regime. Column (3) is the proportion of workers whose wage is modified in a given quarter compared to the previous quarter for a given wage agreement regime. Column (4) is the average wage change conditional on observing a wage change by wage agreement regimes. We report the same statistics for two different subperiods: years 2006-2009, 2011-2012 where wage inflation was close to 2% or above on average and years 2010, 2013-2015 where wage inflation was below 2%. Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

Table 3: Determinants of Wage Changes: Tobit Estimates

	Probability of wage change			Size of wage change		
	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)
CPI Inflation	0.046***	0.031***	0.025***	0.330***	0.267***	0.217***
	(0.000)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Unemployment	−0.001**	−0.007***	−0.012***	−0.043***	−0.062***	−0.089***
	(0.001)	(0.001)	(0.001)	(0.004	(0.004)	(0.004)
NMW		0.022***	0.020***		0.124***	0.114***
		(0.000)	(0.000)		(0.002)	(0.002)
Wage floors			0.023***			0.136***
			(0.000)			(0.002)
Firm agreement			0.109***			0.327***
			(0.001)			(0.005)
Duration						
1 quarter	Ref.	Ref.	Ref.			
2 quarters	0.031***	0.029***	0.015***			
	(0.001)	(0.001)	(0.001)			
3 quarters	0.012***	0.002*	-0.026***			
	(0.001)	(0.001)	(0.001)			
1 year	0.387***	0.365***	0.311***			
	(0.001)	(0.001)	(0.002)			
5 quarters	0.069***	0.048***	-0.003*			
	(0.002)	(0.002)	(0.002)			
6 quarters	-0.043***	-0.059***	-0.099***			
	(0.002)	(0.002)	(0.002)			
7 quarters	-0.064***	-0.085***	-0.123***			
	(0.002)	(0.002)	(0.002)			
2 years	0.054***	0.020***	-0.042***			
	(0.004)	(0.003)	(0.003)			
>2 years	-0.100***	-0.122***	-0.157***			
	(0.002)	(0.002)	(0.001)			
Q1	Ref.	Ref.	Ref.			
Q2	-0.097***	-0.092***	-0.087***			
	(0.001)	(0.001)	(0.001)			
Q3	-0.102***	-0.115***	-0.103***			
	(0.001)	(0.001)	(0.001)			
Q4	-0.170***	-0.174***	-0.162***			
	(0.001)	(0.001)	(0.001)			
Mills ratio				0.763***	0.752***	0.751***
				(0.003)	(0.003)	(0.003)
Time linear trend				0.973***	0.835***	0.483***
				(0.012)	(0.012)	(0.013)
Observations		1,986,531			466,585	

Note: We report in this table the marginal effects calculated from the estimation of the Probit model and the parameter estimates obtained from the second step of the Tobit model. Determinants are calculated as cumulative variable since the last wage adjustment. Duration is a dummy variable for durations since the last wage changes. Q1-Q4 are dummy variables for every quarter of the year. Sector, size and wage deciles controls are introduced in all specifications. In the second equation of the Tobit model, time linear trends are interacted with sector, size and wage deciles, we here report the estimates of the time trend for the reference (smallest firm size, first decile, and metalworking industry). *p<0.1; **p<0.05; ***p<0.01.

Table 4: Duration Before Aggregate Wage Adjustment

	Duration (in Q) Before Full Adjustment			% of Long-Term Effect At Date:		
	90%	95%	98%	t	t+1	t+2
Inflation						
Exogenous Freq.	8	10	13	0.40	0.58	0.70
Direct effect	13	15	18	0.54	0.75	0.88
Overall effect	17	19	> 20	0.34	0.49	0.58
NMW						
Exogenous Freq.	8	10	13	0.40	0.58	0.70
Direct effect	15	17	19	0.59	0.82	0.95
Overall effect	18	> 20	> 20	0.52	0.74	0.88

Note: this table reports results on the dynamic aggregate effect of a shock on wages. In the first three columns we report the number of quarters before the cumulative effect is equal to 90, 95 or 98% of the long term effect of a shock on aggregate wages. Our criterion is the following: the first date at which the cumulative response is equal to a given ratio and this ratio should not be lower the four quarters ahead. The last three columns reports the ratio between the cumulative response and the long run effect measured at t (date of the shock), t+1 one quarter after the shock and t+2 two quarters after the shock. Using our baseline specification with NMW and sectoral MW, we have reported results for a NMW or inflation shock. "Exogenous Freq." is the case where the shock does not affect the probability of a wage adjustment. "Direct effect" is the case where the shock affects only base wages directly (and not wage floors). "Overall effects" is the case where in the simulations, we allow sectoral and national minimum wages to respond to the shock.

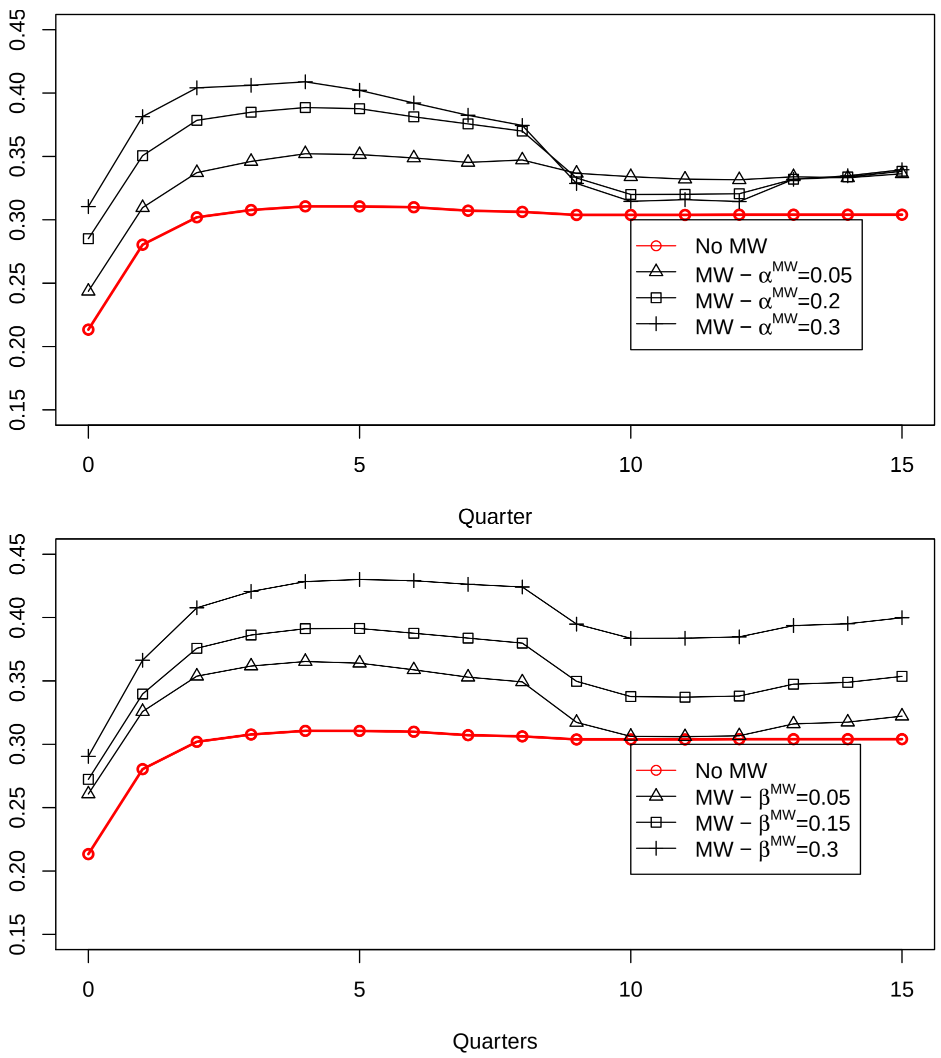
Table 5: Long-Term Aggregate Direct Effects

	Direct	Direct + Indirect	Overall
NMW and Industry-Level MW (Specification 3)			
CPI Inflation	0.239	0.286	0.417
	(0.004)	(0.012)	(0.020)
NMW	0.129	0.162	0.172
	(0.004)	(0.011)	(0.016)
Wage floors	0.156	-	-
	(0.004)		
Unemployment	−0.050	-	-
	(0.002)		
NMW only (Specification 2)			
CPI Inflation	0.300	-	0.397
	(0.008)		(0.003)
NMW	0.142	-	0.146
	(0.005)		(0.002)
No Minimum Wage (Specification 1)			
CPI Inflation	0.362	-	-
	(0.007)		

Note: This table reports results from simulation exercise described in section 4.4 where we allow wage floors and the NMW to react to changes in CPI and NMW (indirect effects) but also to aggregate wage changes due to the response to the shock (feedback loop effects). We report the long-run impact of 1% increase in a given variable on wage changes. Column (1) reports direct long run effects coming from the adjustment of wages to shocks under the assumption that wage floors and the NMW are not responding to shocks in CPI or NMW. Column (2) reports the indirect effect of the shock on base wages coming from the adjustment of wage floors to a given shock. The last column reports the overall effect of the shock on base wages including the direct effect, indirect effect coming from wage floor adjustments and feedback loop effects coming from the adjustment of NMW, wage floor and aggregate wage changes.

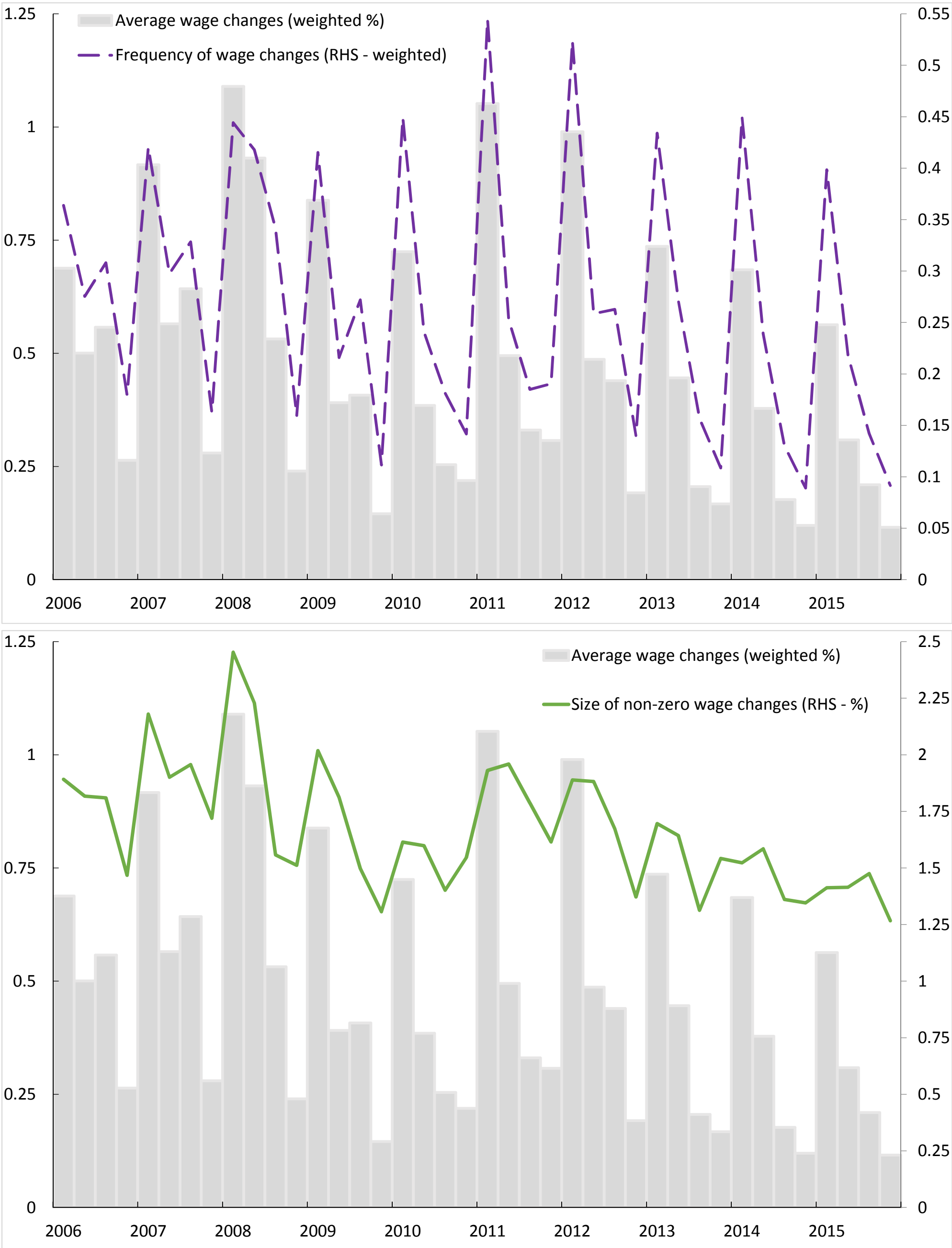
Figures

Figure 1: Aggregate Wage Dynamics with MW - Calibration Exercizes



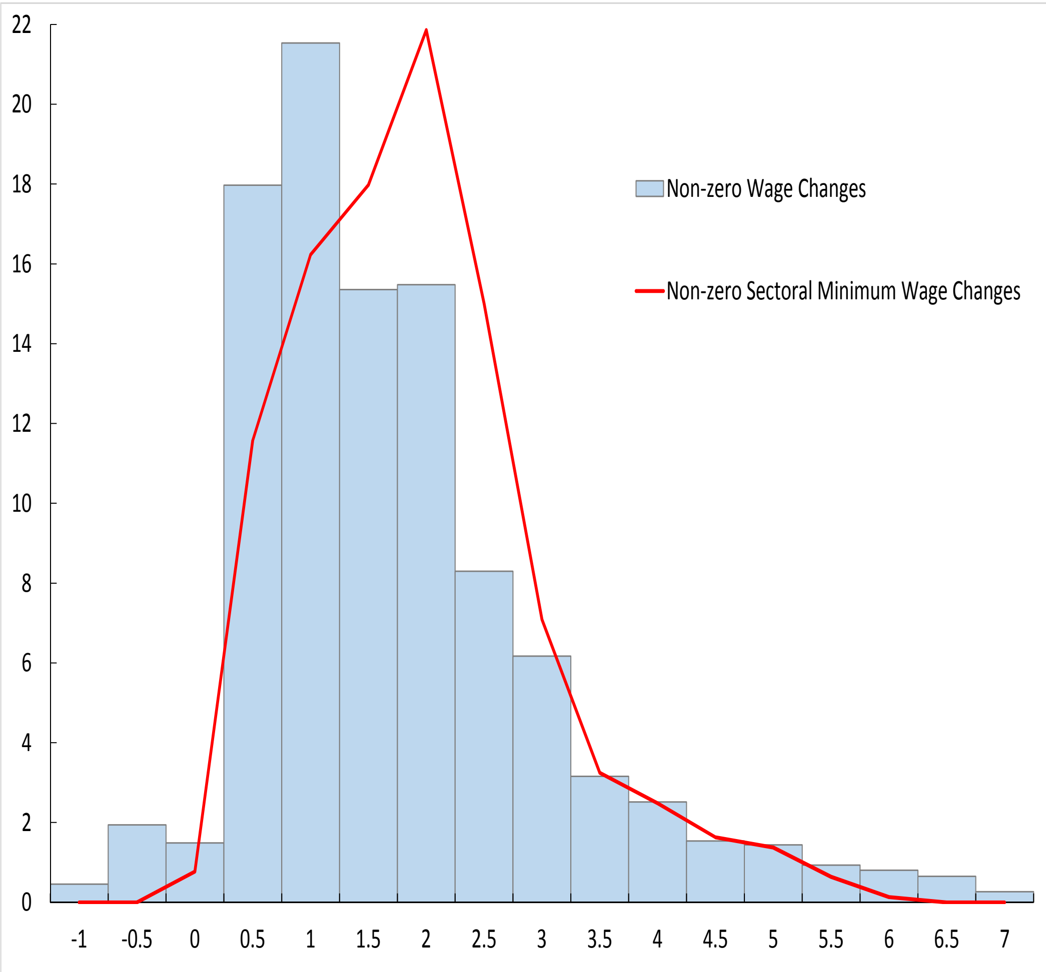
Note: we here report aggregate wage response to a shock in a model where the shock affects directly wages but also indirectly through its effect on MW. The red line represents the cumulative aggregate wage response in a model where there is no MW. The top panel reports aggregate wage response where we vary the parameter associated with the shock in the equation describing the probability of a MW adjustment α^{MW} whereas the other panel plots aggregate wage response to a shock where we vary the parameter associated with the shock in the equation describing the frictionless MW adjustment β^{MW}. See Appendix A for a full description of the calibration exercize.

Figure 2: Aggregate Wage Growth, Frequency and Size of Wage Adjustments



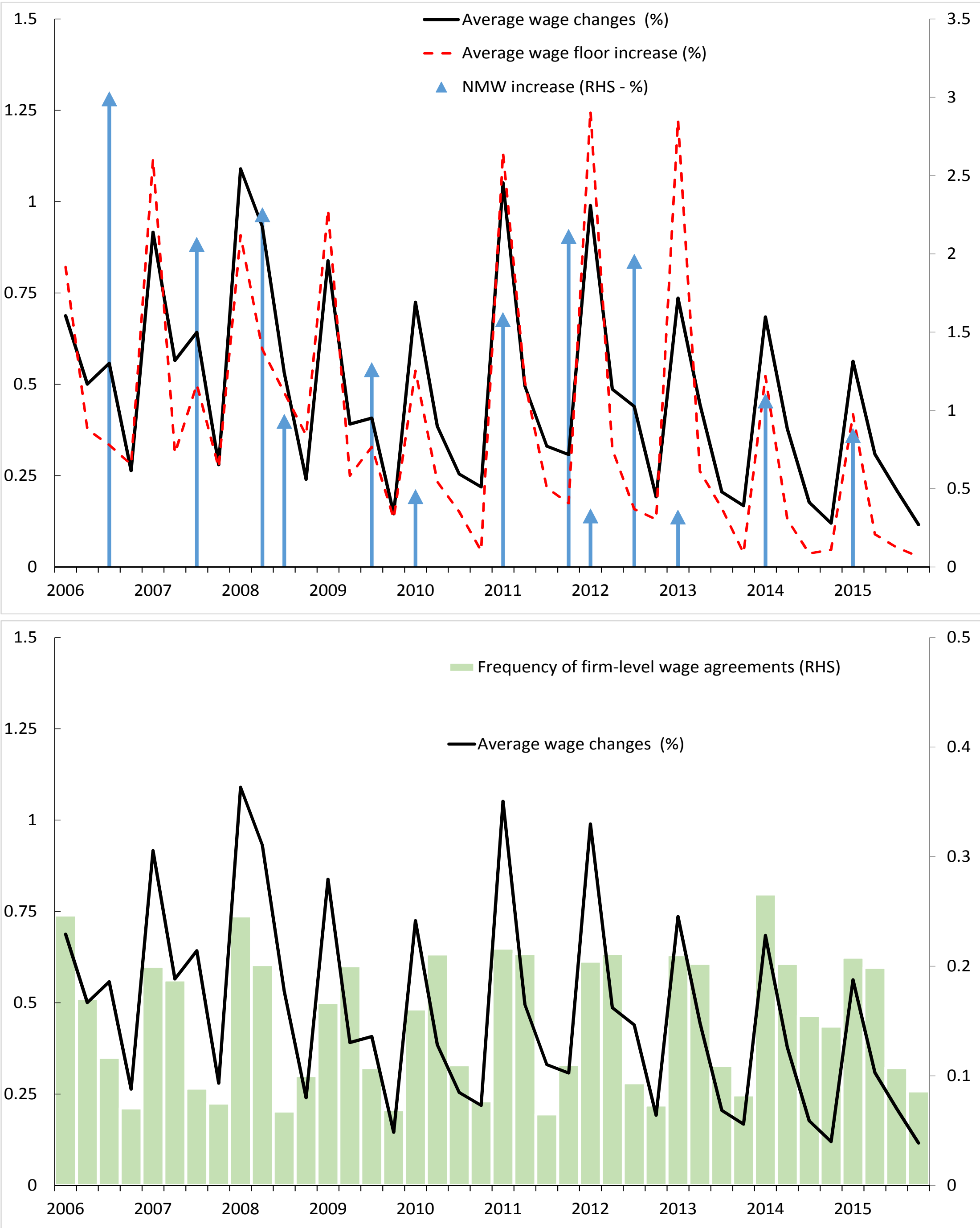
Note: we compute for each quarter the average wage growth as the average of all wage changes of our sample (including 0 change), the frequency of wage changes is calculated as the ratio of the number of wage changes over the number of observations in a given quarter, the average size of wage changes is calculated as the average of all wage changes but excluding wage changes equal to 0. Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

Figure 3: Distribution of Non-Zero Wage Changes



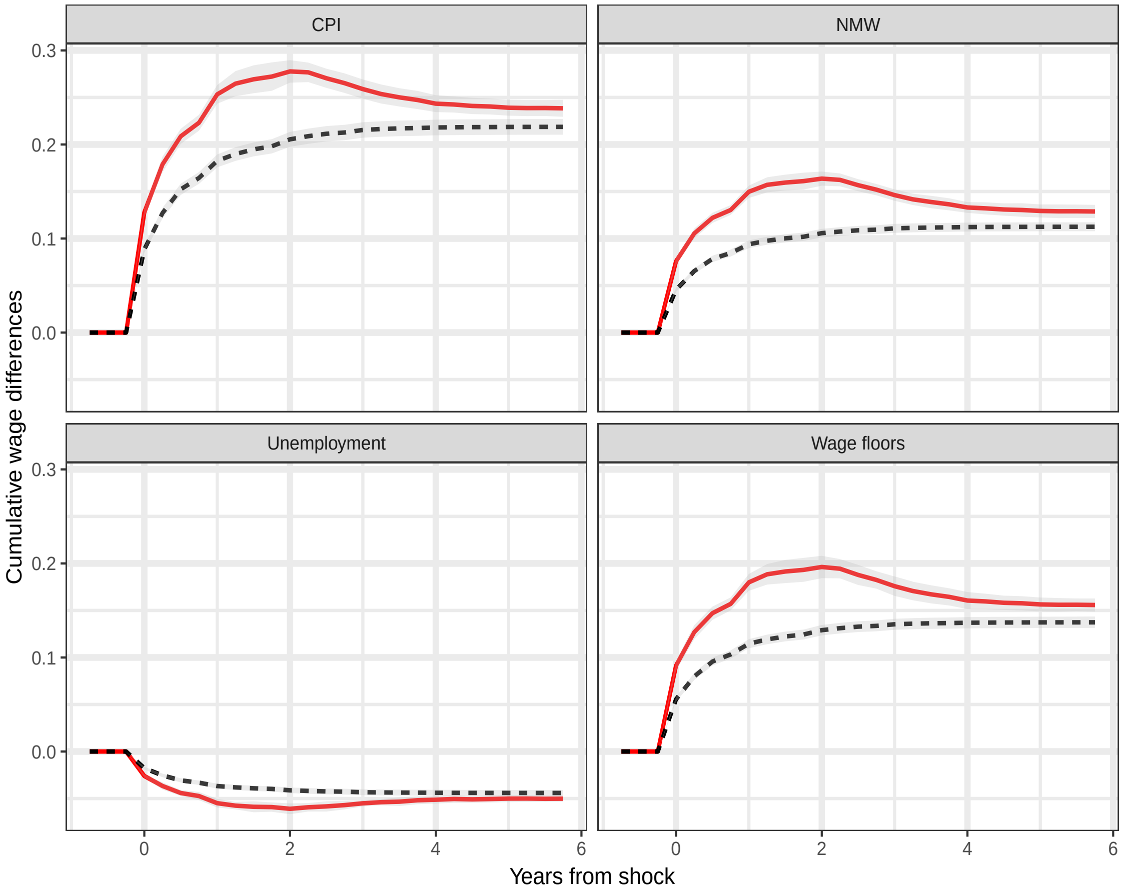
Note: we here compute the distribution of all non-zero wage changes (quarter-on-quarter) (blue histogram) and the distribution of quarter-on-quarter changes in sectoral wage floors (red line). Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

Figure 4: Aggregate Wage Growth, Sectoral Minimum Wage Increase and Frequency of Firm-Level Wage Agreements



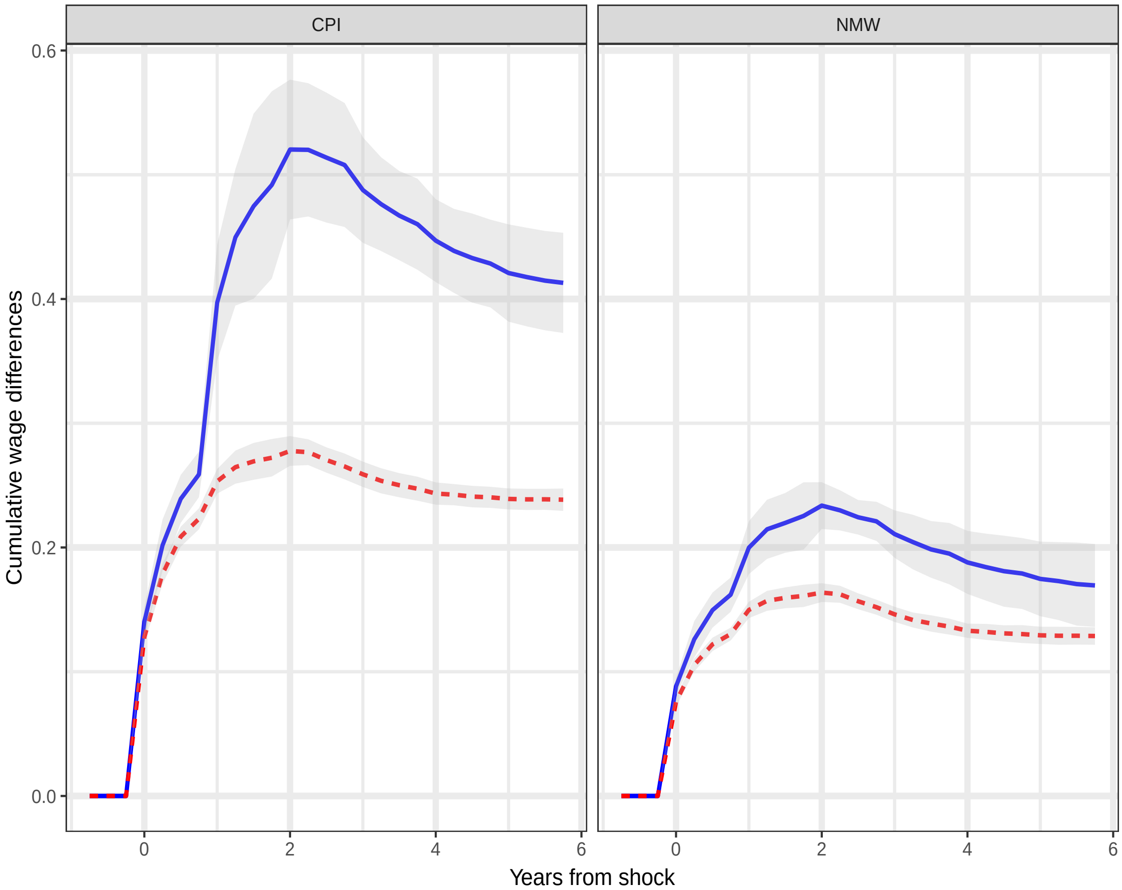
Note: we compute for each quarter the average wage growth calculated as the average of all individual wage changes of our sample (including 0 change) (black line). Top panel: we plot with the average wage change, the average wage floor increase decided in a given quarter for all workers of our sample (including 0 increase when there is no wage bargaining) (dashed red line) and the NMW increase (blue bars - in %, right handside scale). Bottom panel: we plot the frequency of firm-level wage agreements as the ratio between the number of workers covered by a firm-level wage agreement on the total number of workers (proportion, green bars, right handside scale). Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

Figure 5: Aggregate Wage Adjustment to Shocks (Direct Effects)



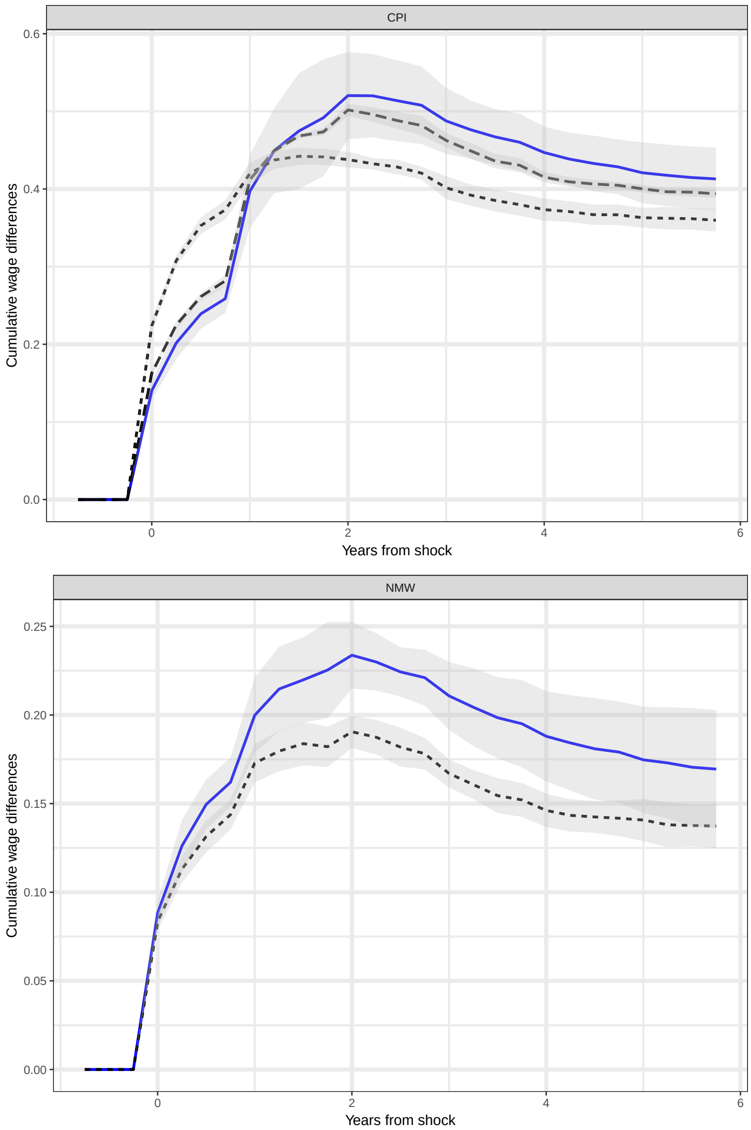
Note: we here report the results of our simulation exercize: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants (see section 4.4 for a full description). The shock is introduced in 2010Q1. We compute the average of all wage change trajectories by date and report the difference between the average caculated using simulations including a shock and the average calculated with simulations without any shock. The red line corresponds to the aggregate average wage response to a given shock. The black line corresponds to the aggregate wage response when we do not allow the probability of a wage change to respond to the shock (i.e. the frequency of wage change is given as exogenous). We also report confidence intervals (grey shaded area) using bootstrap simulations.

Figure 6: Aggregate Response of Wages to NMW and Inflation Shocks (Direct and Second-Round Effects)



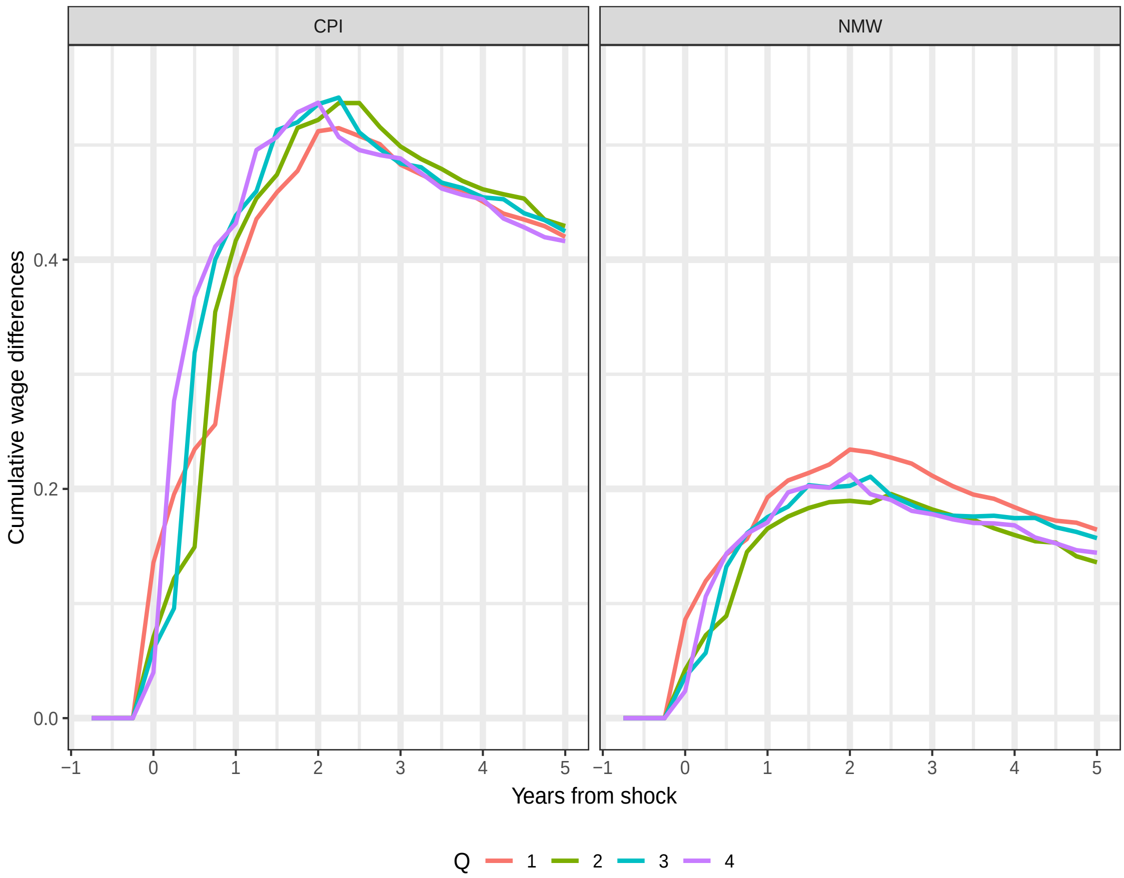
Note: we report the results of our simulation exercize when we allow indirect effects of shocks feeding wages through wage floor adjustment and we also allow feedback loop effects: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in CPI inflation or NMW. We also allow wage floors and NMW to react to these shocks. Therefore, individual wage changes would also respond to second round effects due to the reaction of NMW and wage floors to the initial increase in aggregate base wages. We compute the average of all wage change trajectories by date and the difference between the average with shock and the average with no shock. We plot on this graph the overall effect including all effects (i.e. direct, indirect and feedback loop effects, dark blue line) and also direct effects (red dashed line). Confidence intervals are also reported (grey shaded area) they are obtained using bootstrap simulations (27 simulations).

Figure 7: Aggregate Wage Adjustment to Shocks Taking into Account or Not for Minimum Wages



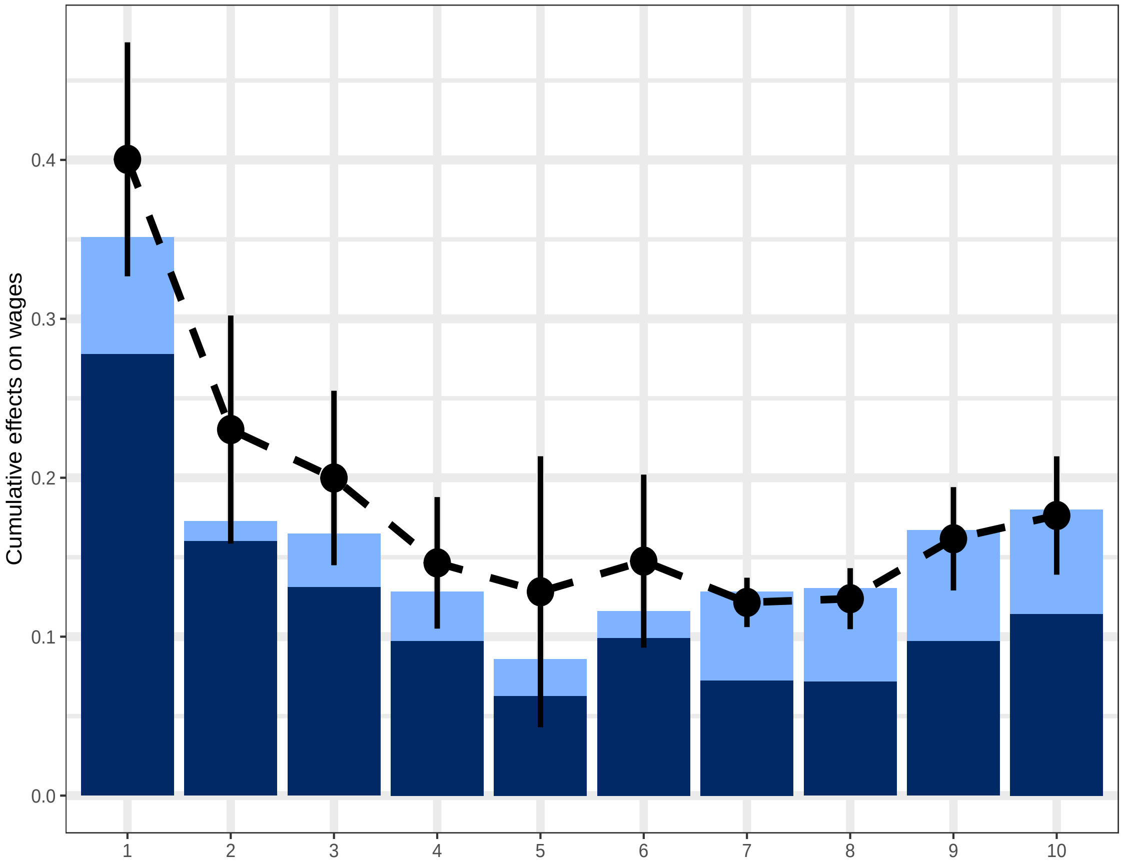
Note: we report the results of our simulation exercize: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants. The shock is introduced in 2010Q1. We compute the average of all wage change trajectories by date and report the difference between the average with shock and the average with no shock. We also report confidence intervals using bootstrap simulations. The response to the shock ignoring wage-setting institutions is computed with the Tobit specification (1), without any indirect or feedback loops effects. The full response to the shock (with indirect and feedback loop effects) is derived from the multi-level simulated model described in the simulation section.

Figure 8: Aggregate Wage Adjustment to Shocks by Quarter



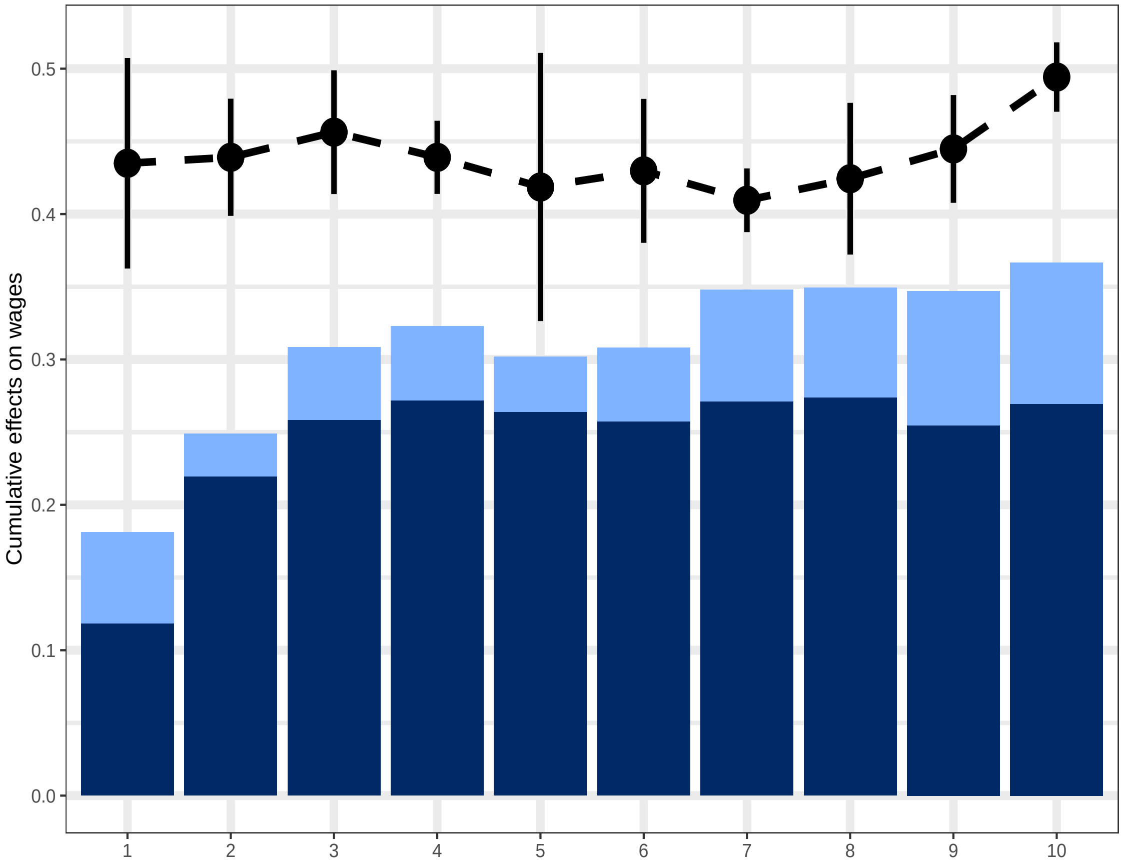
Note: We here report the results of our simulation exercize: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants. We compute the average of all wage change trajectories by date and the difference between the average with shock and the average with no shock. We plot on this graph the aggregate response to a shock when we assume that the shock is introduced either in 2010Q1, 2010Q2, 2010Q3, or 2010Q4. The long-run effects incorporate indirect and feedback loop effects.

Figure 9: Aggregate Wage Effects of the NMW Along the Wage Distribution



Note: We plot long-run effects of a 1% increase of the NMW on base wages. These effects are obtained using our simulation exercize where we allow for indirect effects through wage floor adjustment, NMW response and feedback loop effects. Simulations are made using parameter estimates from a Tobit model where all exogenous variables interact with dummy variables corresponding to deciles of the wage distribution. We report separately long run effects coming from direct effects of the shock on base wages (dark blue histograms), indirect effects through wage floor adjustment (light blue). The black dashed line also includes feedback loop effects and corresponds to the overall effect of a shock.

Figure 10: Aggregate Wage Effects of Inflation along the Wage Distribution



Note: We plot long-run effects of a 1% increase of the CPI inflation on base wages. These effects are obtained using our simulation exercize where we allow for indirect effects through wage floor adjustment, NMW response and feedback loop effects. Simulations are made using parameter estimates from a Tobit model where all exogenous variables interact with dummy variables corresponding to deciles of the wage distribution. We report separately long run effects coming from direct effects of the shock on base wages(dark blue histograms), indirect effects through wage floor adjustment (light blue). The black dashed line also includes feedback loop effects and corresponds to the overall effect of a shock.

APPENDIX - Not intended to be published

A Calibration Exercize

The aim of this appendix is to describe a simple micro wage rigidity set-up where we can provide simple predictions on the shape and duration of the aggregate response of wages to a given shock. These predictions should be considered as qualitative since our aim is not here to reproduce all the patterns of the micro data. In this calibration, we define simple processes for individual wages and minimum wages.

The frictionless wage is defined as:

$$w_{it}^{*} = \eta_w z_{it} + \gamma t + \alpha \times S 1_{\{t \geq 0\}} \tag{7}$$

where z_{it} is the MW, t a time trend, S an exogenous shock to w^{*}. The propensity to increase wage is defined as:

$$R_{it}^{*} = d 1_{\{t-\tau_{it}=4\}} + \eta_p (z_{it} - z_{i\tau_{it}}) + \beta \times S 1_{\{\tau_{it} \leq 0\}} + \epsilon_{it} \tag{8}$$

where τ_{it} is the date since the last wage w_i adjustment and S is the shock, we allow the probability of a wage change to be higher every 4 quarters (like in Taylor).

Adjustments in z_{it} are also assumed to be infrequent. The frictionless minimum wage is defined as:

$$z_{it}^{*} = \gamma^{z} t + \alpha^{MW} \times S 1_{\{t \geq 0\}} \tag{9}$$

and

$$z_{it} = z_{i\tau_i^z} + R_{it}^{z} (z_{it}^{*} - z_{i\tau_i}^{*}) \tag{10}$$

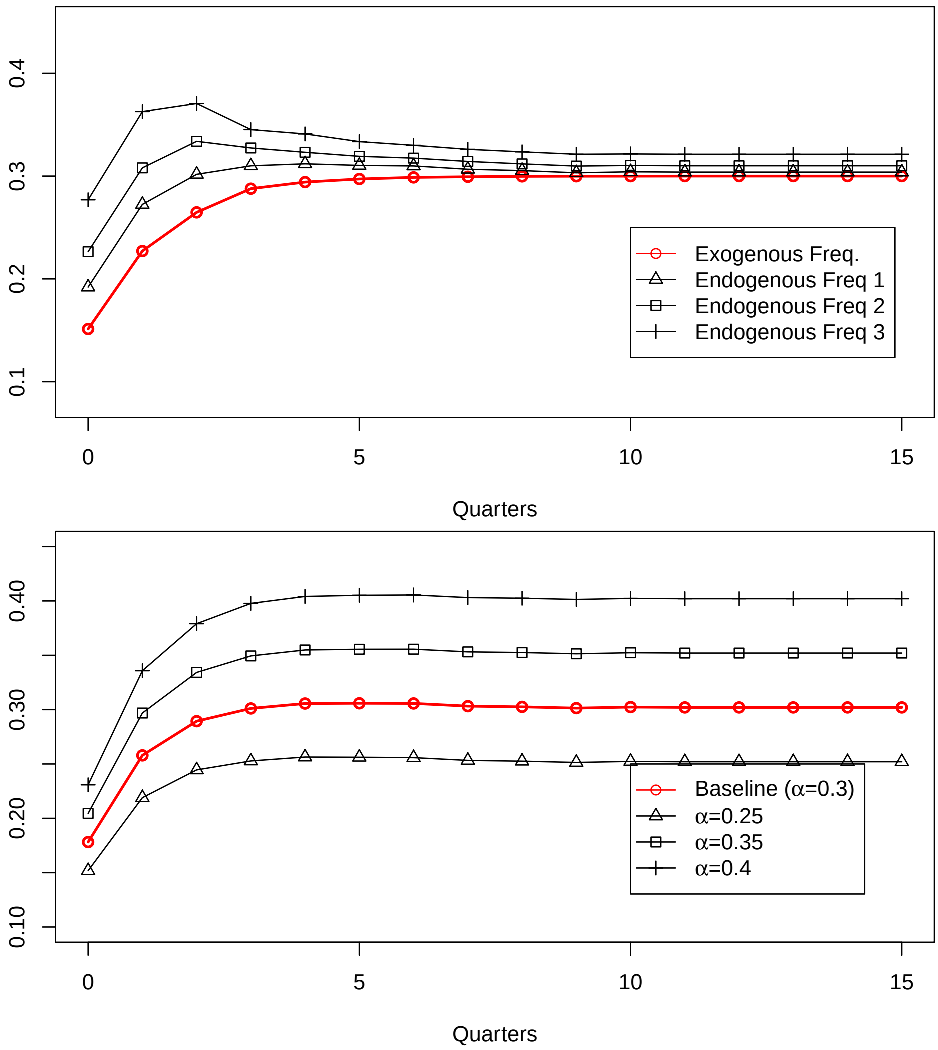
.

Minimum wage adjusts when $R^z_{it} = 1$ when $R^{z*}_{it} > 0$ where:

$$R^{z*}_{it} = d^z 1\{t - \tau^z_{it} = 4\} + \beta^{MW} \times S1\{\tau^z_{it} \leq 0\} + \epsilon^z_{it} \tag{11}$$

To obtain impulse response functions, we compare the case where $S = 1$ with $S = 0$. In our baseline exercize, we set $(\alpha = 0.3, \beta = 0.0, \gamma = 0.5)$. In the figures below, we allow, α and β to vary. To illustrate the role of MW in the transmission of shocks, we also run exercizes where the shock only affects the MW and so wages through MW. For that, we set $\eta_w = 0.3$ and $\eta_p = 0.1$ and we allow α^{MW} and β^{MW} to vary.

Figure A: Aggregate Wage Dynamics without MW - Calibration Exercizes



Note: We here report aggregate wage response to a shock affecting in a model without MW. The top panel reports aggregate wage response where we vary the parameter associated with the shock in the equation describing the probability of a wage adjustment whereas the other panel plots aggregate wage response to a shock where we vary the parameter associated with the shock in the equation describing the frictionless wage

B Data Appendix

B.1 Measurement issues

Measurement issues in our individual wage data are very limited here for two reasons. First, wages are reported by firms and not by workers. Second, the statistical office of the French Ministry of Labour is very careful in the conduct of this survey to maintain its high quality since the evolution of base wage partially grounds the NMW increase formula. Surveyors monitor quite closely unusual wage increases or decreases and they can interview the firm several times to check the answer to the questionnaire. One potential measurement issue arises when wage trajectories are not associated with the same employee over time (for instance, a given firm chooses a new employee to report the base wage associated with a given job position). The information on employee substitution is not reported in the data set. We consider here that the wage trajectory is continuous as long as the wage change between two quarters stands between -1% and +7%. If not, we assume that the job is not occupied by the same individual and we assume a new wage trajectory. The proportion of wage changes outside the range -1% to 7% is very small (less than 1% of all initial survey observations) and results are not sensitive to the choice of the threshold.

We also compute a variable reporting the position of the job occupation in the wage distribution based on its position with respect to the value of its base wage relative to the NMW at its first date of observation. Deciles corresponding to the ratio base wage over NMW are used as thresholds defining dummy variables. For that, at the first date the base wage is observed for worker in a given firm, we calculate the ratio of the base wage over the NMW. We then compute the deciles of this ratio over workers and construct dummy variables equal to one if the initial wage of a given worker is between two deciles of this ratio. The deciles are the following: 0.97*NMW, 1.04*NMW, 1.12*NMW,

1.2*NMW, 1.3 NMW, 1.5*NMW, 1.6*NMW, 1.9*NMW, 2.2*NMW, 2.9*NMW. Wages below 0.97*NMW and above 8*NMW are discarded from our data set, they represent less than 1% of our overall sample. These dummy variables allow us to investigate the heterogeneity across workers according to the distance of their wage to the NMW.

Measurement issues on wage agreement data.

- Industry-level agreements

The data set consists of wage floors collected by hand on a governmental web site (https://www.legifrance.gouv.fr/) publishing texts of all wage agreements for almost all industries. Measurement issues are very limited.

- Firm-level agreements

We have removed all firm-level wage agreements dealing with specific bonuses due to Villepin Law 2006 and Sarkozy law in 2008. These two laws have led to a large increase in the number of wage agreements but most of them were signed by small firms and were dealing with a specific annual bonus not monthly base wage increases.

Unemployment: We use unemployment data at the local level (*Zone d Emploi* and associate to each firm either the local unemployment rate corresponding to its location or the average (weighted) unemployment rate if this firm has several locations. The cumulated change in unemployment is calcualed as the simple difference between date t and the date of the last wage update.

B.2 Data Matching Procedure

The ACEMO survey does not collect the industry-specific wage floor associated with a given worker or the position of the worker in the industry-specific wage scale. Thus, it is difficult to match the two data sets comparing only levels of actual wages and wage floors. Using Portuguese data, Cardoso and Portugal [2005] use the mode of wages to assign a given wage floor to a certain category of employees. This procedure cannot be implemented here since we do not have information on the job category of the worker in the ACEMO survey. Thus, we use the following procedure to assign a wage floor growth to every worker of our sample. We first calculate by bargaining industry (and when possible by broad job categories in the industry) percentiles of the distribution of individual wage levels (ACEMO survey) and percentiles of the distribution of wage floors (industry-level wage agreements data set). We then calculate the wage floor increase associated with the percentiles of the wage floor distribution. Finally, we assign to actual wages in a given percentile of the wage distribution the wage floor increase corresponding to the same percentile in the wage floor distribution. Our main assumption is that in a given industry and job category, lower actual wages are more likely to be affected by increases of lower wage floors.[34] Finally, we match this sample with our data set of firm-level wage agreements using a common firm identifier. The date at which the wage agreement comes into effect is not available and we only have information on the date of signature: we here assume that the wage agreement comes into effect the month after the date of signature.

[34]Most of the variance of wage floor increases in a given industry is however due to variations over time rather than across job occupations in the industry (about 80% of the variance is explained by variations over time and 20% by variations across occupations in the same industry. The variance of wage floor increase across occupations is even smaller when we consider the variance of wage floor increase within a broad job category in a given industry).

C Supplementary Empirical Results

Table A: Aggregate Moments of Wage Changes - by firm size

	Base Wage changes			Collective wage agreements			
				Industry			Firm
	Average (%)	Freq.	Size (%)	Average (%)	Freq.	Size (%)	Freq.
All	0.47	0.27	1.75	0.38	0.21	1.91	0.15
Less 20 workers	0.46	0.22	2.06	0.38	0.20	1.94	0.00
Btw 20 and 50	0.45	0.23	1.96	0.39	0.21	1.92	0.01
Btw 50 and 100	0.44	0.24	1.88	0.39	0.21	1.92	0.03
Btw 100 and 200	0.44	0.24	1.84	0.37	0.20	1.88	0.08
Btw 200 and 500	0.46	0.26	1.76	0.39	0.22	1.85	0.13
More than 500	0.48	0.29	1.68	0.38	0.20	1.92	0.22

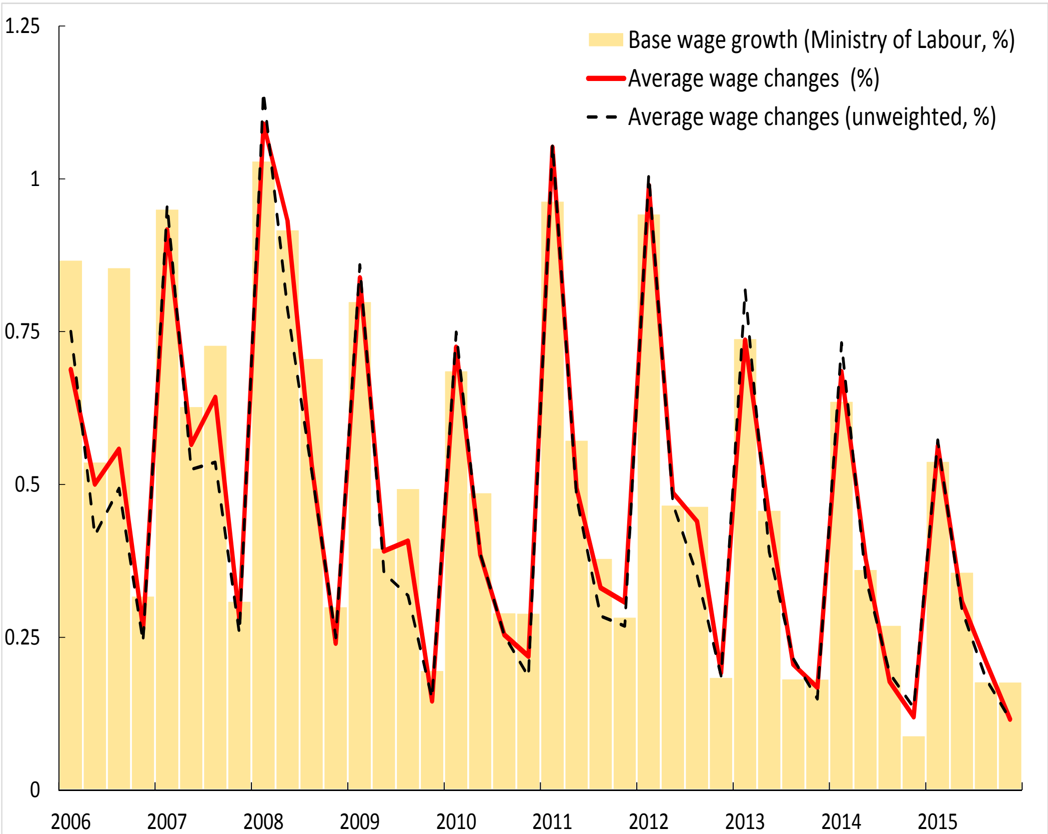
Note: Moments are calculated using the data set matching ACEMO individual data, firm-level and industry-level wage agreements data sets. The first column contains the average quarterly wage changes for all workers of our data set. The second column is the proportion of workers whose wage is modified in a given quarter compare to the previous quarter. The third column is the average wage change conditional on observing a wage change. Columns 4-5-6 are the same statistics but calculated for sectoral minimum wage changes in industry-level agreements. The last column is the proportion of workers covered in a given quarter by a firm-level wage agreement. Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

Table B: Aggregate Moments of Wage Changes - by wage level

	Base Wage changes			Collective wage agreements			
				Industry			Firm
	Average (%)	Freq.	Size (%)	Average (%)	Freq.	Size (%)	Freq.
All	0.47	0.27	1.75	0.38	0.21	1.91	0.15
Btw 0.99 and 1.04*NMW	0.47	0.30	1.53	0.41	0.23	1.86	0.12
Btw 1.04 and 1.12*NMW	0.45	0.27	1.70	0.40	0.21	2.00	0.15
Btw 1.12 and 1.2*NMW	0.46	0.26	1.76	0.40	0.21	2.02	0.14
Btw 1.2 and 1.3*NMW	0.48	0.27	1.79	0.39	0.21	1.91	0.14
Btw 1.3 and 1.5*NMW	0.47	0.28	1.66	0.38	0.21	1.91	0.17
Btw 1.5 and 1.6*NMW	0.48	0.27	1.78	0.38	0.21	1.89	0.16
Btw 1.6 and 1.9*NMW	0.48	0.26	1.86	0.37	0.20	1.94	0.16
Btw 1.9 and 2.2*NMW	0.48	0.25	1.95	0.35	0.19	1.88	0.17
Btw 2.2 and 2.9*NMW	0.47	0.23	2.05	0.33	0.19	1.80	0.15
More than 2.9*NMW	0.44	0.20	2.16	0.35	0.19	1.80	0.16

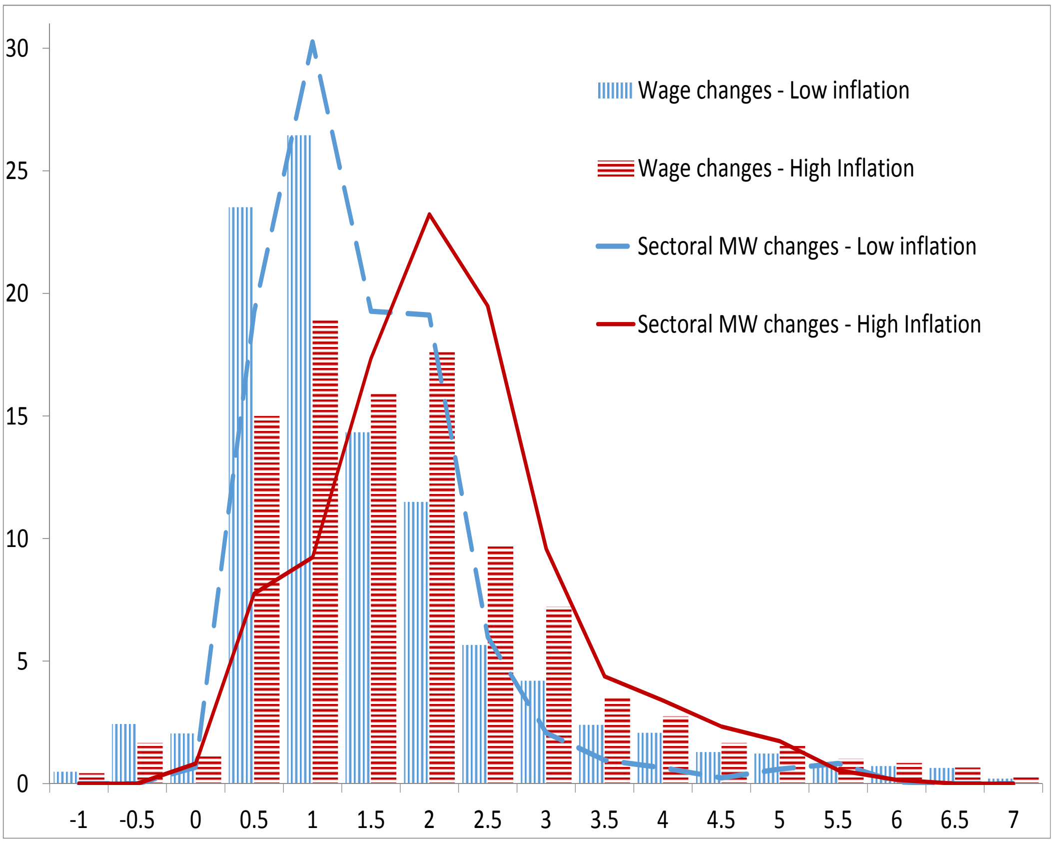
Note: Moments are calculated using the data set matching ACEMO individual data, firm-level and industry-level wage agreements data sets. The first column contains the average quarterly wage changes for all workers of our data set. The second column is the proportion of workers whose wage is modified in a given quarter compare to the previous quarter. The third column is the average wage change conditional on observing a wage change. Columns 4-5-6 are the same statistics but calculated for sectoral minimum wage changes in industry-level agreements. The last column is the proportion of workers covered in a given quarter by a firm-level wage agreement. Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year. The deciles are the following: 0.97*NMW, 1.04*NMW, 1.12*NMW, 1.2*NMW, 1.3 NMW, 1.5*NMW, 1.6*NMW, 1.9*NMW, 2.2*NMW, 2.9*NMW.

Figure B: Comparison of Average Wage Changes in our Sample and Aggregate Base Wage Growth (Min of Labour)



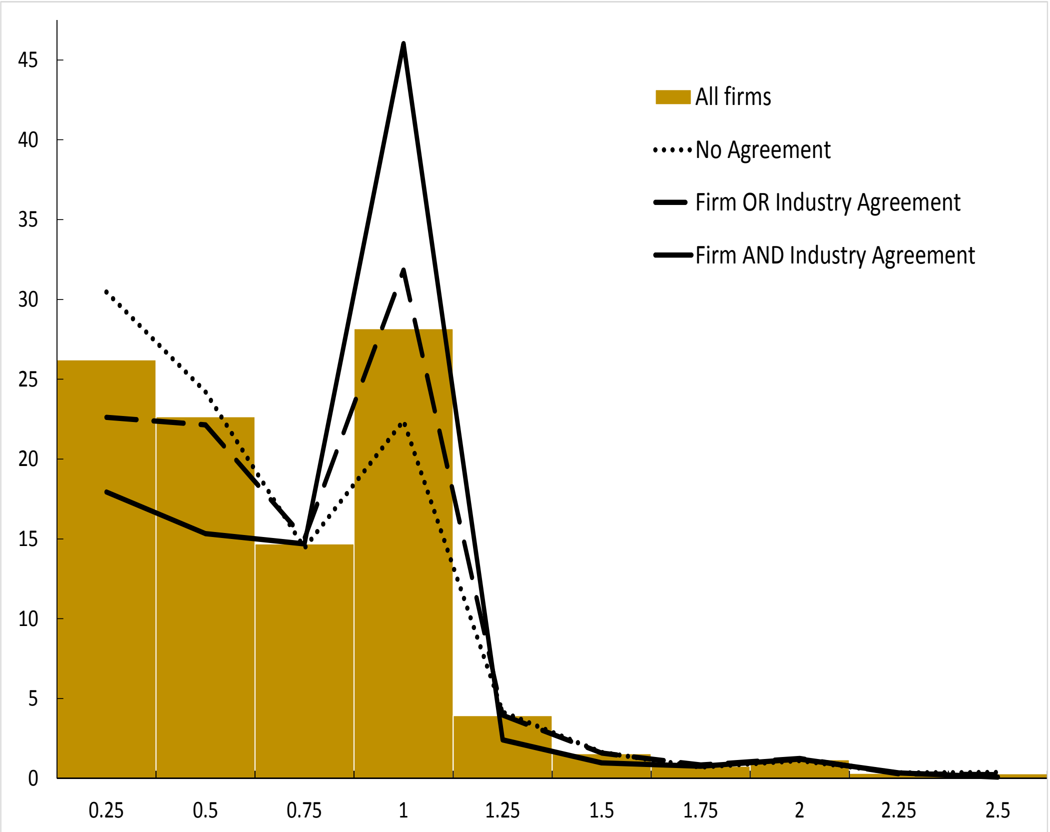
Note: We compute for each quarter the average wage growth as the average of all wage changes of our sample (including 0 change) (weighted (red line) or unweighted (dashed black line)) and compare this average to the time-series of aggregate base wage growth released by the Ministry of Labour (yellow bars). Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

Figure C: Distribution of Wage Changes by Inflation Regime



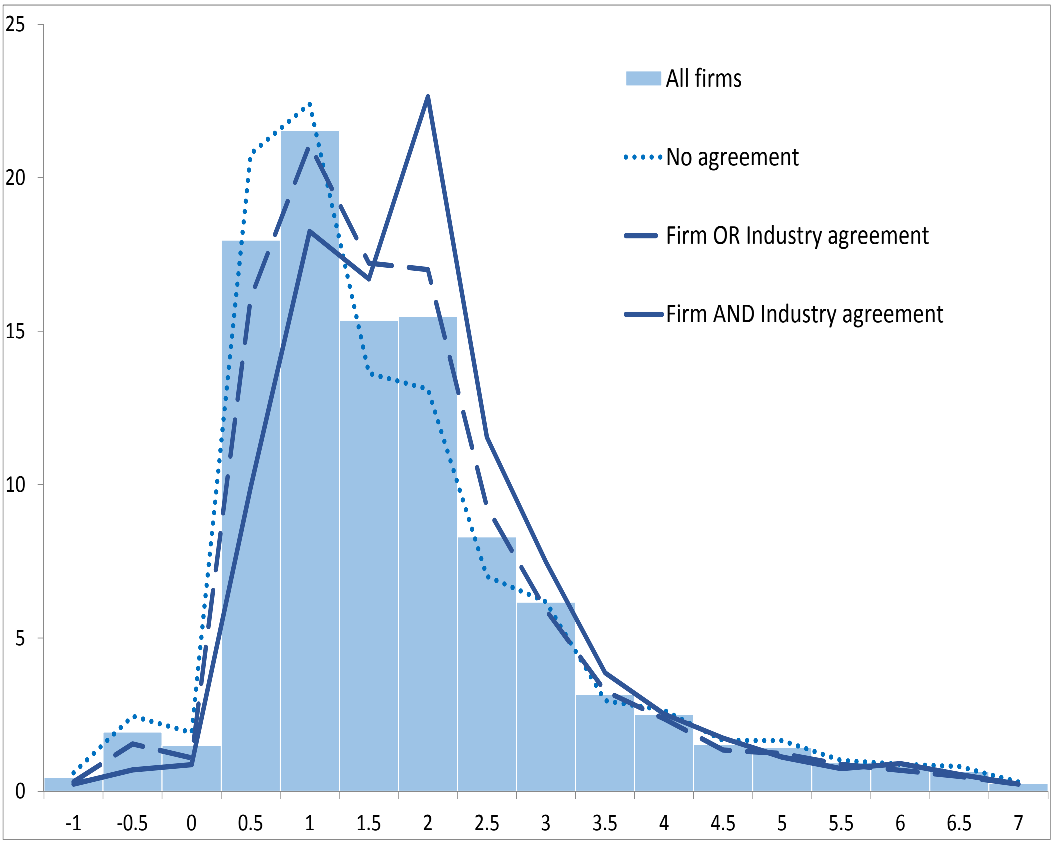
Note: we here compute the distribution of all non-zero wage changes (quarter-on-quarter). We plot the distribution of wage changes for two periods, the first includes years 2010, 2013-2015 (low inflation) (blue bars) whereas the second one includes 2006-2008, 2009, and 2011-2012 (high inflation) (red bars). We do the same for the distribution of changes in wage floors (blue dashed line and red solid line). Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

Figure D: Distribution of Durations Between Two Wage Changes



Note: We here compute the distribution of durations between two wage changes. We plot the distribution of durations considering different bargaining regimes (considering whether to a worker is covered or not by a firm-level or an industry-level agreement). Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

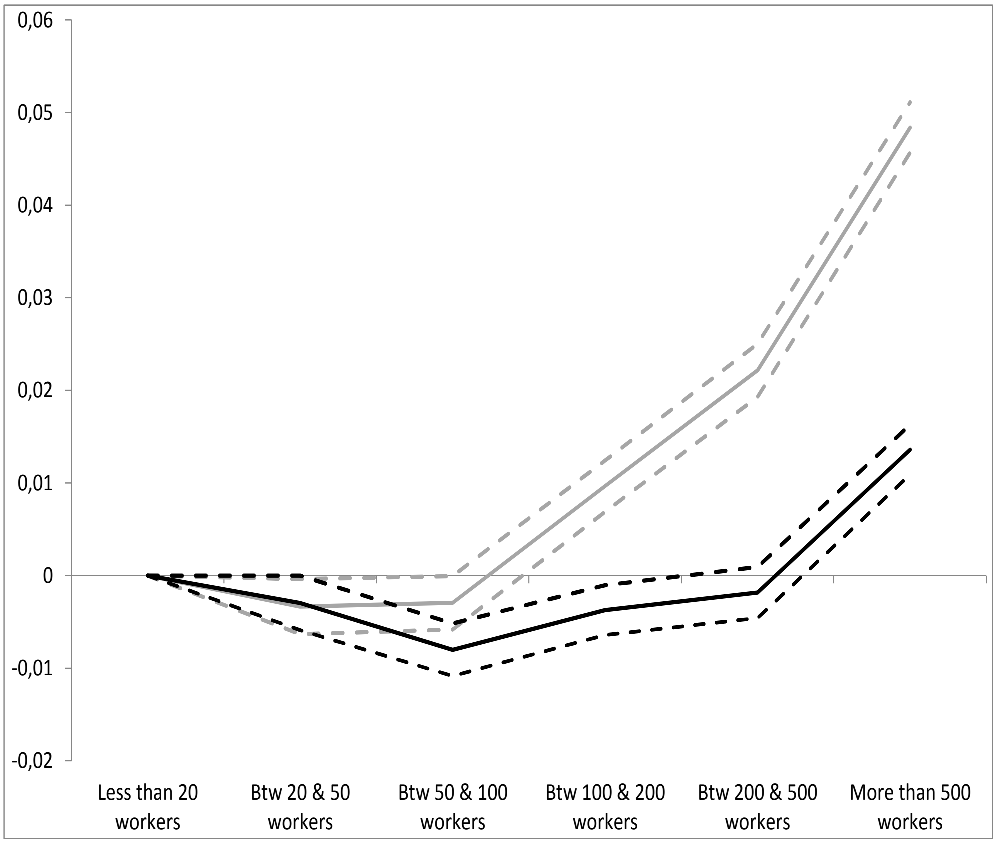
Figure E: Distribution of Wage Changes by Wage Agreement Regime



Note: We here compute the distribution of all non-zero wage changes (quarter-on-quarter). We plot the distribution of wage changes considering different bargaining regimes (considering whether to a worker is covered or not by a firm-level or an industry-level agreement). Statistics are weighted using the number of workers corresponding to each category of workers within the firm in a given year.

D Supplementary Estimation Results

Figure F: Marginal Effects of the Firm's Size on the Probability of a Wage Change: Including or not Wage Bargaining Variables



Note: We plot on this graph the marginal effects associated with the dummy variable for firms' size. These marginal effects are obtained from the Probit regression. We here compare marginal effects obtained using the regression without wage bargaining variables (in grey line, confidence intervals are in dashed lines) and the ones obtained including these variables (in black line, confidence intervals are in dashed lines).

Table C: Determinants of Wage Changes - Tobit Estimates - Robustness

	Probability of wage change			Size of wage change		
	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)
CPI Inflation	0.045***	0.026***	0.016***	0.224***	0.214***	0.215***
	(0.000)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Unemployment	0.003***	−0.012***	−0.009***	−0.085***	−0.092***	−0.091***
	(0.001)	(0.001)	(0.001)	(0.004)	(0.005)	(0.004)
NMW	0.012***	0.009***	-0.014***	0.116***	0.110***	0.110***
	(0.000)	(0.000)	(0.001)	(0.002)	(0.002)	(0.002)
Wage floors	0.030***	0.022***	0.021***	0.137***	0.136***	0.136***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.002)
Firm agreement	0.117***	0.110***	0.110***	0.320***	0.326***	0.326***
	(0.001)	(0.001)	(0.001)	(0.005)	(0.005)	(0.005)
Duration						
1 quarter	Ref.	Ref.	Ref.			
2 quarters	0.014***	0.021***	0.037***			
	(0.001)	(0.001)	(0.001)			
3 quarters	-0.041***	-0.015***	0.017***			
	(0.001)	(0.001)	(0.001)			
1 year	0.346***	0.332***	0.394***			
	(0.001)	(0.002)	(0.002)			
5 quarters	-0.029***	0.020***	0.090***			
	(0.002)	(0.002)	(0.003)			
6 quarters	-0.119***	-0.077***	-0.014***			
	(0.001)	(0.002)	(0.003)			
7 quarters	-0.145***	-0.103***	-0.038***			
	(0.001)	(0.002)	(0.003)			
2 years	-0.049***	-0.006*	0.103***			
	(0.003)	(0.003)	(0.005)			
>2 years	-0.178***	-0.133***	-0.052***			
	(0.001)	(0.002)	(0.004)			
Mills ratio				0.770***	0.751***	0.749***
				(0.003)	(0.003)	(0.003)
Time linear trend				0.441***	0.492***	0.507***
				(0.012)	(0.013)	(0.013)
Time dummies	No	No	Yes	No	No	No
Quarter dummies	No	Yes*2010	No	No	No	No
Observations	1,986,531	1,986,531	1,986,531	466,585	466,585	466,585

Note: We report in this table the marginal effects calculated from the estimation of the Probit model and the parameter estimates obtained from the second step of the Tobit model. Determinants are calculated as cumulative variable since the last wage adjustment. Duration is a dummy variable for durations since the last wage changes. Q1-Q4 are dummy variables for every quarter of the year. Sector, size and wage deciles controls are introduced in all specifications. Time linear trends are interacted with sector, size and wage deciles: here is reported the time trend for the reference (smallest firm size, first decile, and metal industry). *p<0.1; **p<0.05; ***p<0.01.

Robustness Estimation on Annual Wage Growth and Productivity Growth as a Determinant of Wage Growth

Firm-level productivity growth might be one important determinant of the wage dynamics. However, productivity measures are only available at the annual frequency using firms' balance sheet data. In this Appendix, we run robustness analysis linking annual wage growth and annual productivity growth.

Using our ACEMO survey micro data, we first calculate for every worker in our sample, the annual log change in base wage (keeping only wages collected in Q4).[35] Using administrative fiscal data (FICUS-FARE) containing information on the balance sheet of the universe of firms in France, we compute a basic productivity measure constructed as the ratio between value added and the number of workers in the firm. Then, we calculate the log annual change of this firm-level productivity measure. Finally, we match our annual ACEMO data set with the administrative data set containing productivity. This new sample contains a little less than 150,000 observations (year$\times$worker). This sample covers mainly workers in large firms because of the sampling design of the ACEMO survey.

In terms of basic wage rigidity statistics, about 20% of annual wage changes are exactly equal to 0 and less than 0.5% of observations are wage decreases. To take into account that there is a large peak of wage change at zero in the distribution of wage changes, we follow the standard empirical strategy in the DNWR literature (see for instance Altonji and Devereux [2000]) and we estimate a type 1 Tobit model. We define ΔW^*_{ijt} the annual unobserved wage growth which depends on several determinants:

$$\Delta W^*_{ijt} = \beta \Delta X_{ijt} + \mu_{ij} + \lambda_t + \epsilon_{ijt} \tag{12}$$

where X_{ijt} include the annual wage floor growth for worker i in a given sector, a dummy variable equal to 1 if there is a firm-level wage agreement in the firm in a given year, the

[35] Results are robust to the choice of quarter. We here choose to keep Q4 since most wage changes are observed at the beginning of the year (Q1 and to a lesser extent Q2).

local unemployment rate and the annual firm-level productivity growth and possibly its lagged value. We also control for year effects λ_t, wage level effects, sectoral effects and firm size effects (μ_{ij}).[36] the type 1 Tobit model can be written as:

$$\text{If } \Delta W^*_{ijt} \leq 0 \text{ then } \Delta W_{ijt} = 0$$
$$\text{If } \Delta W^*_{ijt} \geq 0 \text{ then } \Delta W_{ijt} = \Delta W^*_{ijt}$$

The estimation results of the model are presented in Table D below. First, when we do not include productivity growth, wage floors, occurrence of a firm-level agreement and unemployment have all very similar impacts in the annual data model than in the quarterly data model (even if the composition of workers/firms is a little different in this new sample). Productivity growth has a positive but very small on annual wage growth: a 1% increase in the firm productivity will increase wage growth by 0.003 pp.[37] We also find that lagged productivity growth has a somewhat larger effect than the contemporaneous value. Finally, introducing productivity growth left almost unchanged parameter estimates of sectoral wage floors, firm agreement or unemployment.

[36] Using annual data, we cannot use any more cumulated changes in inflation or NMW since the support of distribution is more limited than with quarterly data. We introduce year dummies which will capture macro effects.

[37] Le Bihan et al. [2012] provide similar evidence using a productivity growth proxy at the sectoral level. They find almost no significant effect of productivity growth on base wage growth.

Table D: Determinants of Annual Wage Changes: Type 1 Tobit Estimates

	(1)	(2)	(3)
Productivity growth t		0.003^{***}	0.002^{**}
		(0.000)	(0.001)
Productivity growth $(t-1)$			0.002^{***}
			(0.001)
Wage Floors	0.123^{***}	0.116^{***}	0.115^{***}
	(0.004)	(0.005)	(0.005)
Firm Agreement	0.302^{***}	0.304^{***}	0.302^{***}
	(0.010)	(0.010)	(0.011)
Unemployment	-0.019^{***}	-0.019^{***}	-0.021^{***}
	(0.003)	(0.004)	(0.004)
Intercept	0.467^{***}	0.580^{***}	0.559^{***}
	(0.106)	(0.116)	(0.119)
σ_ϵ	1.745	1.716	1.707
	(0.003)	(0.004)	(0.004)
Observations	181,315	146,106	141,579

Note: We report in this table the parameter estimates of the Tobit 1 model estimated using annual wage growth. Productivity growth and change in wage floors are calculated as annual changes. Unemployment is introduced in levels and firm agreement is a dummy equal to 1 if there is a wage firm-level agreement in a given year, equal to 0 otherwise. We have also inluced sector, size, wage deciles and year controls in all specifications. *p<0.1; **p<0.05; ***p<0.01.

Table E: Wage Floor Adjustment: Estimation Results

	Probit Marginal Effects	OLS Param. Estimates
CPI inflation	0.023***	0.253***
	(0.005)	(0.006)
Unemployment	−0.002	0.054***
	(0.002)	(0.002)
NMW	0.029***	0.238***
	(0.004)	(0.006)
Past aggregate wage changes	0.010**	0.312***
	(0.005)	(0.014)
Duration 2Q	0.021**	
	(0.010)	
Duration 1Year	0.337***	
	(0.012)	
Duration 2Years	0.152***	
	(0.026)	
Quarter 1	Ref.	
Quarter 2	-0.088***	
	(0.007)	
Quarter 3	-0.108***	
	(0.007)	
Quarter 4	-0.143***	
	(0.007)	
Mills ratio		0.168***
		(0.011)
Time linear trends by industry		Yes
Observations	14,049	42,603

Note: we report in this table parameter estimates from the Tobit model estimated on wage floor adjustments. The endogenous variable in the Probit part of the model is a dummy variable for wage agreement in a given industry at date t and in the OLS part the endogenous variable is the wage change for position j in industry i at date t. In every industry, there are several positions. Determinants are calculated as cumulative variable since the last wage adjustment, all in nominal terms. Controls for sectors and quarters are included. *p<0.1; **p<0.05; ***p<0.01.

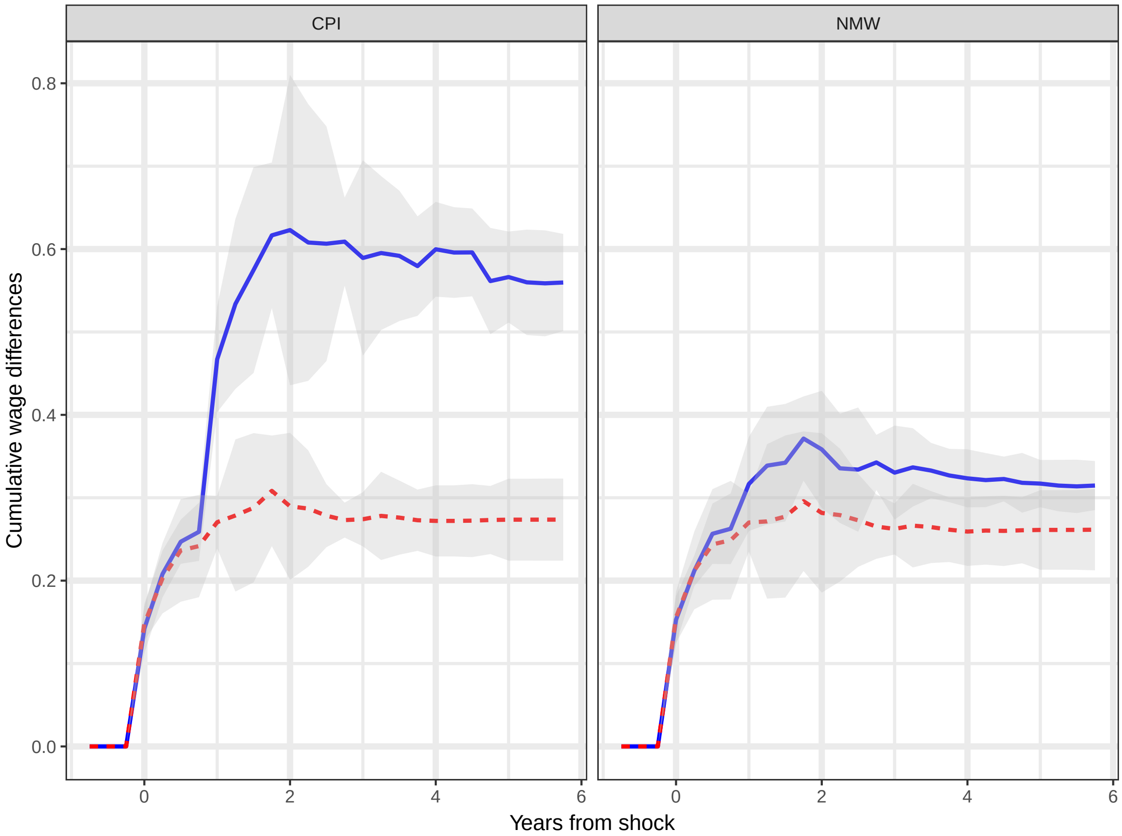
Table F: Firm-level Agreements: Probit Results

Marginal Effects			
Time variables		*Firm-level characteristics*	
CPI inflation	0.004***	% of NMW earners	−0.053***
	(0.001)		(0.004)
Unemployment	0.001***	% of full-time workers	0.016***
	(0.000)		(0.004)
NMW	−0.004***		
	(0.001)		
Wage Floors	−0.002***		
	(0.000)		
Duration		*Size*	
2Q	0.015***	< 20 employees	Ref.
	(0.002)		
3Q	0.076***	20 - 50 employees	0.053***
	(0.003)		(0.011)
4Q	0.414***	50 - 100 employees	0.085***
	(0.004)		(0.011)
5Q	0.172***	100 - 200 employees	0.107***
	(0.004)		(0.010)
6Q	0.015***	200 - 500 employees	0.143***
	(0.004)		(0.012)
7Q	0.037***	> 500 employees	0.176***
	(0.004)		(0.012)
8Q	0.226***		
	(0.006)		
More than 8Q	0.017***		
	(0.004)		
Seasonal effects			
Quarter 1	Ref.		
Quarter 2	−0.020***		
	(0.002)		
Quarter 3	−0.093***		
	(0.001)		
Quarter 4	−0.048***		
	(0.001)		
Observations		326,624	

Note: we report in this table marginal effects from the Probit model estimated on the occurrence of a firm-level wage agreement in a given firm at date t. CPI inflation, unemployment, NMW and wage floors are calculated as cumulative change since the last wage adjustment. % of NMW earners is the share of employees paid close to the NMW (less than 1.2× the NMW) in a given firm in a given year (source DADS). % of full-time workers is the share of employees whose contract is an open-ended contract (CDI in French) in a given firm in a given year (source DADS). Controls for sectors and quarters are included. *p<0.1; **p<0.05; ***p<0.01

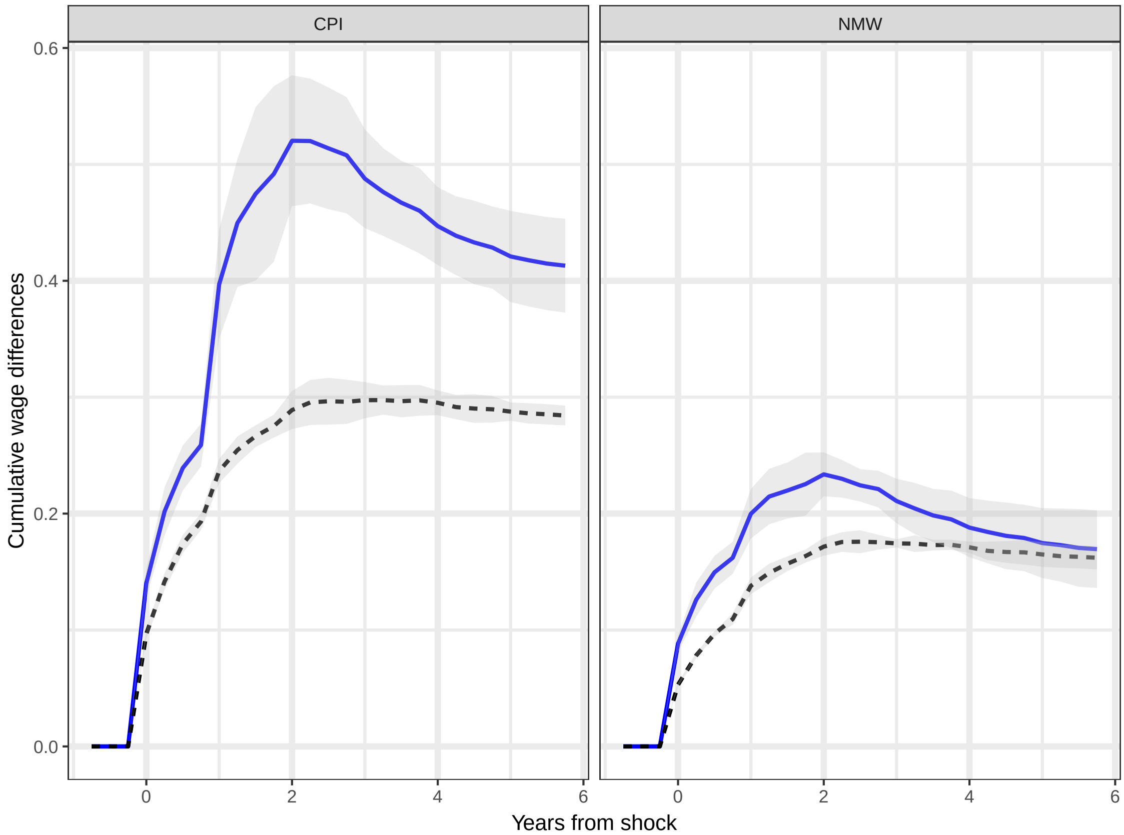
E Supplementary Simulation Results

Figure G: Aggregate Wage Floor Response to NMW and CPI Shocks



Note: We here report the results of our simulation exercize on wage floors in industry-level agreements. Using our estimated model on wage floors, we simulate two groups of wage floor trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants. We compute the average of all wage floor trajectories by date and the difference between the average with shock and the average with no shock. We plot on this graph the aggregate response over time of wage floors to a 1%-increase in NMW and inflation. The red dashed line corresponds to the direct effects of a shock (without feedback loop effects) whereas the blue solid line corresponds to the overall effect (including feedbakc loop effects). We also report confidence intervals using bootstrap simulations.

Figure H: Aggregate Wage Adjustment to Shocks - Exogenous Frequencies of Sectoral Minimum Wage Changes and Base Wage Changes



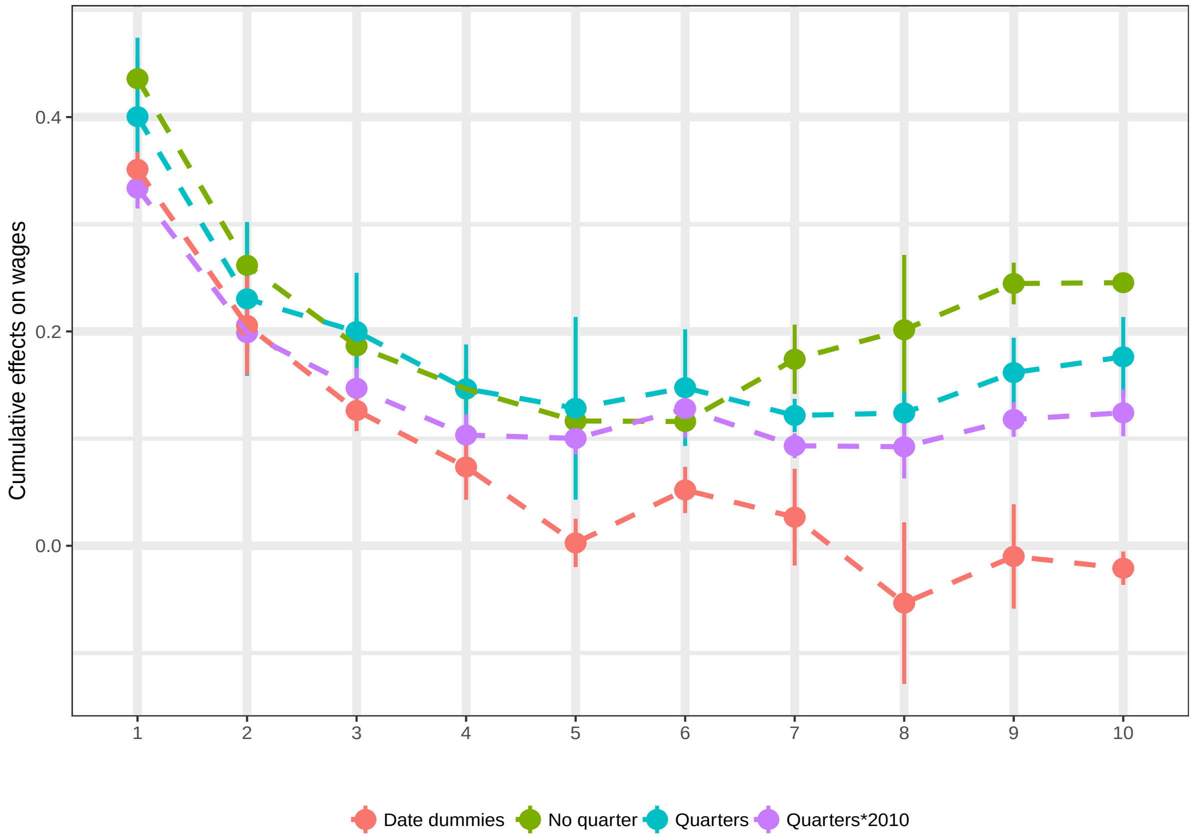
Note: We here report the results of our simulation exercize: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants. The shock is introduced in 2010Q1. We compute the average of all wage change trajectories by date and report the difference between the average with shock and the average with no shock. We also report confidence intervals using bootstrap simulations. The response to the shock in the case where we assume exogenous frequencies of minimum wage and individual wage adjustment is obtained by assuming that the shock does not affect the probability of a wage adjustment (probabilities of wage changes are taken as predicted by the model without shock). The full response to the shock (with indirect and feedback loop effects) is derived from the multi-level simulated model described in the simulation section.

Table G: Duration Before Long-Term Adjustment

	Duration (in Q) Before Full Adjustment			% of Long-Term Effect At Date:		
	90%	95%	98%	t	t+1	t+2
NMW and Industry-Level MW (Specification 3)						
Inflation						
Direct effect	13	15	18	0.54	0.75	0.88
Overall effect	17	19	> 20	0.34	0.49	0.58
NMW						
Direct effect	15	17	19	0.59	0.82	0.95
Overall effect	18	> 20	> 20	0.52	0.74	0.88
NMW only (Specification 2)						
Inflation						
"Direct"	13	16	17	0.56	0.78	0.9
Overall	16	18	> 20	0.41	0.57	0.66
NMW						
"Direct"	15	17	19	0.61	0.84	0.96
Overall	17	18	> 20	0.61	0.82	0.96
No Minimum Wage (Specification 1)						
Inflation						
"Direct"	14	17	20	0.62	0.86	0.98

Note: this table reports results on the dynamic aggregate effect of a shock on wages. In the first three columns we report the number of quarters before the cumulative effect is equal to 90, 95 or 98% of the long term effect of a shock on aggregate wages. Our criterion is the following: the first date at which the cumulative response is equal to a given ratio and this ratio should not be lower the four quarters ahead. The last three columns reports the ratio between the cumulative response and the long run effect measured at t (date of the shock), t+1 one quarter after the shock and t+2 two quarters after the shock. We report the results for the three models estimated. For each specification, we have reported results for a NMW or inflation shock. "Direct effect" is the case where the shock affects only base wages directly (and not wage floors). "Overall effects" is the case where we allow sectoral and national minimum wages to respond to the shock.

Figure I: Aggregate Wage Effects of the NMW Along the Wage Distribution - Robustness to the Probit Specification



Note: We plot long-run effects of a 1% increase of the NMW on base wages by decile of the wage distribution. These effects are obtained using our simulation exercize where we allow for indirect effects through wage floor adjustment, NMW response and feedback loop effects. Simulations are made using parameter estimates from a Tobit model where all exogenous variables interact with dummy variables corresponding to deciles of the wage distribution. The different lines correspond to different Tobit specifications used for the simulation exercize. In blue, we plot our baseline estimates (including quarter dummies in the Probit model), in green, the estimates when we assume no quarter dummies, in red light with date dummies and in purple, quarter dummies interacted with a dummy before/after 2010.

Table H: Long-Term Aggregate Effects - Robustness to the Timing of the Shock

	Direct	Direct + Indirect	Overall
NMW			
Baseline (Q1 2010)	0.129	0.162	0.172
	(0.004)	(0.010)	(0.016)
(Q1) 2008	0.114	0.139	0.136
	(0.003)	(0.002)	(0.003)
(Q1) 2009	0.146	0.202	0.209
	(0.004)	(0.002)	(0.006)
(Q1) 2011	0.118	0.155	0.139
	(0.003)	(0.002)	(0.002)
Q2 (2010)	0.112	0.140	0.135
	(0.003)	(0.003)	(0.005)
Q3 (2010)	0.115	0.144	0.160
	(0.001)	(0.001)	(0.007)
Q4 (2010)	0.114	0.146	0.150
	(0.001)	(0.001)	(0.007)
CPI Inflation			
Baseline (Q1 2010)	0.239	0.286	0.417
	(0.004)	(0.012)	(0.020)
(Q1) 2008	0.223	0.260	0.429
	(0.006)	(0.004)	(0.003)
(Q1) 2009	0.263	0.330	0.243
	(0.006)	(0.008)	(0.008)
(Q1) 2011	0.230	0.283	0.519
	(0.003)	(0.008)	(0.005)
Q2 (2010)	0.221	0.258	0.425
	(0.005)	(0.006)	(0.006)
Q3 (2010)	0.225	0.263	0.430
	(0.005)	(0.006)	(0.018)
Q4 (2010)	0.222	0.263	0.425
	(0.007)	(0.007)	(0.018)

Note: This table reports results from simulation exercise described in section 4.4 where we allow wage floors and the NMW to react to changes in CPI and NMW (indirect effects) but also to aggregate wage changes due to the response to the shock (feedback loop effects). We report the long-run impact of 1% increase in a given variable on wage changes. Column (1) reports direct long run effects coming from the adjustment of wages to shocks under the assumption that wage floors and the NMW are not responding to shocks in CPI or NMW. Column (2) reports the indirect effect of the shock on base wages coming from the adjustment of wage floors to a given shock. The last column reports the overall effect of the shock on base wages including the direct effect, indirect effect coming from wage floor adjustments and feedback loop effects coming from the adjustment of NMW, wage floor and aggregate wage changes.

Table I: Dynamic Effect of Shocks - Sensitivity to Quarter of the Shock

	Number of Quarters Before Full Adjustment			% of Long-Term Effect At Date:		
	90%	95%	98%	t	t+1	t+2
Direct effect						
Inflation						
Q1	13	15	18	0.54	0.75	0.88
Q2	13	16	> 20	0.32	0.52	0.63
Q3	12	15	17	0.25	0.39	0.84
Q4	11	14	16	0.17	0.72	0.91
NMW						
Q1	15	17	19	0.59	0.82	0.95
Q2	16	18	> 20	0.37	0.59	0.72
Q3	14	16	> 20	0.28	0.44	0.94
Q4	14	15	17	0.19	0.81	1.01
Overall Effect						
Inflation						
Q1	17	19	> 20	0.34	0.49	0.58
Q2	19	> 20	> 20	0.17	0.29	0.36
Q3	16	> 20	> 20	0.14	0.23	0.76
Q4	16	> 20	> 20	0.1	0.67	0.88
NMW						
Q1	18	> 20	> 20	0.52	0.74	0.88
Q2	> 20	> 20	> 20	0.32	0.56	0.69
Q3	> 20	> 20	> 20	0.23	0.37	0.85
Q4	> 20	> 20	> 20	0.16	0.74	0.99

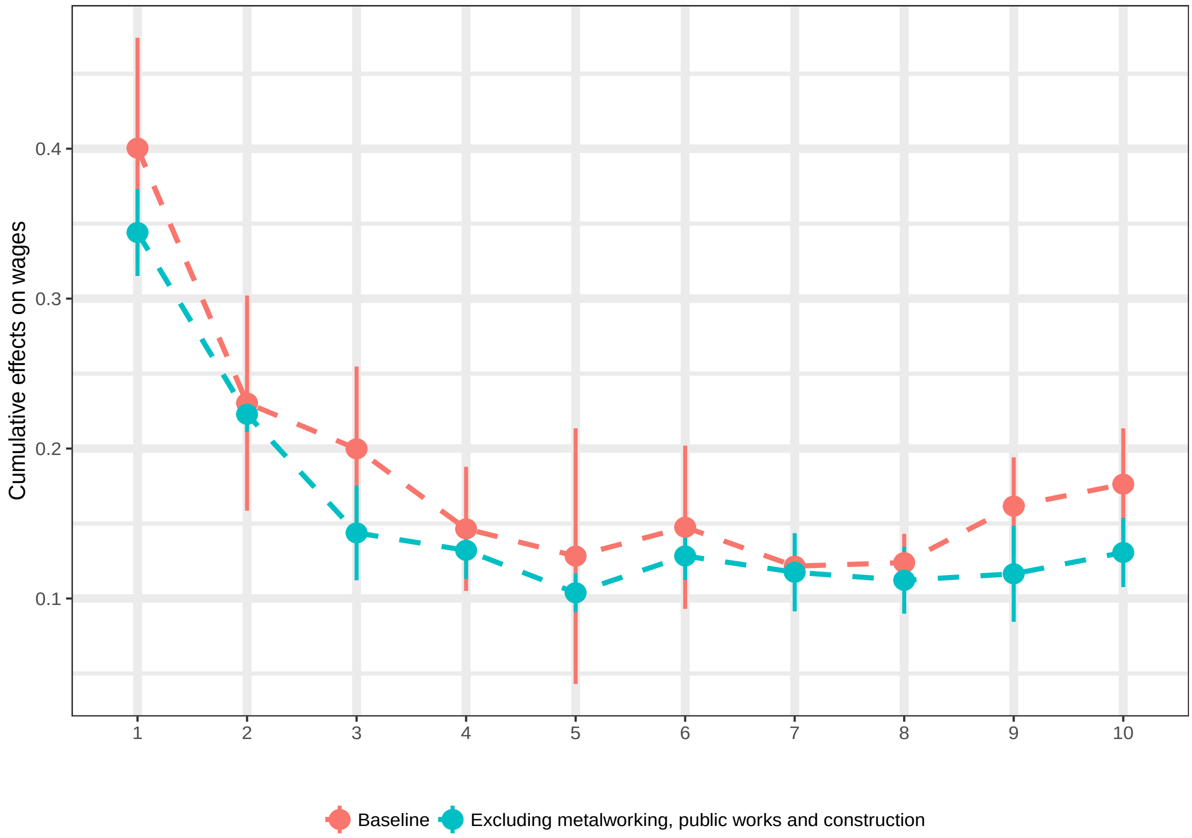
Note: this table reports results on the dynamic aggregate effect of a shock on wages. In the first three columns we report the number of quarters before the cumulative effect is equal to 90, 95 or 98% of the long term effect of a shock on aggregate wages. Our criterion is the following: the first date at which the cumulative response is equal to a given ratio and this ratio should not be lower the four quarters ahead. The last three columns reports the ratio between the cumulative response and the long run effect measured at t (date of the shock), t+1 one quarter after the shock and t+2 two quarters after the shock. "Direct effect" is the case where the shock affects only base wages directly (and not wage floors). "Overall effects" is the case where we allow sectoral and national minimum wages to respond to the shock.

Table J: Long-Term Aggregate Effects - Robustness to the Probit Specification

	Direct	Direct + Indirect	Overall
NMW			
Baseline (Quarter effects)	0.129	0.162	0.172
	(0.004)	(0.010)	(0.016)
No Quarter Effects	0.128	0.191	0.211
	(0.005)	(0.003)	(0.002)
Quarter Effects * Before/After 2010	0.116	0.148	0.157
	(0.002)	(0.003)	(0.002)
Time dummies	0.067	0.107	0.120
	(0.002)	(0.006)	(0.004)
CPI Inflation			
Baseline (Quarter effects)	0.239	0.286	0.417
	(0.004)	(0.012)	(0.020)
No Quarter Effects	0.270	0.349	0.460
	(0.003)	(0.006)	(0.008)
Quarter Effects * Before/After 2010	0.237	0.286	0.420
	(0.004)	(0.005)	(0.004)
Time dummies	0.257	0.313	0.423
	(0.002)	(0.002)	(0.002)

Note: This table reports results from simulation exercise described in section 4.4 where we allow wage floors and the NMW to react to changes in CPI and NMW but also to aggregate wage changes due to the response to the shock (feedback loop effects). Column (1) reports direct long run effects coming from the adjustment of wages to shocks under the assumption that wage floors and the NMW are not responding to shocks. Column (2) reports the indirect effect of the shock on base wages coming from the adjustment of wage floors to a given shock. The last column reports the overall effect of the shock on base wages including the direct effect, indirect effect coming from wage floor adjustments and feedback loop effects coming from the adjustment of NMW, wage floor and aggregate wage changes. Confidence interval are provided in brackets and are obtained using bootstrap simulations.

Figure J: Aggregate Wage Effects of the NMW Along the Wage Distribution - Excluding Metalworking, Public Works and Construction Wage Agreements Covering Managers



Note: We plot long-run effects of a 1% increase of the NMW on base wages by decile of the wage distribution. These effects are obtained using our simulation exercize where we allow for indirect effects through wage floor adjustment, NMW response and feedback loop effects. Simulations are made using parameter estimates from a Tobit model where all exogenous variables interact with dummy variables corresponding to deciles of the wage distribution. In blue dashed line, we plot the estimates obtained when we exclude from the sample workers covered by national wage agreements covering managers in the construction, public works and metalworking industries. In light red, we plot our baseline estimates.

F Direct, Indirect and Feedback Loop Effects

Figure K: Direct and Indirect Effects of NMW on Wages

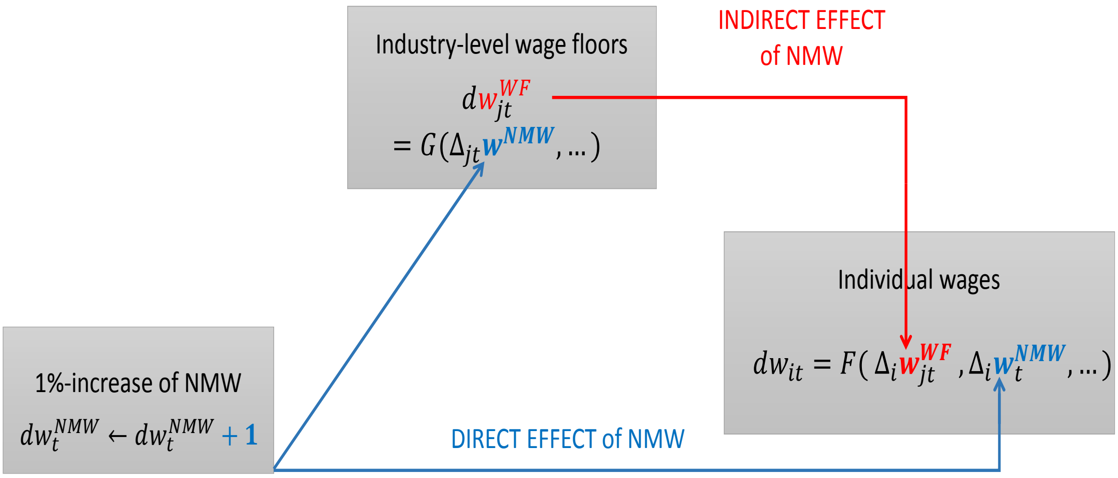
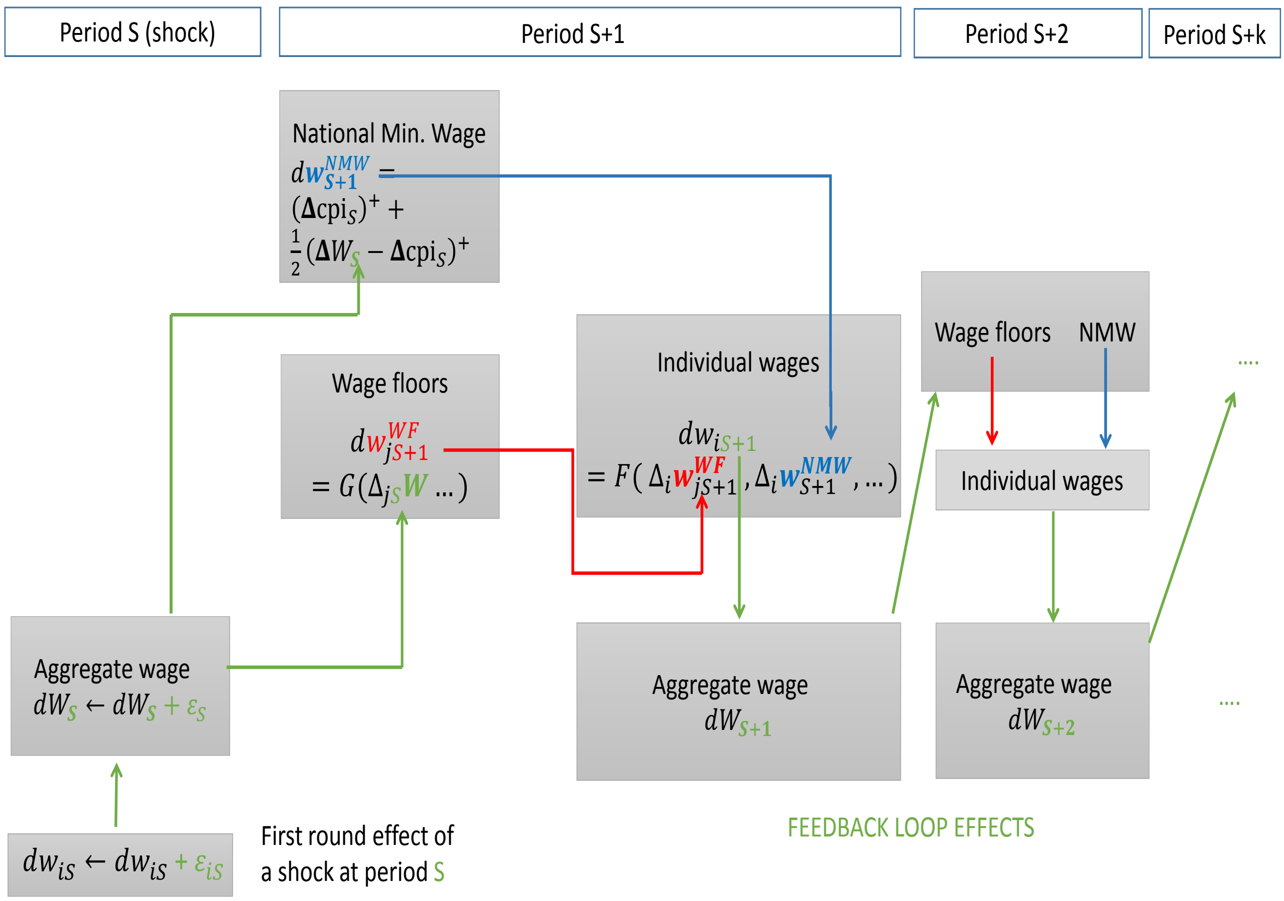


Figure L: Feedback Loop Effects of a Base Wage Increase



G Simulation Exercize: Detailed Algorithms

In this section, we present our simulation setting. We will denote:

- cpi_t, w_t^{NMW}, w_{jt}^{WF}, w_{it} and W_t, respectively CPI at quarter t, NMW at t, sectoral wage floor at t for industry and classification j, wage for individual i at quarter t, and aggregate wage W_t.
- The notation dX stands for the quarter-to-quarter variation of X
- The notation ΔX is the cumulated variation of X since last wage change. The wage considered is either the NMW, sectoral wage floor or individual base wage depending on the wage variation defined by the equation.

We start with the fully simulated set-up without shocks (our benchmark simulation) described below in Algorithm 1. In Algorithm 2, we describe how this algorithm is modified to take into account for indirect effects. To obtain a setting without feedback loop, we use Algorithm 1 without the steps involving the update of W_t and dw_t^{NMW}, that are instead taken as given and therefore not affected by the shock[38]. To obtain a setting with only direct effects, we use Algorithm 1 with the previous modification and without updating w^{WF} that is taken as given. In this last case, we only set new individual wages with w^{WF}, W, w^{NMW} taken as the observed values and therefore not affected by the shock that only enters directly the equation of individual wages through the specified shock.

[38]Except when dw_t^{NMW} is explicitly hit by a shock, but it is then computed with observed values plus the value of the shock without further modifications due to the variations of the aggregate wage entering the legal rule.

Algorithm 1 Simulation setting - with indirect effects and feedback loop - NO SHOCK

Require: $\{dcpi_t\}_{1\leq t\leq T}$, initial values at $t = 1$ (set at observed values) for all variables and their cumulated sums.

while $t \neq T$ **do**

if NMW has to be updated at t **then**

$dw_t^{NMW} = max(\Delta cpi_{t-1}, 0) + \frac{1}{2}(\Delta W_{t-1} - \Delta cpi_{t-1})$

else

$dw_t^{NMW} = 0$

end if

(STEP t) Setting of new wage floors and individual wage changes and update cumulated values for $t + 1$

- Update the cumulated structure of wage floors and individual wages due to current minimum wage change:
$\Delta w_{j,t}^{NMW} = \Delta w_{j,t}^{NMW} + dw_t^{NMW}$
$\Delta w_{i,t}^{NMW} = \Delta w_{i,t}^{NMW} + dw_t^{NMW}$

- Set new wage floors for industry and job classification j at quarter t:
$dw_{jt}^{WF} = F(\Delta_j cpi_t, \Delta_j w_t^{NMW}, \Delta_j W_{t-1}, \cdots)$ as specified in the Tobit model for wage floors (Table E for parameter estimates)

- Update the cumulated structure of wage floors at the individual level:
$\Delta w_{i,t}^{WF} = \Delta w_{i,t}^{WF} + dw_{j(i)t}^{WF}$

- Set new individual wages for i in industry and job classification j:
$dw_{it} = G(\Delta cpi_{it}, \Delta w_{it}^{WF}, \Delta w_{it}^{NMW}, \cdots)$ as specified by the Tobit model described in Section 4.1 (Table 3 for parameter estimates)

dW_t is computed as the weighted average of all simulated dw_{it}

- According to dw_{jt}^{WF}, update cumulated structure at $t + 1$ for wage floors for X_t in CPI_t, W_{t-1}:
$\Delta X_{j,t+1} = (\Delta X_{j,t} + dX_{j,t+1}) \times 1\{dw_{jt}^{WF} = 0\} + dX_{j,t+1} \times 1\{dw_{jt}^{WF} \neq 0\}$

- According to dw_{jt}^{WF}, update cumulated structure at $t + 1$ for wage floors for $X_t = w_t^{NMW}$ (dw_{t+1}^{NMW} is still to be determined):
$\Delta X_{j,t+1} = (\Delta X_{j,t}) \times 1\{dw_{jt}^{WF} = 0\}$

- According to dw_{it}, update cumulated structure at $t+1$ for individual wages, except for $X \notin w^{WF}, w^{NMW}$:
$\Delta X_{i,t+1} = (\Delta X_{i,t} + dX_{i,t+1}) \times 1\{dw_{it} = 0\} + dX_{i,t+1} \times 1\{dw_{it} \neq 0\}$

- For $X \in w^{WF}, w^{NMW}$ (dw_{t+1}^{WF} and dw_{t+1}^{NMW} are still to be determined):
$\Delta X_{i,t+1} = (\Delta X_{i,t}) \times 1\{dw_{it} = 0\}$

end while

Algorithm 2 Simulation setting - with indirect effects and feedback loop - WITH SHOCK

Require: $\{dcpi_t\}_{1\leq t\leq T}$, t_s time of shock, variable potentially hit by a shock $\in \{CPI, NMW\}$, value of the shock K, and initial values at $t = 1$ (set at observed values) for all variables and their cumulated sums.

if the shock hits CPI **then**
  $dcpi_{t_s} = dcpi_{t_s} + K$
end if
while $t \neq T$ **do**
  if NMW is to be updated at t **then**
    $dw_t^{NMW} = max(\Delta cpi_{t-1}, 0) + \frac{1}{2}(\Delta W_{t-1} - \Delta cpi_{t-1})$
  else
    $dw_t^{NMW} = 0$
  end if
  if $t = t_s$ and the shock hits NMW **then**
    $dw_t^{NMW} = dw_t^{NMW} + K$
  end if

  (STEP t) Setting of new wage floors and individual wage changes and update cumulated values for $t + 1$
  as defined in algorithm 1.

end while

H Long Term Effects of a Shock

In this appendix, we compute in a stylized case the long-term effect of a shock. The long-term effect can be decomposed in three terms: (1) the shock to the notional wage, (2) the effect of an increased frequency of wage changes, (3) a selection effect.

We represent as follows the process of wage adjustment:

$$\begin{aligned} R_{it}^{*} &= \left(X_t - X_{\tau_{it}}\right)\alpha + Z\left(t, \tau_{it}\right) b + \nu_{it} \\ w_{it} - w_{it-1} &= \left(\left(X_t - X_{\tau_{it}}\right)\beta + \varepsilon_{it}\right) 1\{R_{it}^{*} > 0\} \end{aligned}$$

where X_t are time-varying macro variables affecting the potential wage and $Z\left(t, \tau_{it}\right)$ are variables affecting the wage change probability (such as calendar effects). ϵ_{it} and ν_{it} may be correlated, we denote the correlation ρ, and assume $\sigma_\nu = 1$. Both residuals are assumed normal.

We compute the exact long term effect in the following simpler case. First, $Z(t, \tau) = 1$. Second, $X_t = S \times 1\{t \geq t_0\}$ varies only through the introduction of a shock S. Our simulation exercizes aim at finding the long term effects which we can not compute analytically in our more complex framework.

There, the model writes simply:

$$\begin{aligned} R_{it}^{*S} &= \alpha S \times 1\{t_0 > \tau_{it}^{S}\} + b + \tilde{\nu}_{it} \\ w_{it}^{S} - w_{it-1}^{S} &= \left(a + \beta S \times 1\{t_0 > \tau_{it}^{S}\} + \varepsilon_{it}\right) 1\{R_{it}^{*} S > 0\} \end{aligned}$$

We introduce a constant a in the wage change equation.[39] The shock appears in an individual trajectory i until the occurrence of a wage change after t_0 (then, $\tau_{it}^{S} \geq t_0$).

Let us denote the event of no wage change since the shock $C_t = \{t_0 > \tau_{it}^{S}\}$. We may compute the evolution at t with $S \neq 0$:

[39] In our estimated model, it takes rather the form of a linear trend whose length depends on past duration since last wage change: $a(t - \tau_{it})$, which we approximate to simplify computations.

$$
\begin{aligned}
E[W_t^S] - E[W_{t-1}^S] &= E[w_{it}^S - w_{it-1}^S] \\
&= E[w_{it}^S - w_{it-1}^S | C_t]\mathbb{P}(C_t) + E[w_{it}^S - w_{it-1}^S | C_t^C](1 - \mathbb{P}(C_t))
\end{aligned}
$$

With respect to the situation without a shock, the difference of aggregate wage variation may be written as follows:

$$
E[w_{it}^S - w_{it-1}^S] - E[w_{it} - w_{it-1}] = (E[w_{it}^S - w_{it-1}^S | C_t] - E[w_{it} - w_{it-1}])\mathbb{P}(C_t)
$$

This is because after the shock, trajectory i is the same in both situation and thus $E[w_{it}^S - w_{it-1}^S | C_t^C] = E[w_{it} - w_{it-1}]$. With the normality assumptions, we can easily check that:

$$
\begin{aligned}
E[w_{it}^S - w_{it-1}^S] - E[w_{it} - w_{it-1}] &= [(a + \beta S)\Phi(\alpha S + b) - a\Phi(b) + \rho\sigma_\epsilon \times (\phi(\alpha S + b) - \phi(b))] \\
&\quad \times \Phi(-\alpha S - b)^{t - t_0}
\end{aligned}
$$

Summing this difference from t_0 to T, and letting T going to infinity, we obtain the following long-term effect:

$$
\beta S + (1 - \frac{\Phi(b)}{\Phi(\alpha S + b)})a + \rho\sigma_\epsilon \frac{\phi(\alpha S + b) - \phi(b)}{\Phi(\alpha S + b)}
$$

The first term reflects the shock to the notional wage in all trajectories, the second term corresponds to the effect of increasing the frequency of wage changes and the third term is the selection effect.