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Evidence from French Micro Data

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Abstract

We document new empirical findings on the effects of minimum wages on wage rigidity using quarterly micro wage data matched with sectoral minimum wages. We first estimate a micro empirical model of wage rigidity taking into account minimum wage dynamics. We then use a simulation method to investigate implications of lumpy micro wage adjustment for aggregate wages. Both national and sectoral minimum wages have a large effect on the timing and on the size of wage adjustments. At the aggregate level, minimum wages contribute to amplify, by a factor of 1.7, the response of wages to past inflation. Ignoring minimum wages leads to underestimate the speed of aggregate wage adjustment by about one year. The elasticities of wages with respect to past inflation, the national minimum wage and sectoral minimum wages are respectively 0.42, 0.17 and 0.16. Finally, there are significant spillover effects of the national minimum wage on higher wages transiting through sectoral minimum wages.

JEL codes: E24, E52, J31, J50

Keywords: Wage Rigidity, Minimum Wage, Collective Bargaining

1 Introduction

In standard macro models, wage stickiness is one of the key ingredients to generate fluctuations in employment or real effects of monetary policy (Erceg et al. [2000] and Smets and Wouters [2003]).[1] Micro empirical evidence on wage rigidity is thus highly relevant for macro models and a recent literature has documented new stylised facts on wage stickiness (Taylor [2016] for a survey). However, this literature often disregards minimum wage as a potential source of wage rigidity while, in most European countries, minimum wage policies potentially affect a large majority of workers. This paper aims at filling this gap and provides new empirical evidence on how minimum wages – set at the national or the sectoral level – can shape aggregate wage dynamics.

France is a relevant case study since the French labour market combines one of the highest minimum wages in the world (in terms of minimum wage to median wage ratio) with one of the most extensive collective bargaining system (almost 100% of workers are covered by a collective bargaining agreement). However, one key empirical challenge when measuring the impact of minimum wages on wage rigidity is to link - at the micro level and at an infra annual frequency - wage trajectories to the appropriate sector- and job-specific minimum wage. In this paper, we use a large data set of individual wages collected at a quarterly frequency by the French Ministry of Labour over the period 2005 to 2015. We match this data set with quarterly hand-collected data on bargained sectoral wage floors for more than 350 industries (covering almost all workers in the private sector) but also with data on firm-level wage agreements.

Using this matched micro data set on wages and minimum wages, we first estimate a microeconometric wage rigidity model where the timing and the size of wage adjustments depend on inflation or unemployment but also on national or sectoral minimum wages. We then show that the aggregate wage response to a shock cannot be easily derived

[1] 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.

from parameter estimates of the 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 and micro estimates do not provide any direct information on the speed of adjustment to a shock.[2] Second, the transmission of a shock to wages is complicated by the existence of job-specific minimum wages. A shock can first affect negotiated minimum wages which then affect individual wages, leading to potential indirect effects of the initial shock on workers' wages. One novelty of this paper is that using parameter estimates of our micro wage rigidity models, we simulate individual trajectories of wages and minimum wages, we then aggregate these trajectories to describe how aggregate wages respond to a shock. Our simulation exercise allows us: (i) to assess the aggregate wage persistence due to micro lumpiness in wage changes; (ii) to investigate how minimum wages shape but also amplify the transmission of a shock to aggregate wages.

We document three sets of new empirical findings. First, micro wage stickiness translates into a delayed aggregate wage response to a shock: a 1%-increase in inflation will take a little less than 4 years to be fully incorporated into wages. Taking into account state-dependent factors modifies the aggregate dynamics response to a shock compared to a set-up where we assume exogenous frequency of wage adjustment. Second, we estimate medium-run direct effects of the main drivers of aggregate wages. After 5 years, a 1%-increase in inflation has a direct effect of +0.24 pp on aggregate wage increase while 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 after 5 years, a 1%-increase in NMW (National Minimum Wage) or sectoral wage floors have an impact of respectively 0.13 pp and 0.16 pp, each effect representing more than half the effect of inflation. Third, minimum wages do amplify the effect of past inflation on aggregate wages. Once we allow NMW and sectoral minimum wages to

[2]See also Berger et al. [2019] for analytical results on the ability of macro empirical models to capture aggregate persistence when micro adjustment is lumpy.

react to aggregate shocks, the overall effect of inflation on aggregate wages raises to 0.42 pp and the effect of NMW to 0.17 pp. Besides, ignoring the multi-level system of wage setting leads us to underestimate the speed of adjustment of aggregate wages by about a 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 firm-level wage agreement data for the United States and Canada (Christofides and Wilton [1983], Taylor [1983], Cecchetti [1987], Christofides [1987]), or Sweden (Fregert and Jonung [1998]) and more recently for France (Avouyi-Dovi et al. [2013] and Fougère et al. [2018]). On the other hand, a recent growing literature has documented new facts on wage rigidity using administrative sources of actual wage data (Barattieri et al. [2014] or Grigsby et al. [2021] for the United States, Le Bihan et al. [2012] for France, Sigurdsson and Sigurdardottir [2016] for Iceland or Lunneman and Wintr [2015] for Luxemburg). However, these papers do not include any information on minimum wages or wage agreements although these minimum wages cover a vast majority of workers in European countries and contribute to shape wage adjustment (see for instance OECD [2019] documenting that the collective bargaining coverage ranges between 60% and 100% across continental European countries).[3] Our contribution is here to fill this gap and to relate infrequent adjustments of actual wages to the way minimum wages adjust in sectoral collective agreements. Moreover, the most recent wage rigidity literature usually investigates the main drivers of wage adjustments by estimating wage rigidity microeconometric models. Sigurdsson and Sigurdardottir [2016] use a Probit model to document the main determinants of the probability of wage changes and Le Bihan et al. [2012] estimate a Tobit model on individual wages. In this paper, we go a step further: we use simple simulation exercises to derive implications of micro wage rigidity for the aggregate wage

[3] Díez-Catalán and Villanueva [2014], Martins [2020], and Guimaraes et al. [2017] describe also how the existence of sectoral wage floors affect employment in Portugal and Spain. See also Magruder [2012] for similar evidence in South Africa.

dynamics (in particular for the speed of aggregate wage adjustment). To our knowledge, this is the first attempt to derive empirically the implied aggregate wage dynamics from estimates of micro wage rigidity models. Besides, using these simulation exercises, we are able to quantify quite precisely how national or sectoral minimum wages contribute to aggregate wage dynamics.

We also contribute to the empirical literature on the pass-through of minimum wages to other wages. Several empirical studies find that the NMW not only affects wages close to the NMW but has also spillover effects to higher wages (see for instance Grossman [1983], Card and Krueger [1995], Lee [1999], Neumark et al. [2004], Autor et al. [2016], or Fortin et al. [2021]). Sectoral minimum floors set by industry-level agreements can be a relevant channel through which the NMW can affect higher wages. In France - as in many 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 them above the NMW. In addition, the NMW increase is considered as the fair value for sectoral wage negotiations or as the norm and might be transmitted to the whole scale of sectoral wage floors.[4] 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 floors as a channel for spillover effects of NMW to higher wages. Doing so, we can also better identify NMW pass-through to other wages. In particular, we show that lower paid employees are more reliant on institutions (like the legal rule of NMW indexation) to achieve wage indexation whereas better paid workers are more able to protect their wage settlements (through collective wage bargaining) against the direct impact of inflation.

The remainder of the paper is organized as follows. In Section 2, we present a simple

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

sticky wage 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 stylised facts relating wage and minimum wage nominal rigidities. In Section 4, we present estimation results of our microeconometric model of wage rigidity. In Section 5, using a simple simulation-aggregation exercise, we document empirical results on how aggregate wages respond to shocks. Section 6 concludes.

2 Theoretical Background

In this section, we first present a quite general model of staggered wage adjustment and its implications for the aggregate wage persistence.[5] Then, we allow the wage adjustment process to depend on minimum wage changes and describe possible consequences for the aggregate wage dynamics.

2.1 A Simple Model of Wage Rigidity

Most macro models assume that wages do not adjust at every period. This pattern 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 cannot 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 if wages could have been adjusted (herein called the "desired" wage, w^*_{it}) and the actual wage (w_{it}). When wages adjust, the new wage w_{it} is then equal to w^*_{it}. Overall, we can write:

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

[5] In a recent contribution, Berger et al. [2019] provide evidence on how the estimated persistence in linear time series can be downward biased because of underlying lumpiness in the micro adjustment.

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:

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

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 "desired" 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 a 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.

In this set-up, a shock affecting the "desired" wage will not be transmitted instantaneously to individual wages. At the date of the shock t_0, only updated wages 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 "desired" wage since the last wage adjustment). Thus, they will incorporate the shock later, at their next adjustment. 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}. Overall, this delayed response to the shock at the micro level will lead to some persistence in the aggregate wage response.[6]

[6] In Appendix A, we provide some calibration exercises to illustrate how staggered wage changes can

2.2 How Do Minimum Wages Affect Aggregate Wage Dynamics?

In France as in many European countries, wages of most workers depend on minimum wages set either at the national level or at the industry level. These minimum wages directly affect workers whose wage is close to the minimum wage but also other workers because increases in minimum wages are often considered as the norm or the reference point for higher wages. Knell and Stiglbauer [2012] for instance provide theoretical and empirical results showing that wage setting can be strongly influenced by reference norms such as sectoral wage floors.

The existence of such minimum wages can then 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. In France, for instance, the NMW adjustment is explicitly related to past inflation and past wage increases by a legal formula:[7]

$$\Delta NMW_t = Max\,(0, \Delta CPI_{t-1}) + \frac{1}{2} Max\,(0, \Delta W_{t-1} - \Delta CPI_{t-1}) + \epsilon_t \tag{4}$$

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.[8] Similarly, bargained sectoral wage floors depend strongly on past inflation and on the NMW change (Fougère et al. [2018]).[9] Thus, national or sectoral minimum wages can be an additional

lead to persistence in aggregate wage dynamics.

[7]These rules of (explicit or implicit) indexation to set minimum wage increase are also observed in other countries. For instance, in the United States, State Minimum Wages are also explicitly indexed to inflation in about half of all States (see Bradley [2016]).

[8]The NMW adjusts automatically every year (in July until 2009, then in January since 2010) according to this formula. 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).

[9]In Germany, interactions between the NMW and sectoral minimum wages are also prevalent: the MW commission often refers to past negotiated wage increases in unionized sectors as one of the determinants

channel through which macro shocks will affect individual wages and can amplify the wage response to a given shock. Second, because of negotiation costs, minimum wage adjustments are also infrequent, meaning that a shock will take some time to be transmitted to minimum wages and then much more time to be transmitted to individual wages. This would add some delays in the reaction of wages to a given shock.

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 are thus hard to derive analytically.[10] In this 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 use wage trajectories simulated from this model and we will aggregate them to derive the aggregate response of wages to a change in macro variables (allowing or not minimum wages to respond to this change).

3 Wage Micro Data

In this study, we use three quarterly data sets containing individual wages at the occupation level, job-specific wage floors set in industry-level wage agreements and information on collective wage agreements at the firm level.[11]

3.1 Wages

Our first data set consists of wage micro data collected through the ACEMO (Activité et Conditions d'Emploi de la Main-d'Oeuvre) survey at a quarterly frequency over the

for the NMW increase.

[10]See Appendix A for a simplified illustration.

[11]These micro-data sets are available to researchers after approval from the Ministry of Labour and via a restricted access to a secure data hub (Secure Data Access Center CASD).

period 2005 to 2015.[12] This survey is carried out by the Ministry of Labour to compute official aggregate base wage indices. These indices are closely monitored since the aggregate growth of base wages is one of the two inputs in the legal rule updating every year the NMW (see equation (4)). Every quarter, data are collected in about 40,000 different firms with at least 10 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.[13] In a given firm, several individual wages are collected for workers holding representative job positions within the firm. First, firms define from 1 to a maximum of 12 different representative job positions within the firm (3 different jobs in 4 broad categories: blue-collar workers, white-collar workers, technicians and managers); then, every quarter, firms report individual base wages of employees holding these pre-defined representative jobs. When firms fill the survey, they are explicitly asked to report individual wages for exactly the same employees over the different quarters (without cumulating or averaging). Using this data set, we are able to track individual wage trajectories of employees occupying representative jobs within firms and so, we can compute base wage changes at a quarterly frequency for individual workers. By construction, we focus on wage dynamics of job stayers and we cannot track wage adjustments due to job mobility.[14] However, the effects of collective wage agreements on the wage dynamics might be concentrated on insiders' wages.[15]

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).[16] Looking at recent international

[12] In Appendix B, we provide further details on the conduct of this survey.

[13] For the US, Grigsby et al. [2021] argue that focusing on base wages might be more relevant for wage rigidity models since base wage changes are more procyclical than bonuses or overpay. In France, base wages represent approximately 85% of the overall wage bill.

[14] Grigsby et al. [2021] document for the United States that base wage rigidity is not very different for job-stayers or job-movers controlling for observed characteristics of job-switchers.

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

[16] By comparison, using the same French survey data, Le Bihan et al. [2012] obtain a much higher

evidence, the degree of wage rigidity in France seems to be consistent with US evidence (Barattieri et al. [2014] and Grigsby et al. [2021] find frequencies of base wage changes between 20 and 25%) and for Iceland, Sigurdsson and Sigurdardottir [2016] document a monthly frequency of 13% and a typical wage duration of 7 months. On the size of wage change, the average of non-zero wage changes is 1.8%. Figure 1 plots the average wage growth (q-o-q), the frequency of wage changes and the average size of non-zero wage changes over time. The main time variations of the average wage growth come from strong seasonal movements. Quarterly wage growth is much higher in 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 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 E 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.[17] 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 2), only 2% of all non-zero wage changes are negative (representing less than 0.5% of all wage changes) and about two thirds of all non-zero wage changes are between 0 and 2%.[18]

3.2 Collective Bargaining and Minimum Wages

The French labour market combines different levels of wage regulation. At the national level, a binding and uniform National Minimum Wage (NMW, in French SMIC for *Salaire*

frequency of 38% but their data set cover the period of workweek reduction (1998-2005) with more frequent wage changes.

[17]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 wage changes are less frequent but larger at the top of the wage distribution compared to wages close to the NMW.

[18]Figure D 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 less dispersed when inflation is low.

Minimum Interprofessionnel de Croissance) is updated by the Ministry of Labour once a year (in January since 2010) following a legal rule (see above). The NMW is binding for all workers but only 10 to 15% of workers are paid at the NMW. At the industry level, collective agreements define sector- and job-specific wage floors 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 wage floors or the NMW. We match our sample of micro data on actual wages with information on sectoral wage floors and on firm-level wage agreements (Appendix B for details on the matching procedure).

Our first data source on collective bargaining consists of industry-level wage floors over the period 2005-2015.[19] 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. Every new wage agreement will contain updated values of 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.[20] 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

[19]This data set is also described in Fougère et al. [2018].

[20]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.

(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 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 unions must also open wage negotiation at least once a year[21] but without any 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. 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.[22] 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.

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

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

Overall, our estimation sample contains about 2 millions of individual wage observations matched with information on sectoral minimum wages and firm-level agreements on wages. 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 C in Appendix C).[23]

Two main stylised facts emerge when relating wage agreements to the wage dynamics. 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 3): 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 drive - at least partly - the timetable of actual wage changes.[24] The second main fact is the strong similarities between the distribution of wage changes and the distribution of sectoral minimum wage changes (Figure 2). In particular, there is no minimum wage cut. 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 agreement (Table 2). Wage changes are both more frequent and larger when there is a wage agreement either at the industry- or firm-level.[25]

4 Empirical Micro Model of Wage Rigidity

In this section, we present our empirical model of wage rigidity and the estimation results obtained separately on occupation-level wages and sectoral wage floors.

[23]Some small differences are observed in the beginning of the sample period where the number of observations in our sample is smaller. Our weighting scheme also slightly differs from the one used by the Ministry of Labour, which can explain deviations between the two series.

[24]Moreover, the distribution of durations between two wage changes (Figure E 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.

[25]In presence of a sectoral wage agreement or a firm-level wage agreement, the whole distribution of wage changes shifts to the right (Figure F 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 of a wage change R and second, the size of wage adjustment conditional on observing a wage change ΔW. For a given occupation j in firm i at date t, the model can then be written as follows:

$$R_{ijt} = 1\left(R^*_{ijt} \geq 0\right)$$
$$\Delta_{(t,\tau_{ijt})} w_{ij} = R_{ijt} \times \Delta_{(t,\tau_{ijt})} w^*_{ij}$$

where $\Delta_{(t,\tau_{ijt})}$ is the log difference operator between date t and the date of the last wage change τ_{ijt}, R^*_{ijt} is the propensity to adjust wages and $\Delta_{(t,\tau_{ijt})} w^*_{ij}$ the "desired" wage adjustment at date t. 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]). These cumulative variables capture deviations from the optimal wage change that would have been observed in absence of any friction.[26] 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_{ijt}, as follows:

$$R^*_{ijt} = \beta \Delta_{(t,\tau_{ijt})} X + \sum_d \gamma_d 1\left(t - \tau_{ijt} = d\right) + \mu_{ij} + \lambda_q + \epsilon_{ijt} \tag{5}$$

where X include variables shifting w^* and capturing the state of the economy. These variables are 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 level of the local unemployment rate. $1\left(t - \tau_{ijt} = d\right)$ are duration dummies controlling for Taylor contracts and λ_q are quarter

[26] Our approach can be related to the adjustment hazard model developed by Caballero and Engel [1999]. The probability of a wage change is a function of the gap between wage at date t and a static "desired" optimal wage. This gap is the relevant state variable, so that even if an optimization problem underlies the decision rule, no expectation term is explicitly included.

dummies capturing the seasonality of wage adjustments. We also include firm and occupation controls μ_{ij}: dummy variables for the size category and sector of the firm, and dummy variables for the wage position in the wage distribution (by deciles, measured at the first date of the wage trajectory). Our second equation relates the "desired" wage adjustment to some similar determinants:

$$\Delta_{(t,\tau_{ijt})}W^*_{ij} = b\Delta_{(t,\tau_{ijt})}X + v_{ij} \times (t - \tau_{ijt}) + u_{ijt} \tag{6}$$

where X are the same variables as in the Probit equation and v_{ij} are the same occupation and firm controls interacted with duration (in quarters) since the last wage adjustment. We here assume that duration dummies and quarter-specific dummies do not affect the size of wage adjustment but only the wage change decision. Due to data limitations, we cannot include firm- or worker-level characteristics such as productivity (at a quarterly frequency), skills, effort which might be relevant for wage changes. However, we control for elapsed duration by introducing duration as a linear trend (and interacting with size, decile and sector, $v_{ij} \times (t - \tau_{ijt})$), doing so we are able to capture potential unobserved cumulated determinants of the size of wage changes. Besides, there is no constant term in this equation, which is consistent with the model's prediction that only cumulative shocks since the last wage adjustment will affect the size of wage changes.

As baseline regression, we estimate this model using all base wages but we also run regressions where the effects of covariates depend on the relative position of the wage level in the wage distribution (by deciles). This second exercise allows us to document heterogenous effect of a shock along the wage distribution.

The Tobit model is estimated using a two-step Heckman estimation procedure. Standard errors are obtained using pair cluster (firm) bootstrap simulations.[27] Two identification issues should be addressed.

[27] 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 (see also Fougère et al. [2018]).

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 occupation i in firm j, which should help us to identify the effect of macro variables.[28] In absence of exogenous variations in CPI inflation, sectoral or national minimum wages or of credible instrumental variables, our estimated coefficients cannot be interpreted as pure causal effects. However, in our model, cumulated variables are calculated since the last wage adjustment. This should limit issues of simultaneity bias since, for instance, wage decisions taken today cannot affect cumulated past inflation or NMW.

Second, the identification of the Tobit parameters comes from the assumption that the duration dummies and the quarter dummies have no direct effect on the size of the wage changes controlling for the impact of cumulated macro variables introduced in the model.[29] We argue that these two sets of variables correspond to calendar or seasonal effects, independent of the decision about the size of wage adjustments (once taken into account the cumulated evolution of macro variables). These duration and calendar effects may be related to negotiation costs or legal constraints (e.g. the yearly legal obligation to negotiate wages at the firm and industry levels). These factors will affect much more the timing of a wage change than the desired wage change. These time regularities in wage adjustment can also be related to similar time regularities of other firm decisions like price setting. Synchronized price changes in a given quarter or fixed-period duration of price changes (typically one year) are well documented by Nakamura and Steinsson [2008] for producer prices in the United States or Gautier [2008] in France. These calendar effects are also quite consistent with predictions of the Taylor wage contracts model and would capture the relevance of such theoretical predictions on the probability of a wage change.

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

[29] In the Appendix D, we check the robustness of our results when using various specifications of calendar effects (e.g. date dummies).

4.2 Estimation Results on Base Wages

In Table 3, columns (1a) and (1b) report estimation results for the Tobit model where we do not include any variable 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 raises 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 the first quarter of the year. 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 much in line with the ones provided by Le Bihan et al. [2012] for France or Sigurdsson and Sigurdardottir [2016] for Iceland. These patterns also suggest that any model using a standard Calvo constant probability of wage adjustment will not match the large strong seasonality in wage adjustment and the contribution of state-dependence factors to the timing of wage adjustments.

When we include the NMW, sectoral wage floors 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 direct 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. The firm-agreement dummy fully captures the differences in the probability of wage change due to firm size (Figure G 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 and 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 pp and a firm-level wage agreement increases the average wage change by 0.33 pp.

In Appendix, we report several robustness exercises including or not quarter/duration dummies, date dummies (Tables C and D in Appendix D), results are quite robust. We also run a type-1 Tobit model on annual wage growth to be able to control for annual productivity growth (Appendix D for more details on this model). We find only a small effect of firm-level productivity growth on individual wage changes while the impact of wage floors or firm-level wage agreements on wage changes remain about the same (Table E in Appendix D).

4.3 Estimation Results for Sectoral Minimum Wages

We compare the results obtained on base wage adjustments with the ones obtained using the same model on changes of sectoral wage floors. Moreover, in our simulation exercise, we will use these parameter estimates since we will allow (national and sectoral) minimum wages and the occurrence of firm-level agreements to respond to the same shocks as the ones considered for wages.

At the industry level, since wage floor adjustments are quite infrequent, we assume that sectoral wage floors follow a similar two-stage process as the one assumed for occupation-level wages (Fougère et al. [2018]). Results are reported in Appendix D Table F. Like for base 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 wage floor 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 level (Table G in Appendix D). Firm size and duration effects are the main drivers of the probability of a wage agreement and minimum wages have only small negative effects. The negative effects of minimum wages might suggest the presence of crowding-out effects.[30]

5 Aggregate Wage Response to Shocks

If wages are sticky at the micro level, the transmission of a shock to aggregate wages can take several quarters. To investigate the speed of transmission of shocks to aggregate wages, we resort to simulation exercises using estimates of micro models as data generating processes (DGP). These simulation exercises aim at illustrating the aggregate wage dynamics induced by the lumpiness of wage adjustment and the interactions between wage floors and actual wages. One limitation of this exercise is that the results cannot be interpreted as results of a general equilibrium model since it would also require to model the endogenous response of firms' prices or employment, which is not feasible with our data.

5.1 Simulation Exercise

Our simulation exercise is the following.[31] We simulate four variables: the NMW trajectory using as DGP the legal formula; job-specific wage floors and micro 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,...)

[30] 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.

[31] Appendix G for a full description.

and simulated variables when they enter as inputs in our micro-econometric models (for instance, wage floors for base wages). This exercise aims at deriving the aggregated wage dynamics from our micro estimates and the interpretation of these simulation results relies on the same identification assumptions as in our microeconometric model. In particular, our results can only be interpreted as results of a partial equilibrium model since the endogenous reaction of firms' prices or employment is not taken into account.[32] Our main objective is here to describe the aggregate wage dynamics implied mechanically by the lumpiness of wage adjustments and the interactions between national and sectoral minimum wages and actual 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).[33] 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 individual observations at t. This average aggregate wage change computed without any exogenous shock will be used as a benchmark.

Then, we redo the same simulation exercise but introducing a shock at a given date (2010-Q1 in our baseline simulations). For instance, we consider that the CPI is now 1% higher after 2010Q1 (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). In the end, we compute the average wage change for this new set of

[32] Available evidence on the effect of minimum wage increases on prices point to a significant impact. On French data, Fougère et al. [2010] find that a 1% increase in the NMW raises by 0.1% restaurant prices and more recently, in the US, Lee [2020] and Montialoux et al. [2020] document that a 1% increase in the minimum wage would raise supermarket prices by less than 0.1%. However, making an explicit link between prices and wages in our model would require a detailed data set matching prices, wages and employment at the firm-level.

[33] In these aggregate simulations, we do not take into account for possible changes in job composition in response to the shocks.

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.[34] We will consider different simulation exercises to decompose the impact of a shock on aggregate base wages in several channels.

In the first exercise, 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 exercise will be called the direct effect of a shock on base wages. In a second exercise, 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 L in Appendix F for a diagram). In a third exercise, we assume that base wages, sectoral wage floors 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.[35] In our simulation exercise, we will allow such feedback loop effects from past increase of actual wages (calculated as the

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

[35] As mentioned before, we do not consider possible feedback loop effects coming from the response of inflation and unemployment to a shock even if they are other potential channels for feedback loop effects. This would lead us to underestimate somewhat the overall effect of shocks on wages.

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 M in Appendix F for a diagram). The sum of indirect and feedback loop effects is referred as second-round effects of a shock on base wages.

5.2 Aggregate Direct Effects

We first describe how aggregate wages directly respond to different shocks (introduced separately): a 1%-variation in CPI inflation, NMW, sectoral MW and unemployment. Figure 4 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). 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 some quarters, wage adjustments are less frequent in our baseline model since firms which have already incorporated the shock are then less likely (compared to the case without shock) to update their wages again.

In Table 5, we have reported the cumulative effects of shocks after 5 years.[36] The first column reports direct effects, we find that the medium-run or long-run effects of a 1% shock in inflation on aggregate base wages is 0.24 pp. The cumulative effects of minimum wages on base wages are substantial: after 5 years, a 1%-increase in sectoral wage floors

[36]We measure cumulative effects until the end of the sample period Q4 2015. Standard errors are obtained using bootstrap simulations.

leads to an 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 cumulative 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.[37]

5.3 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 aggregate wages for sectoral MW and inflation and past aggregate wages for the NMW).

Figure 5 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 and 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 medium-run effect is also longer than in the case when we allow only for direct effects (Table 4). Overall, it takes about 5 years for a shock to be fully transmitted to aggregate wages (versus 4 years for the direct effect). This higher degree of persistence in the reaction of aggregate wages to shocks can be explained by the fact that the reaction of minimum wages to shocks is also persistent (Figure H in Appendix E for the aggregate response of wage floors to a 1% increase in the NMW and inflation).[38]

The second and third columns of Table 5 report cumulative effects of inflation and NMW shocks after 5 years when we account for indirect effects (through wage floor ad-

[37]See Appendix H showing in a simplified framework how the long-term effect, in our set-up can be decomposed in three terms.

[38]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 rather weakly on macro variables.

justments) 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).[39] 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 sectoral and national 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 pp when we do not allow this possibility). The indirect effect of inflation coming from sectoral wage floors is estimated close to 0.05 pp while 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 cumulative effects 5 years after the shock obtained in models with only NMW or without any minimum wage variable. In those models, CPI inflation effects are a little lower and might capture part of the minimum wage effect. Figure 6 plots the cumulative response function to a 1%-increase in aggregate prices and NMW with the different specifications. Excluding all wage bargaining variables, we find a quicker response of wages to inflation (by about 2 to 3 quarters, Table H 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

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

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 the first, second, third or fourth quarter of the year. We find that the duration before full adjustment to a CPI shock is a little longer when the shock is introduced in the first quarter whereas a shock has less persistent effect when introduced in the last quarter of the year (Figure 7 and also Table J in Appendix E). This is due to the strong seasonality of minimum wages: if the shock is introduced in the first quarter, it takes more time for wages and minimum wages to adjust since they usually adjust at the beginning of the year. However, cumulative effects 5 years after the shock are of similar magnitude. For a NMW shock, the overall effect is stronger in the first quarter where the marginal effects of NMW increase is larger leading to more frequent wage changes (direct effect) while a NMW shock occuring in the second quarter has a smaller effect (Table I in Appendix E reports results of long-term effect of CPI and NMW shock according to the quarter of the year). Finally, we have run robustness exercises with respect to the year of the introduction of the shock. Cumulative effects of shocks vary only a little.[40]

5.4 Heterogeneity Along the Wage Distribution

We now investigate to which extent cumulative effects of shocks are heterogenous along the wage distribution. Following the empirical literature on minimum wage spillover effects, we might expect in particular some heterogeneity in the transmission of NMW increases along the wage distribution. Moreover, our simulation exercises allow us to investigate whether spillover effects might come from second round effects. In this exercise, 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

[40]We also provide results of robustness exercises where we modify the specification of the Probit model in the Tobit regression (including or not time/quarter controls). We find that cumulative effects 5 years after the shock are quite robust to the different specifications (see Table K in Appendix E).

correspond to deciles of base wages).[41] 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 exercise as previously described.

Figure 8 plots the cumulative effects 5 years after a 1%-shock on NMW for the 10 deciles of 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 (first decile) and then falls to about 0.2 for wages between 1.04 and 1.2 $\times$ the NMW (second and third deciles). For wages higher than 1.3 $\times$ the NMW (fourth to the last deciles), the overall effect of NMW is still positive and significant (about 0.1 pp) and increases for wages higher 2$\times$NMW.[42] 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 lastly 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 it 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.[43] Finally, feedback loop effects are positive and concentrated on wages below $1.6 \times NMW$ (on this part of the distribution, these feedback effects are about 0.04 pp). By comparison, using different administrative

[41] The deciles of the distribution are the following: $1.04 \times NMW$, $1.12 \times NMW$, $1.2 \times NMW$, $1.3 \times NMW$, $1.5 \times NMW$, $1.6 \times NMW$, $1.9 \times NMW$, $2.2 \times NMW$, $2.9 \times NMW$. We have dropped wage observations when base wage is below $0.97 \times NMW$ and above $8 \times NMW$. Each individual worker in a given firm is assigned to the decile of the wage distribution measured at the first date of the wage trajectory (i.e. for a given wage trajectory, the decile remains the same all over the sample period).

[42] Figure J in Appendix E plots robustness analysis with models including different time fixed 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 $1.5 \times NMW$) since time dummies might capture a large share of the NMW effect. The other specifications including duration/quarter dummies or not deliver very similar results along the wage distribution.

[43] Metalworking, Construction and Public Works industries covering managers at the national level (total of 500,000 employees) contribute a lot to explain this increase. In Appendix E, Figure K plots the same estimates but excluding these industries from our sample. The overall effect of NMW is much lower for the highest deciles.

French data sources at annual frequency, Givord et al. [2016] find that spillover effects affect wages until $2 \times NMW$.

If we consider the impact of indexation to past inflation along the wage distribution (Figure 9), 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 increase along the wage distribution, their contribution is rather small for workers paid at the NMW whereas they are about 0.25 pp for wages higher than $1.1 \times NMW$; second, feedback loop effects are 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 lower 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 aggregate wage dynamics. For that, we have matched comprehensive French data sets 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 2005-2015.

First, we have provided new stylised facts on how wage bargaining institutions can affect 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-level wage agreements are signed. The typical duration between two wage changes is one year, which corresponds to the usual duration of wage agreements. This finding is quite consistent with predictions of Taylor [1980] model. We also show that the size of wage adjustment depends not only on inflation and unemployment but also on NMW and sectoral wage floor increases.

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

Third, we have estimated direct effects of the main drivers of the aggregate wage dynamics. Minimum wages play a large role for the aggregate wage dynamics: a 1% increase in NMW or sectoral wage floors have a cumulative impact (over a 5-year horizon) of respectively 0.13 pp and 0.16 pp, more than half the effect of inflation. Besides, minimum wages do amplify the effect of inflation on aggregate wages. Once we allow NMW and sectoral wage floors 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: the NMW pass-through to higher wages is mainly due to sectoral wage floors 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	No	No	No	Yes	Yes	Yes
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.*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 (i.e. 5 years after the shock) 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 4 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.

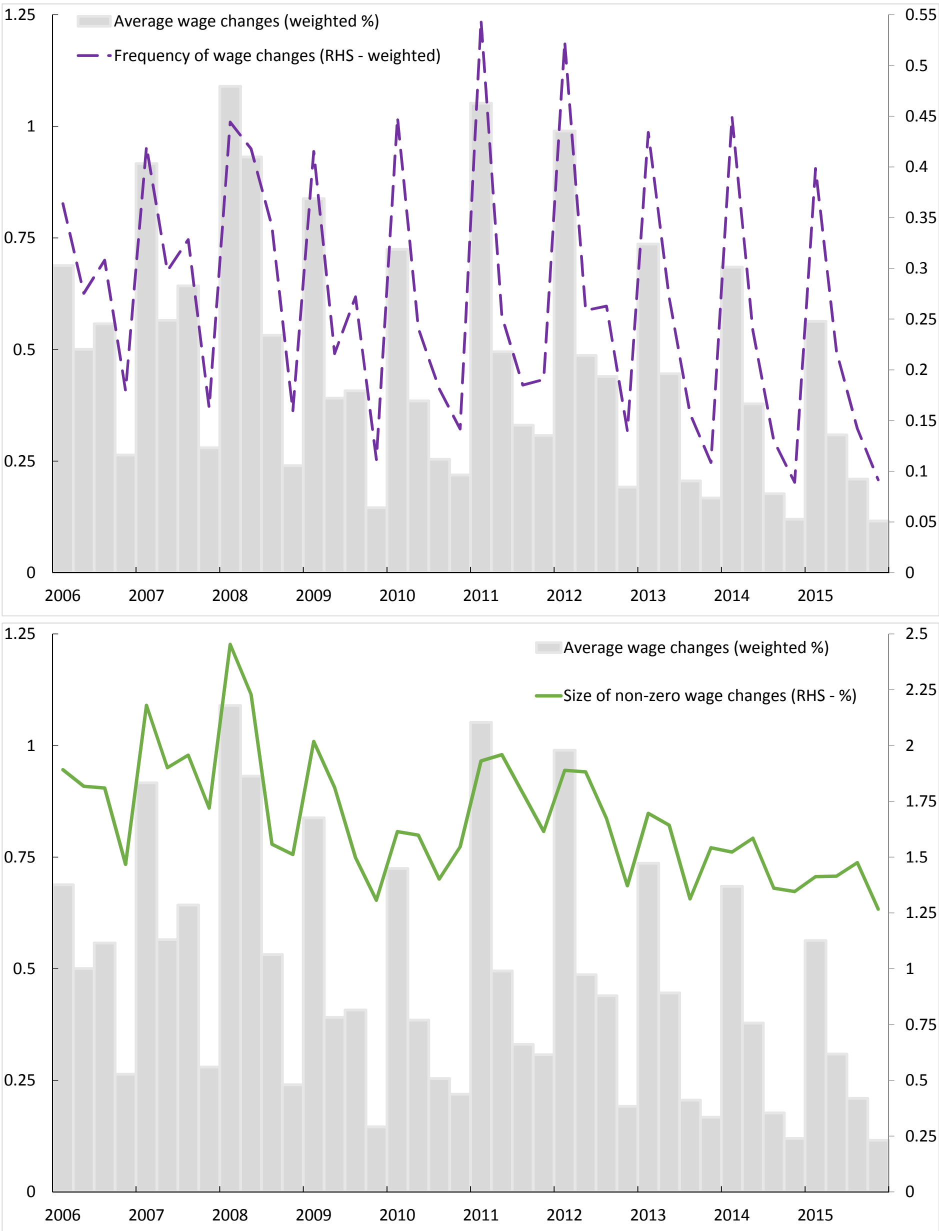
Table 5: Long-Term Aggregate Direct Effects

	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 the simulation exercise described in section 5.1 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.

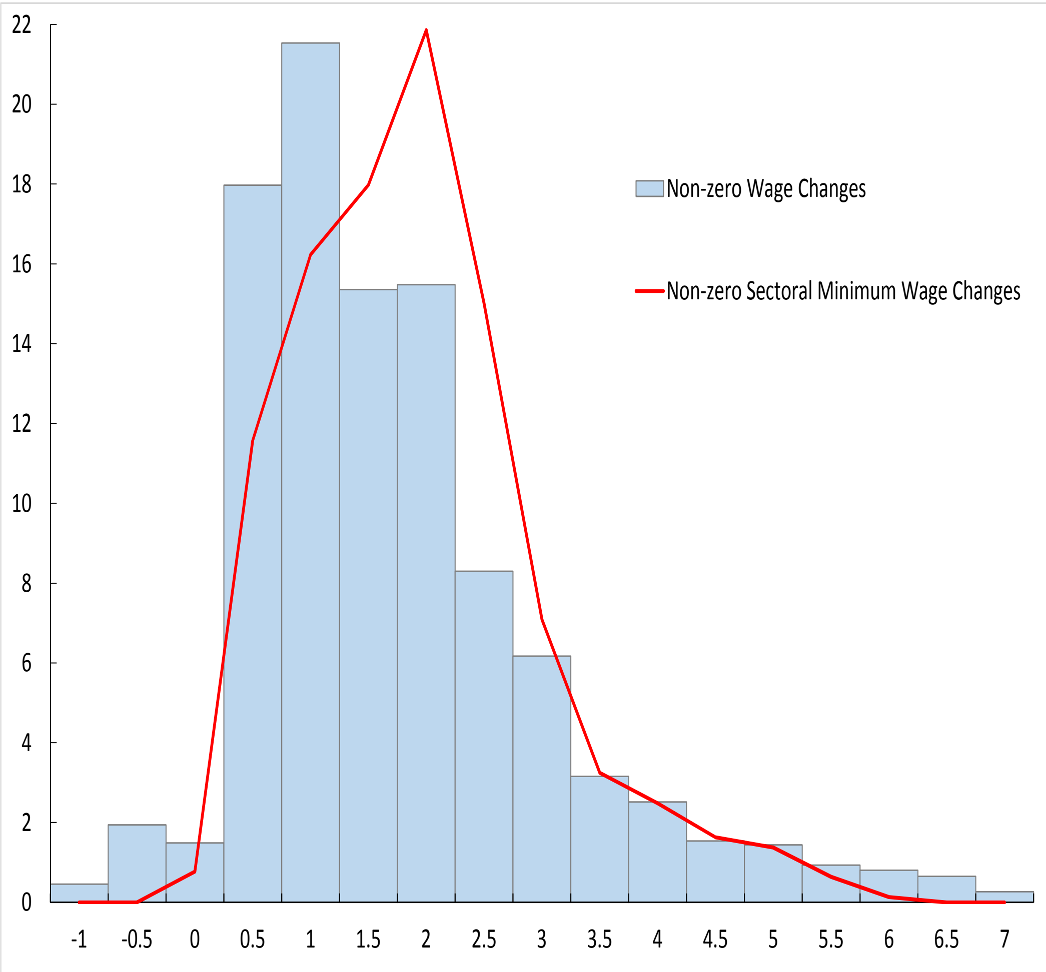
Figures

Figure 1: Aggregate Wage Growth, Frequency and Size of Wage Adjustments



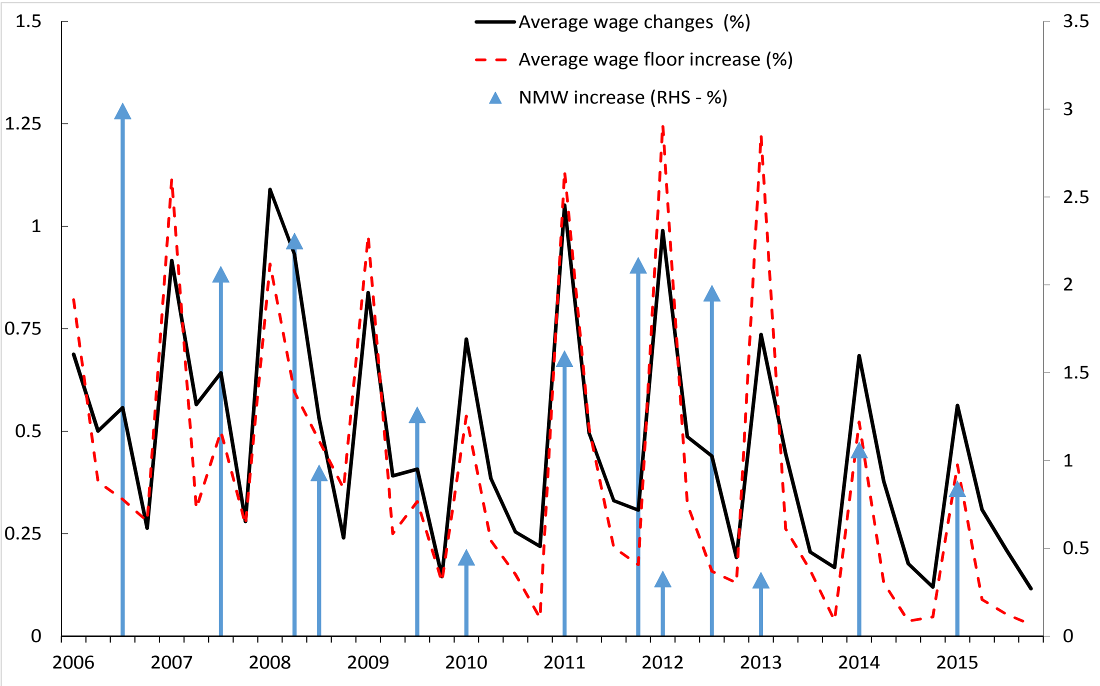
Note: we compute for each quarter the average wage growth as the average of all wage changes of our sample (including 0 change), the frequency of wage changes is calculated as the ratio of the number of wage changes over the number of observations in a given quarter, the average size of wage changes 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.

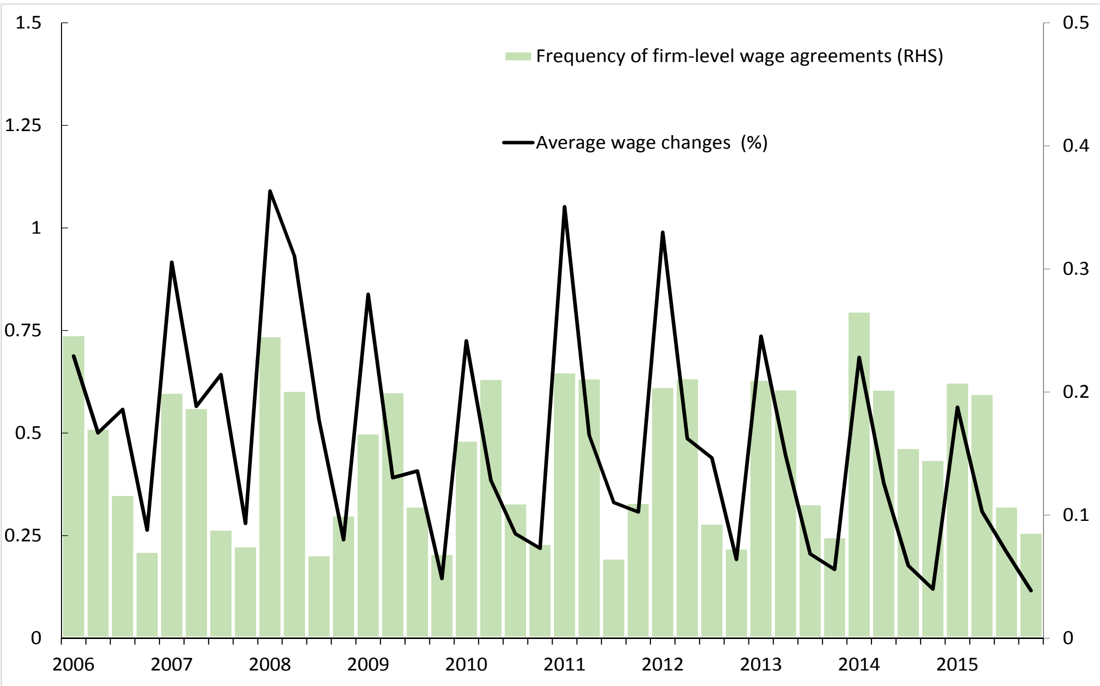
Figure 2: Distribution of Non-Zero Wage Changes



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.

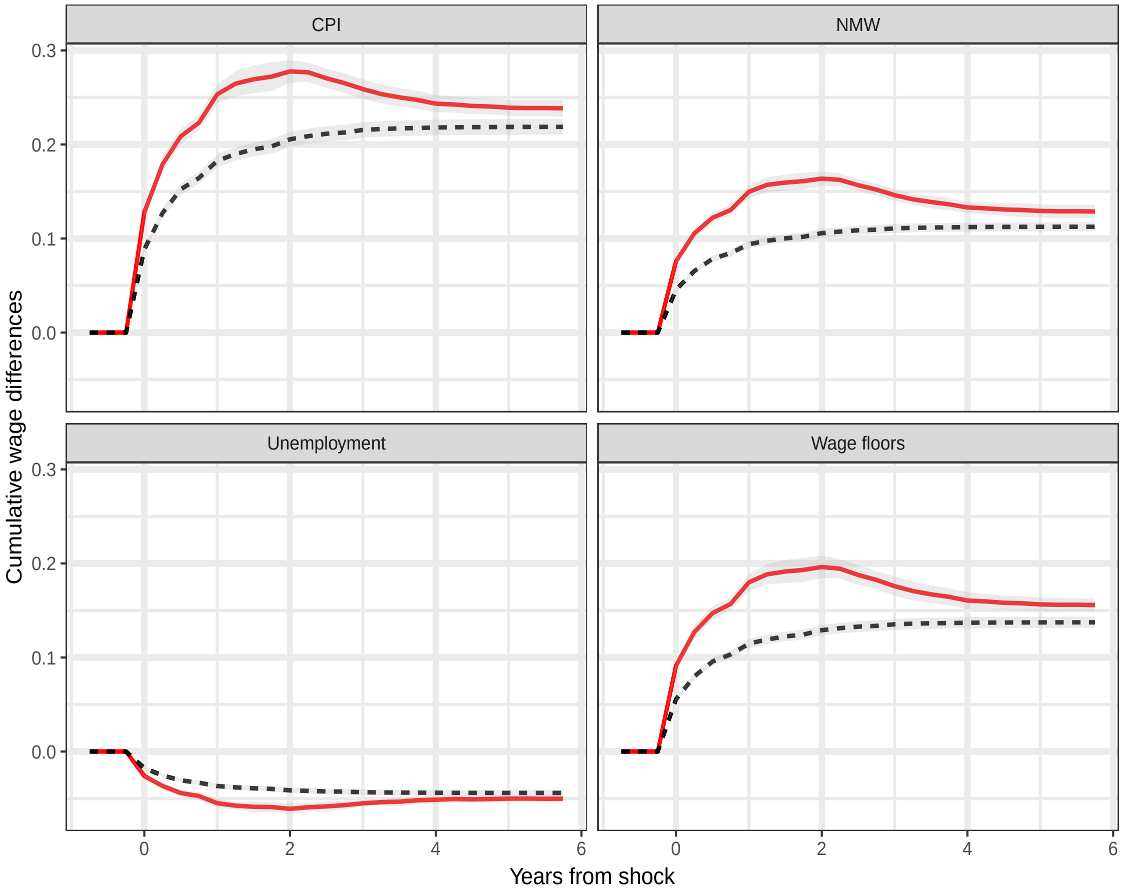
Figure 3: Aggregate Wage Growth, Sectoral Minimum Wage Increase and Frequency of Firm-Level Wage Agreements





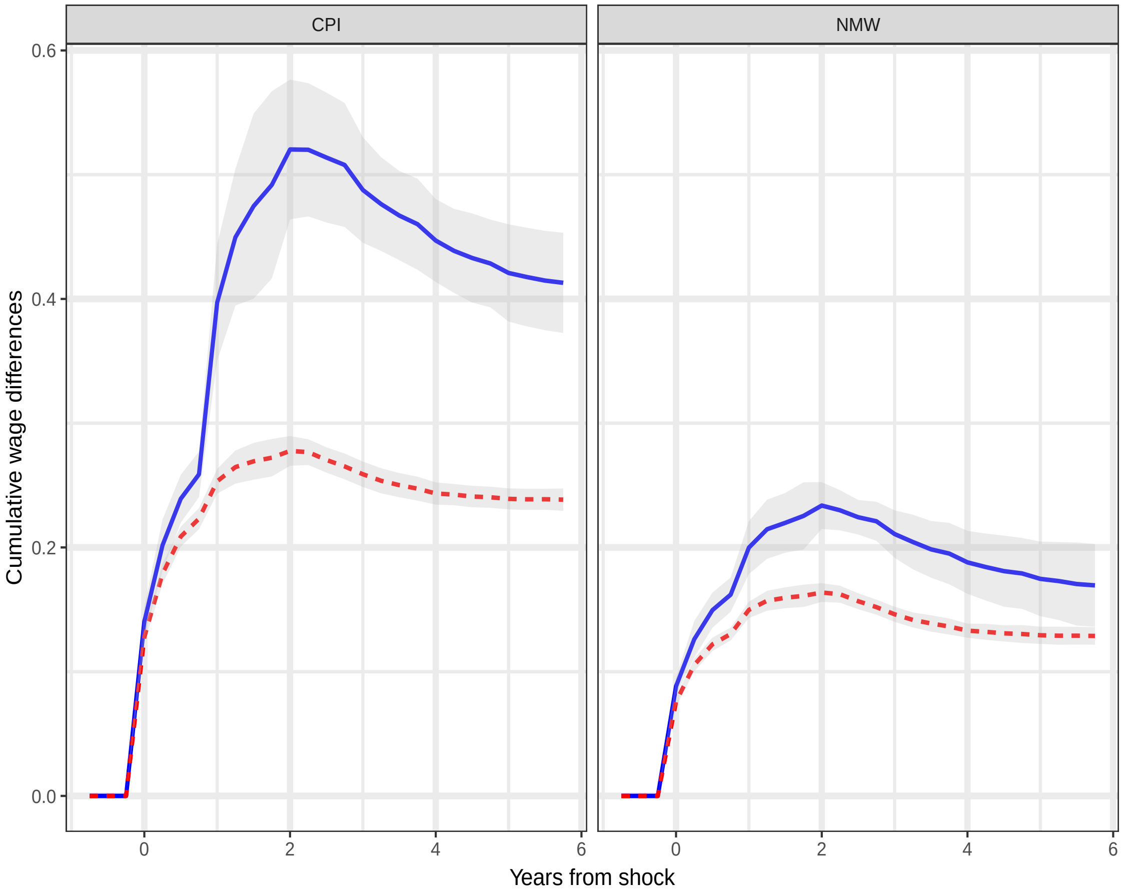
Note: we compute for each quarter the average wage growth calculated as the average of all individual wage changes of our sample (including 0 change) (black line). Top panel: we plot with the average wage change, the average wage floor increase decided in a given quarter for all workers of our sample (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 4: Aggregate Wage Adjustment to Shocks (Direct Effects)



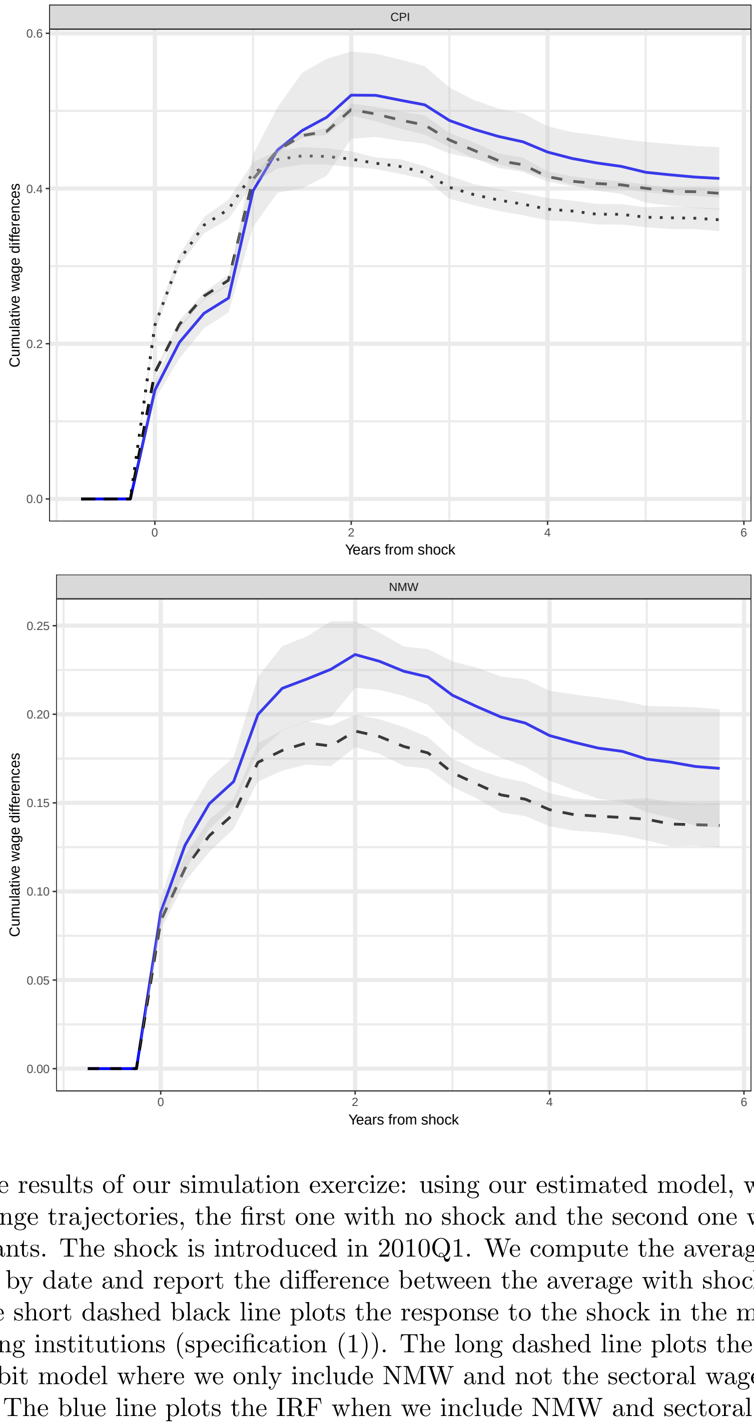
Note: We here report the results of our simulation exercize: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants (see section 5.1 for a full description). The shock is introduced in 2010Q1. We compute the average of all wage change trajectories by date and report the difference between the average calculated 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 95%-confidence intervals (grey shaded area) using bootstrap simulations.

Figure 5: Aggregate Response of Wages to NMW and Inflation Shocks (Direct and Second-Round Effects)



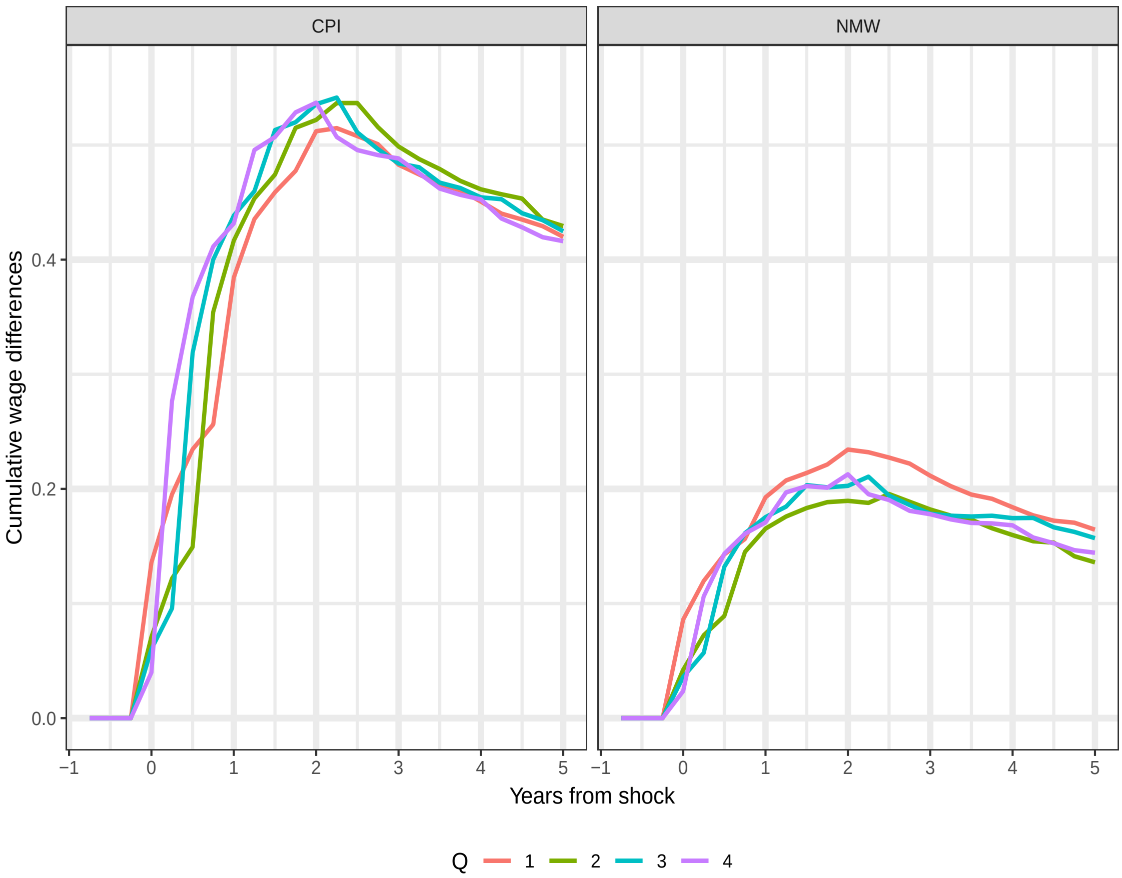
Note: We report the results of our simulation exercize when we allow indirect effects of shocks feeding wages through wage floor adjustment and we also allow feedback loop effects: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second 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 (i.e. including direct, indirect and feedback loop effects) (dark blue line) and also direct effects (red dashed line). 95%- confidence intervals are also reported (grey shaded area) they are obtained using bootstrap simulations.

Figure 6: Aggregate Wage Adjustment to Shocks Taking into Account or Not Minimum Wages



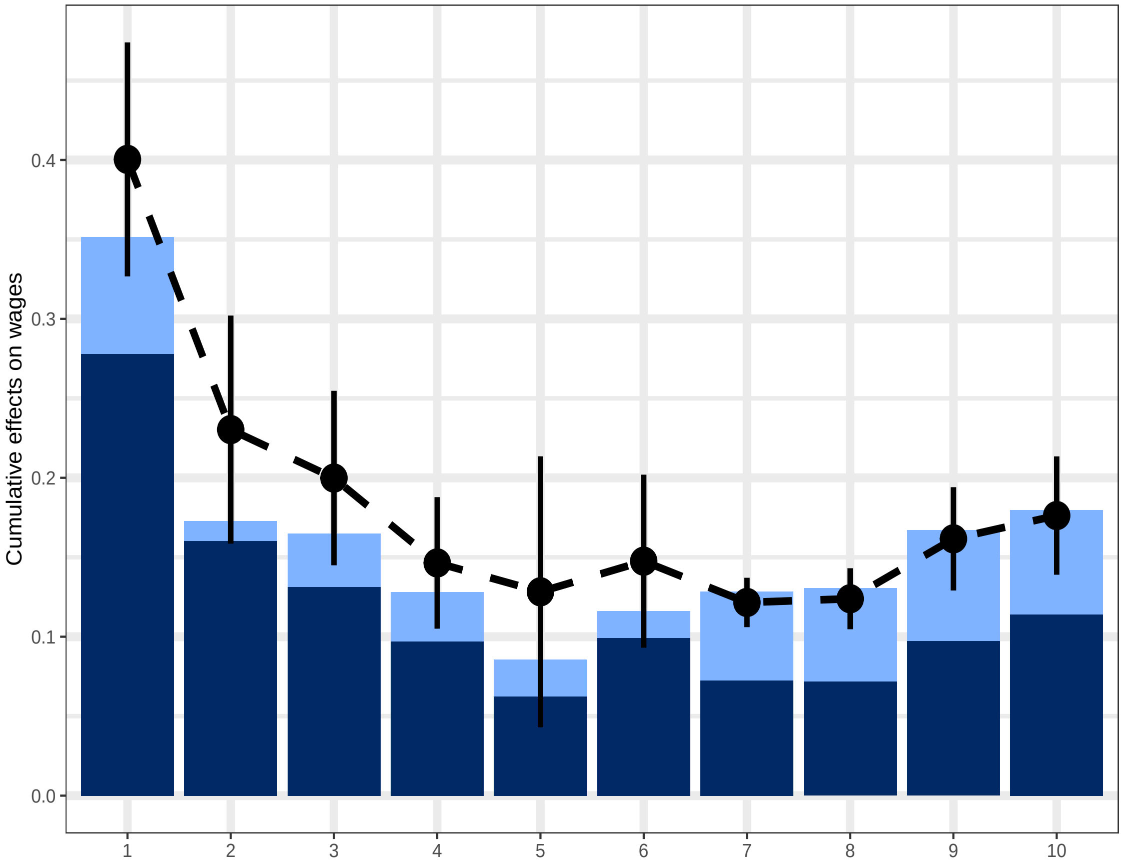
Note: we report the results of our simulation exercize: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants. The shock is introduced in 2010Q1. We compute the average of all wage change trajectories by date and report the difference between the average with shock and the average with no shock. The short dashed black line plots the response to the shock in the micro Tobit model ignoring wage-setting institutions (specification (1)). The long dashed line plots the response to the shock using the Tobit model where we only include NMW and not the sectoral wage floors (specification (2)). The blue line plots the IRF when we include NMW and sectoral wage floors in the Tobit model (specification (3)); this also include indirect and second-round effects. 95%-confidence intervals are also reported (grey shaded area) they are obtained using bootstrap simulations.

Figure 7: Aggregate Wage Adjustment to Shocks by Quarter



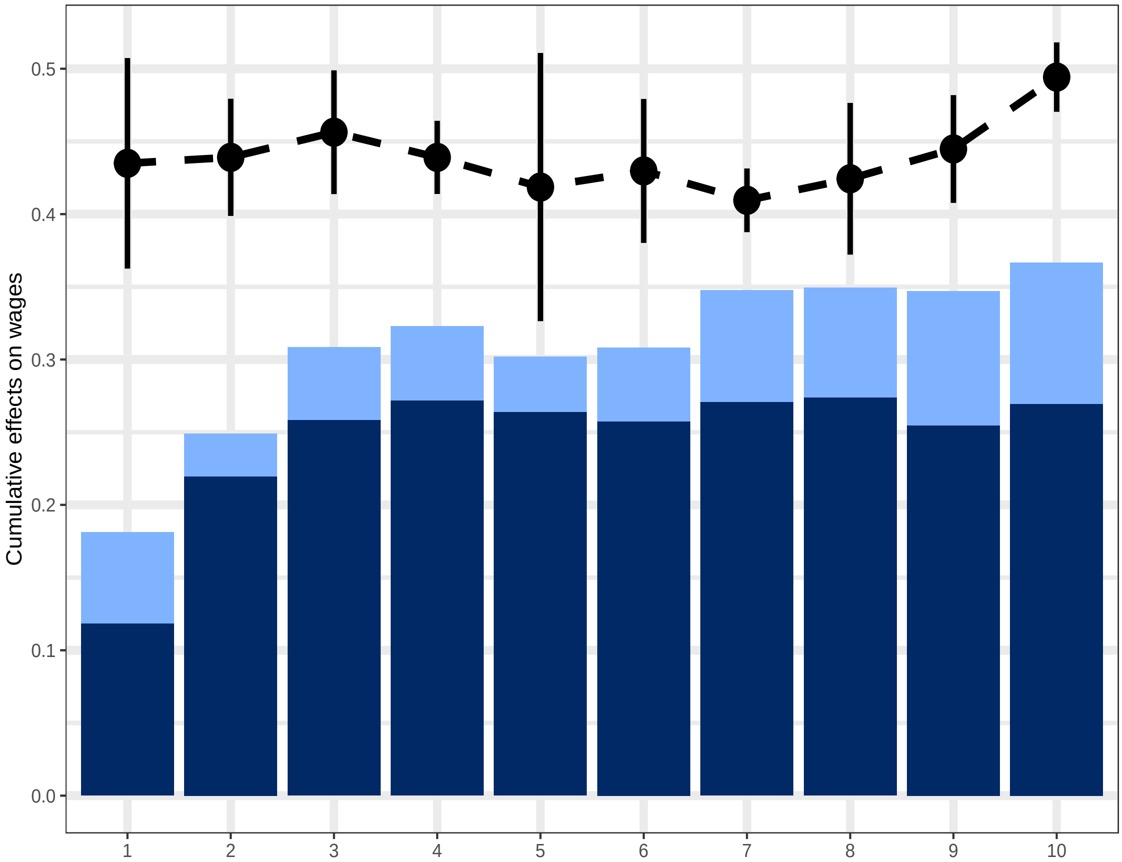
Note: We here report the results of our simulation exercize: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants. We compute the average of all wage change trajectories by date and the difference 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 8: 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. Vertical lines plot the 95%-confidence intervals.

Figure 9: 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. Vertical lines plot the 95%-confidence intervals.

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 "desired" wage is defined as:

$$w^*_{it} = \eta_w z_{it} + \gamma t + \alpha \times S1_{\{t\geq 0\}} \tag{7}$$

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

$$R^*_{it} = d1_{\{t-\tau_{it}=4\}} + \eta_p(z_{it} - z_{i\tau_{it}}) + \beta \times S1_{\{\tau_{it}\leq 0\}} + \epsilon_{it} \tag{8}$$

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 "desired" minimum wage is defined as:

$$z^*_{it} = \gamma^z t + \alpha^{MW} \times S1_{\{t\geq 0\}} \tag{9}$$

and

$$z_{it} = z_{i\tau^z_i} + R^z_{it}(z^*_{it} - z^*_{i\tau_i}) \tag{10}$$

.

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

$$R_{it}^{z*}=d^{z}1\{t-\tau_{it}^{z}=4\}+\beta^{MW}\times S1\{\tau_{it}^{z}\leq 0\}+\epsilon_{it}^{z} \tag{11}$$

From this simple micro wage rigidity model, we can 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 $t-1$) can be written in expectation as:

$$\begin{aligned} E\left(\Delta W_t\right) &= E\left(w_{it}-w_{it-1}\right)=E\left(R_{it}\left(w_{it}^{*}-w_{i\tau}^{*}\right)\right) \\ &= \sum_{\tau=-\infty}^{t-1}\pi_{t,\tau}p_{t,\tau}E\left(w_{it}^{*}-w_{i\tau}^{*}|R_{it}=1,\tau_{it}=\tau\right) \end{aligned} \tag{12}$$

where $p_{t,\tau}=P\left(R_{it}=1|\tau_{it}=\tau\right)$ is the probability of a wage update at date t given the date of the last wage update equal to τ and $\pi_{t,\tau}=P\left(\tau_{it}=\tau\right)$ 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:

$$\begin{aligned} \pi_{t+1,\tau} &= \pi_{t,\tau}\left(1-p_{t,\tau}\right),\ \tau<t \\ \pi_{t+1,t} &= \sum_{\tau=-\infty}^{t-1}\pi_{t,\tau}p_{t,\tau} \end{aligned} \tag{13}$$

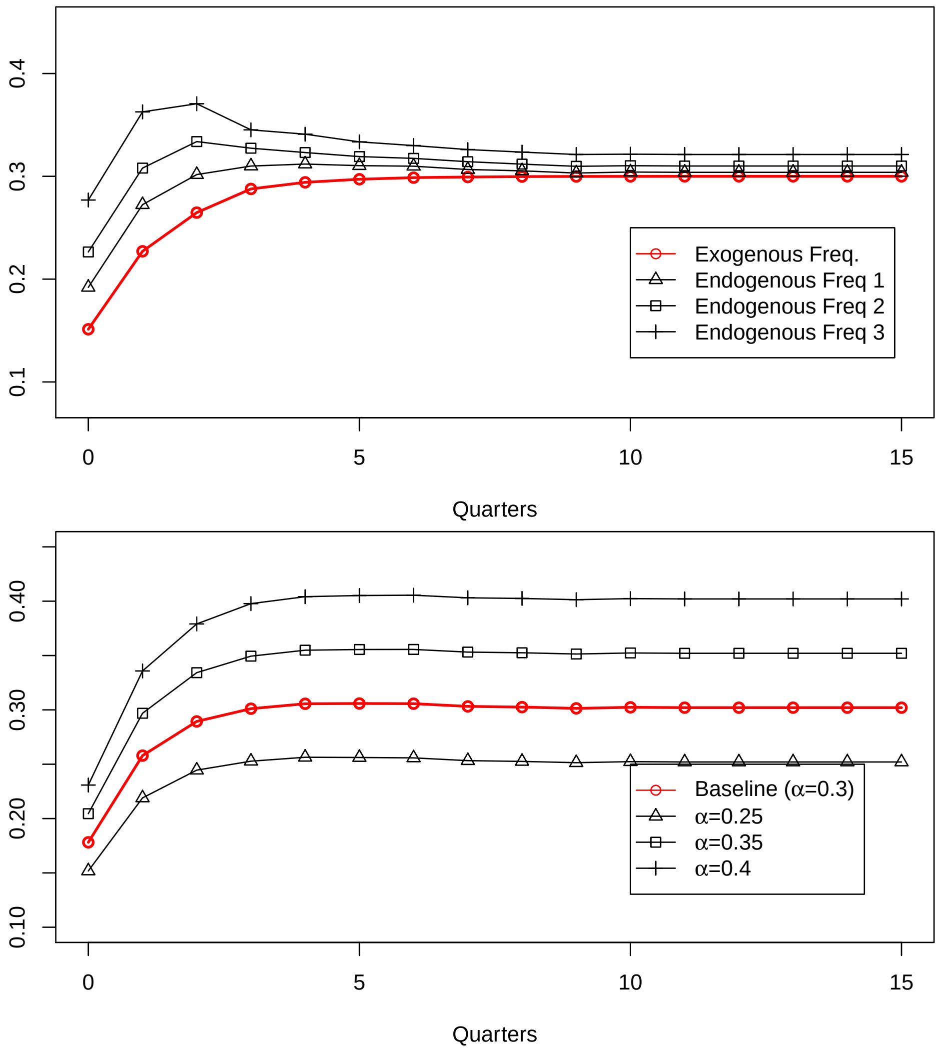
How do aggregate wages respond to a macro shock in this set-up? A shock S affecting the "desired" wage at date t_0 will take time to be incorporated to aggregate wages since a proportion of wages cannot adjust immediately to the shock, leading to persistence in aggregate wages. In Equation (12), the 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 Taylor model), the aggregate response to a shock will only come from the response of the size of wage adjustment (third term in Equation (12)). The duration before a full transmission to aggregate wages will fully depend on the 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 (12)). A positive shock will lead to a quicker aggregate wage adjustment.

As an illustration, we report some calibrations of a stylised model of wage rigidity similar to the one presented above. We also report calibrations on how the aggregate response to a shock depends on the parameters used in the micro model. 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 (i.e. the parameter associated to the shock on the desired wage w^*) and β (i.e. the parameter associated to the shock on the probability of wage to adjust) vary.

Figure A plots aggregate response to a shock affecting either the probability of wage adjustment (top panel) or the "desired" wage w^* (bottom panel). 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 "desried" wage, this only affects the long term effect of the shock and not the speed of aggregate adjustment.

Figure A: Aggregate Wage Dynamics without MW - Calibration Exercizes

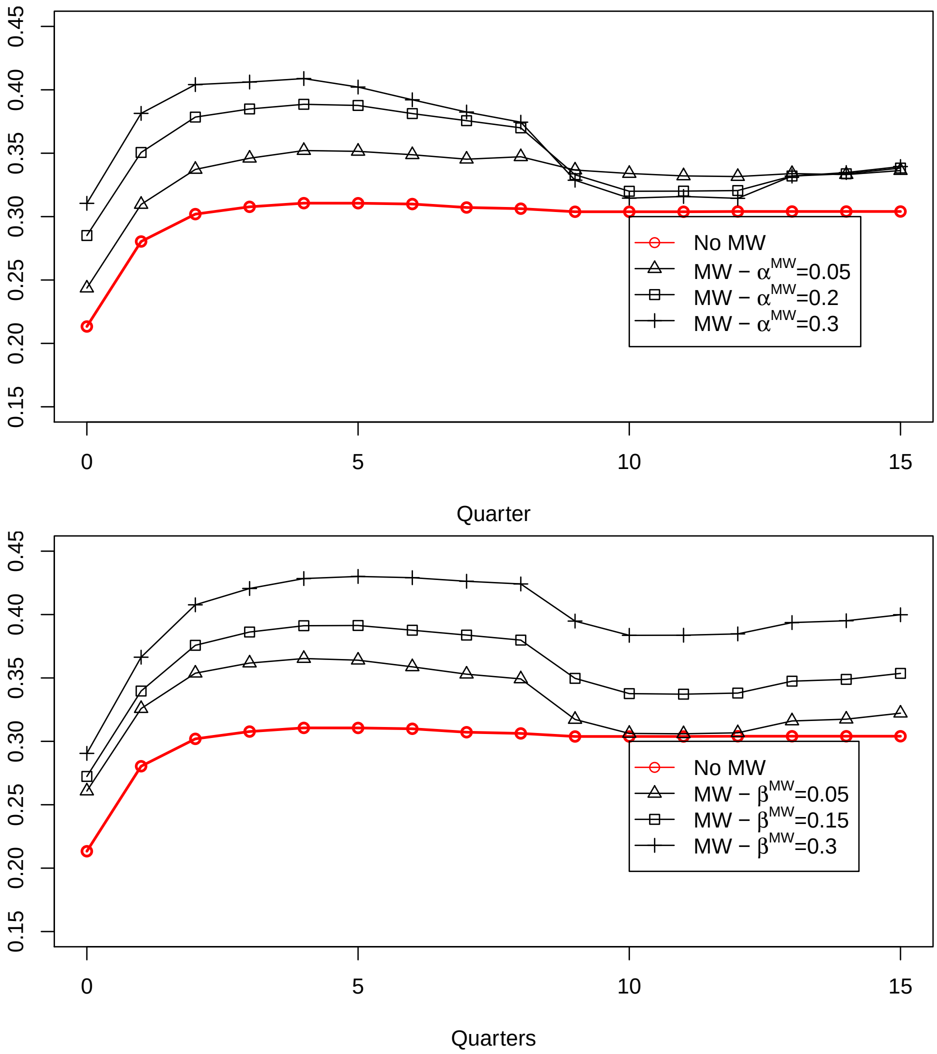


Note: We here report aggregate wage response to a shock affecting in a model without MW. The top panel reports aggregate wage response where we vary the parameter associated with the shock in the equation describing the probability of a wage adjustment (α) whereas the other panel plots aggregate wage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

On Figure B, we 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 wages and actual wages. To illustrate the role of MW in the transmission of shocks, we 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 B 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 "desired" MW (bottom panel). When the shock only affects the probability of MW adjustment, the aggregate wage response is different from the one obtained in a model without any MW (red line): it first accelerates the transmission of the shock but it also takes more time to converge to the long run effect. When the shock only affects the "desired" MW (bottom panel), the long-run effect of MW on aggregate wages is a little larger. The long-run effects of the shock increase with the size of the shock in the "desired" MW because of second-round effects transiting through MW.

Figure B: 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 "desired" MW adjustment β^{MW}.

B Data Appendix

B.1 Measurement issues

Measurement issues in our individual wage data are very limited here for two reasons.

First, individual workers' wages are reported by firms and not by workers The firm is asked to fill a table with maximum of 12 lines corresponding to the possible different occupations within the firm. The table consists of 5 columns: broad job categories (blue-collar workers, white-collar workers, technicians and managers), a number between 1 and 3 for the different specific job category within a broad category, the exact label for each of the max. 12 representative occupations within the firm, the monthly base wage paid to an employee occupying each of the max. 12 job positions. The survey questionnaire explicitly mentions to firms that for each job position, they have to report the base wage of an actual employee holding a representative position within the firm and that over the quarters, they have to report the base wage of the same employee (see the questionnaire that firms have to fill every quarter, the wage table is on page 2 (in French) `https://dares.travail-emploi.gouv.fr/sites/default/files/05cb9ae8ca3eb381da93b98cc12c624d/Questionnaire_acemo_trim_V1.pdf`).

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: $0.97 \times NMW$, $1.04 \times NMW$, $1.12 \times NMW$, $1.2 \times NMW$, $1.3 \times NMW$, $1.5 \times NMW$, $1.6 \times NMW$, $1.9 \times NMW$, $2.2 \times NMW$, $2.9 \times NMW$. Wages below $0.97 \times NMW$ and above $8 \times NMW$ 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 since they are official documents signed by union representatives and federations of employers.

- 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 calculated 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 systematically 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.[44] 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.[45] 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

[44] On 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 worker's job category (defined by sectoral agreements) in the ACEMO survey.

[45] 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).

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.

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

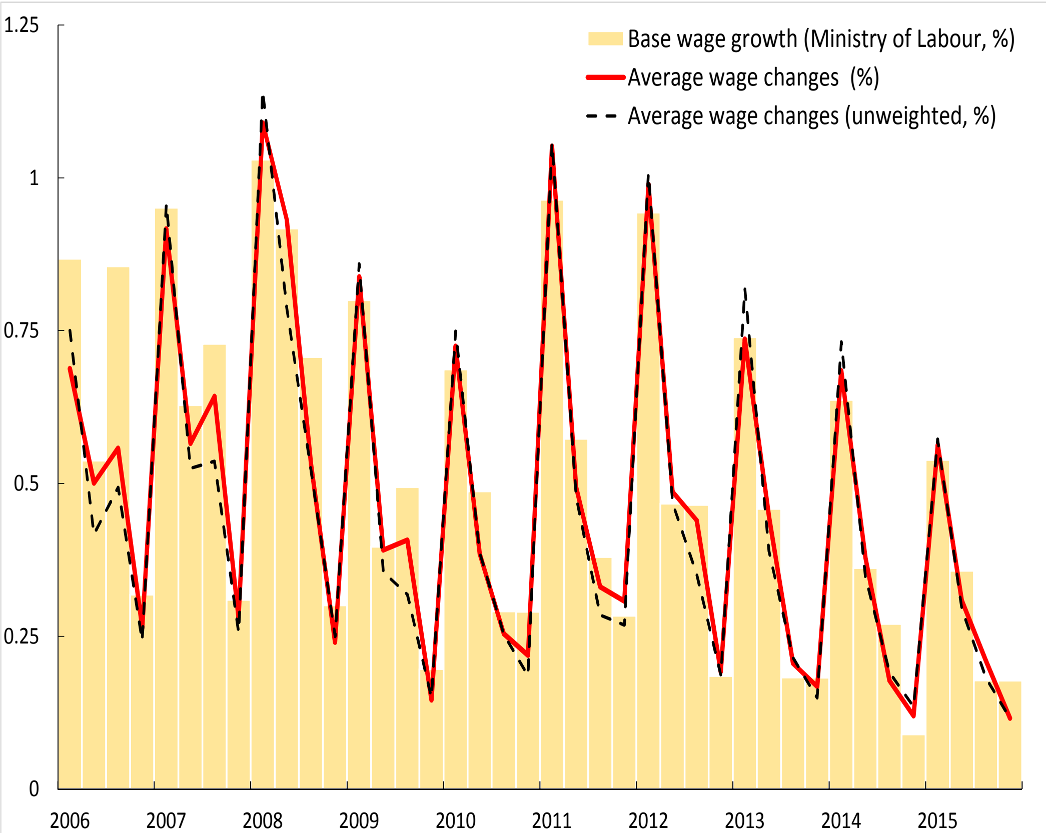
Note: Moments are calculated using the data set matching ACEMO individual data, firm-level and industry-level wage agreements data sets. The first column contains the average quarterly wage changes for all workers of our data set. The second column is the proportion of workers whose wage is modified 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

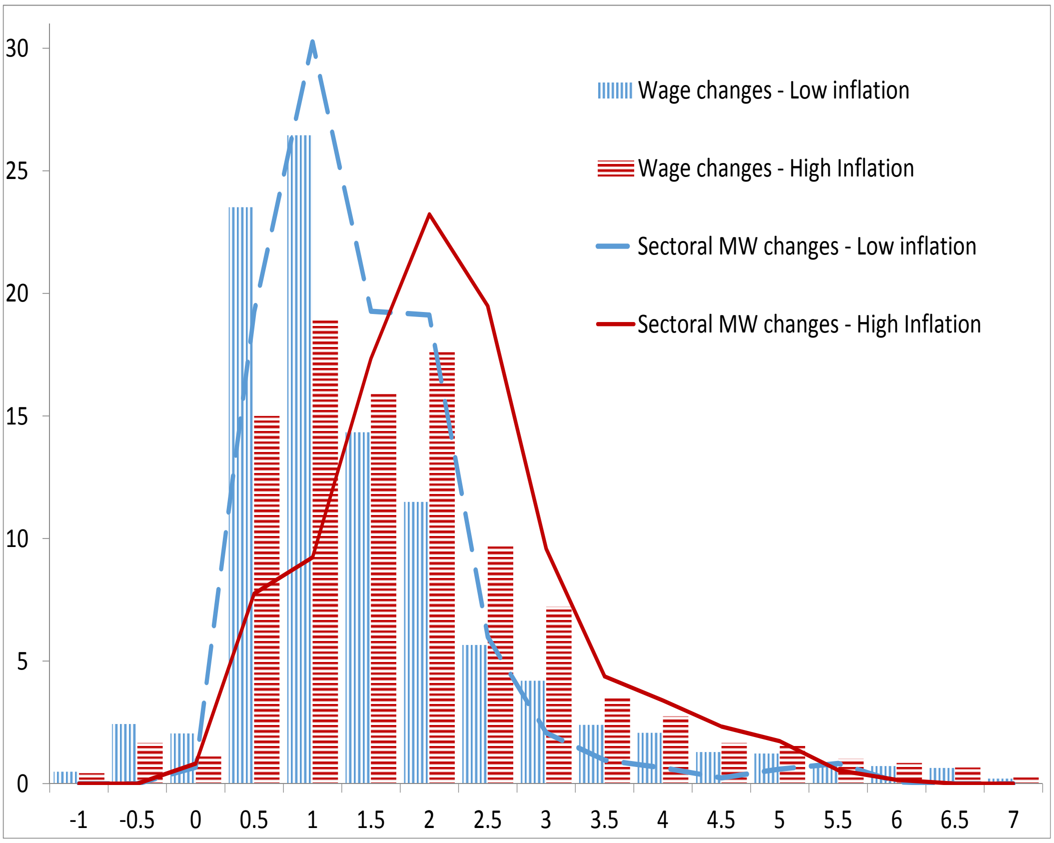
Note: Moments are calculated using the data set matching ACEMO individual data, firm-level and industry-level wage agreements data sets. The first column contains the average quarterly wage changes for all workers of our data set. The second column is the proportion of workers whose wage is modified 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 C: Comparison of Average Wage Changes in our Sample and Aggregate Base Wage Growth (Min of Labour)



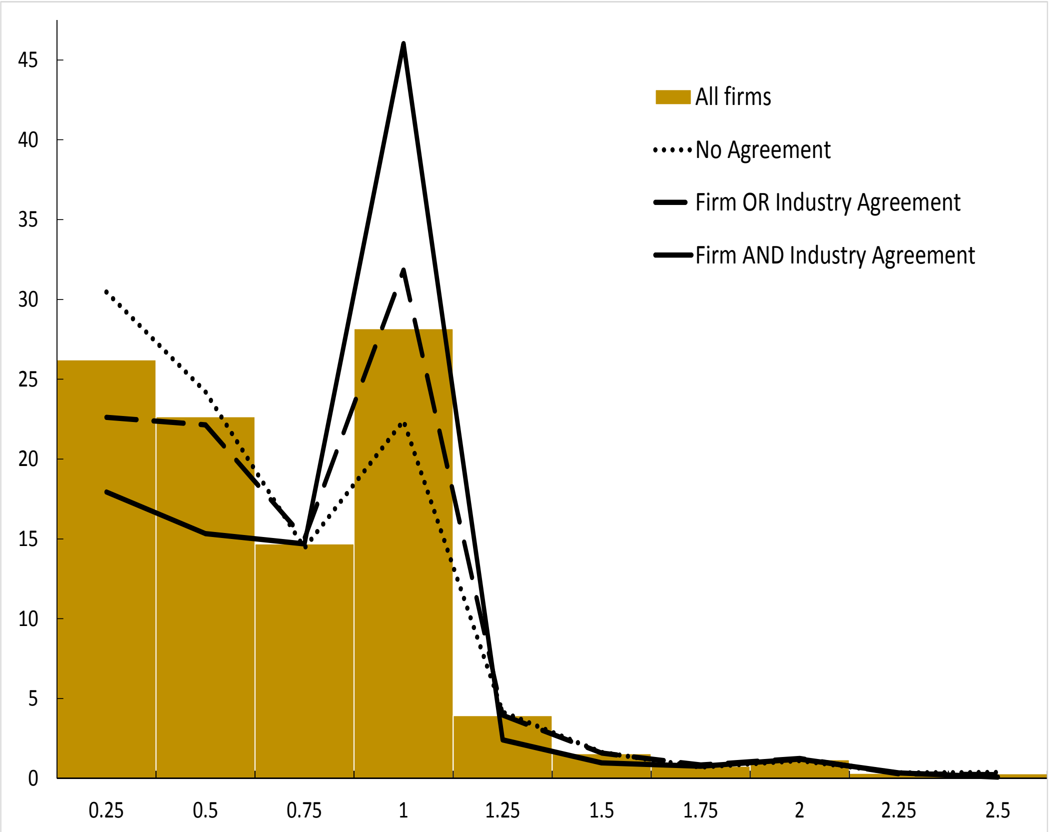
Note: We compute for each quarter the average wage growth as the average of all wage changes of our sample (including 0 change) (weighted (red line) or unweighted (dashed black line)) and compare this average to the time-series of aggregate base wage growth released by the Ministry of Labour (yellow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

Figure D: Distribution of Wage Changes by Inflation Regime



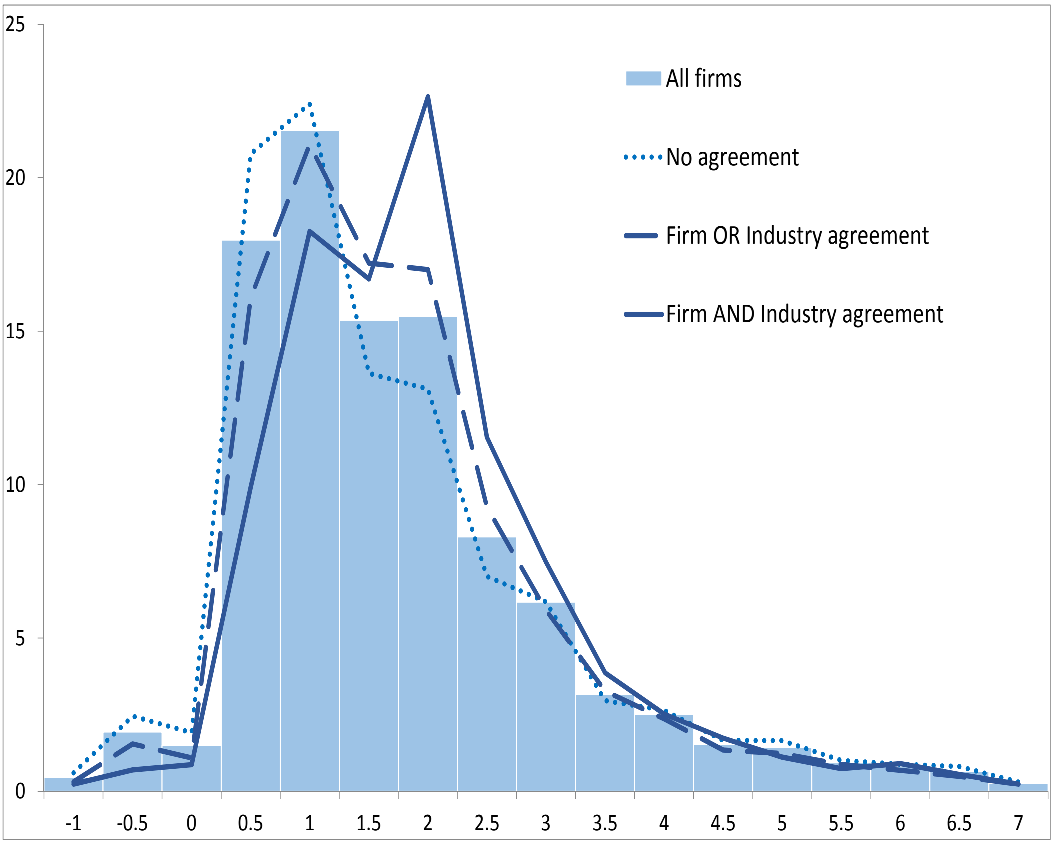
Note: we here compute the distribution of all non-zero wage changes (quarter-on-quarter). We plot the distribution of wage changes for two periods, the first includes years 2010, 2013-2015 (low inflation) (blue bars) whereas the second one includes 2006-2008, 2009, and 2011-2012 (high inflation) (red 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 E: 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.

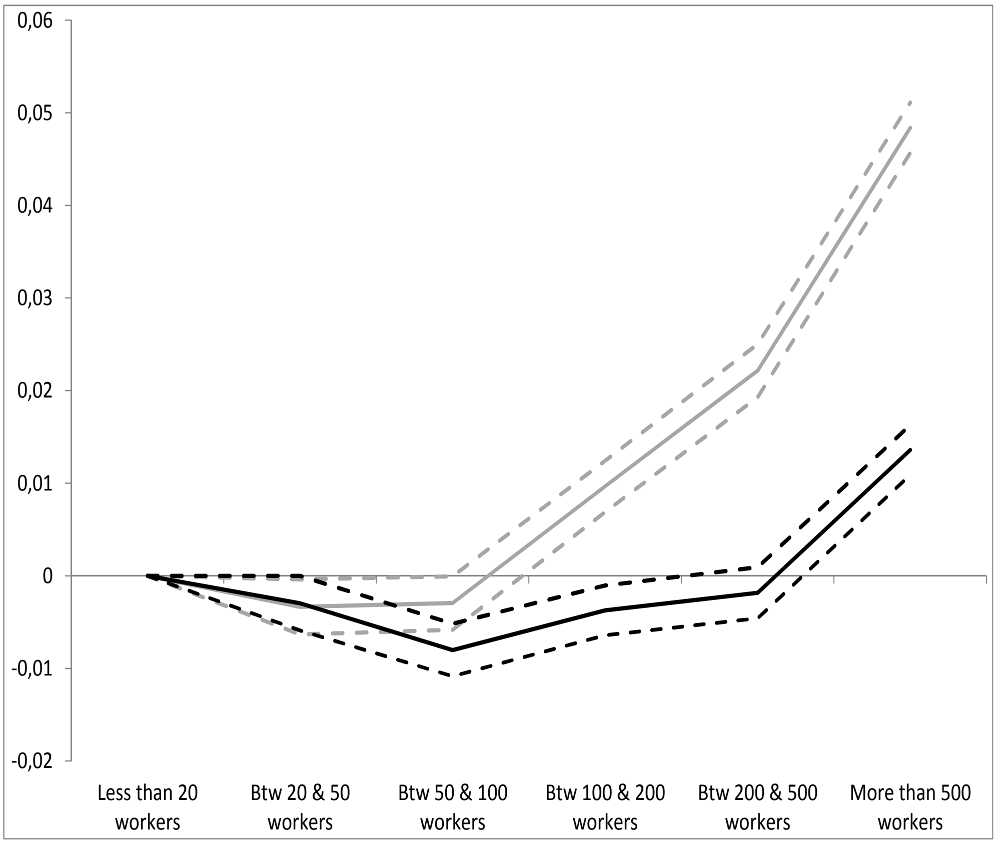
Figure F: Distribution of Wage Changes by Wage Agreement Regime



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 G: 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, 95%-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 (1) Selection equation - Robustness

	Probability of wage change			
	(1a)	(2a)	(3a)	(4a)
CPI Inflation	0.045***	0.026***	0.016***	0.018***
	(0.000)	(0.001)	(0.001)	(0.000)
Unemployment	0.003***	−0.012***	−0.009***	−0.020***
	(0.001)	(0.001)	(0.001)	(0.001)
NMW	0.012***	0.009***	-0.014***	0.026***
	(0.000)	(0.000)	(0.001)	(0.000)
Wage floors	0.030***	0.022***	0.021***	0.025***
	(0.000)	(0.000)	(0.000)	(0.000)
Firm agreement	0.117***	0.110***	0.110***	0.129***
	(0.001)	(0.001)	(0.001)	(0.001)
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)	
Time dummies	No	No	Yes	No
Quarter dummies	No	Yes*2010	No	Yes
Time linear trend	No	No	No	No
Observations	1,986,531			

Note: We report in this table the marginal effects calculated from the estimation of the Probit 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. *p<0.1; **p<0.05; ***p<0.01.

Table D: Determinants of Wage Changes - Tobit Estimates (2) Second equation - Robustness

	Size of wage change			
	(1b)	(2b)	(3b)	(4b)
CPI Inflation	0.224***	0.214***	0.215***	0.243***
	(0.003)	(0.003)	(0.003)	(0.003)
Unemployment	−0.085***	−0.092***	−0.091***	−0.068***
	(0.004)	(0.005)	(0.004)	(0.004)
NMW	0.116***	0.110***	0.110***	0.107***
	(0.002)	(0.002)	(0.002)	(0.002)
Wage floors	0.137***	0.136***	0.136***	0.146***
	(0.002)	(0.002)	(0.002)	(0.002)
Firm agreement	0.320***	0.326***	0.326***	0.353***
	(0.005)	(0.005)	(0.005)	(0.005)
Mills ratio	0.770***	0.751***	0.749***	0.876***
	(0.003)	(0.003)	(0.003)	(0.003)
Time dummies	No	No	No	No
Quarter dummies	No	No	No	No
Time linear trend	Yes	Yes	Yes	Yes
Observations	466,585			

Note: We report in this table the parameter estimates obtained from the second step of the Tobit model. Each specification is associated with a selection equation whose results are reported on the previous table. Determinants are calculated as cumulative variable since the last wage adjustment. Sector, size and wage deciles controls are introduced in all specifications. Time linear trends are interacted with sector, size and wage deciles. *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).[46] 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×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:

$$\Delta W^*_{ijt} = \beta \Delta X_{ijt} + \mu_{ij} + \lambda_t + \epsilon_{ijt} \tag{14}$$

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

[46] 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}).[47] 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 E 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.[48] 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.

[47] 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.

[48] 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 E: 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 included sector, size, wage deciles and year controls in all specifications. *p<0.1; **p<0.05; ***p<0.01.

Table F: 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	0.010**	0.312***
wage changes	(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.

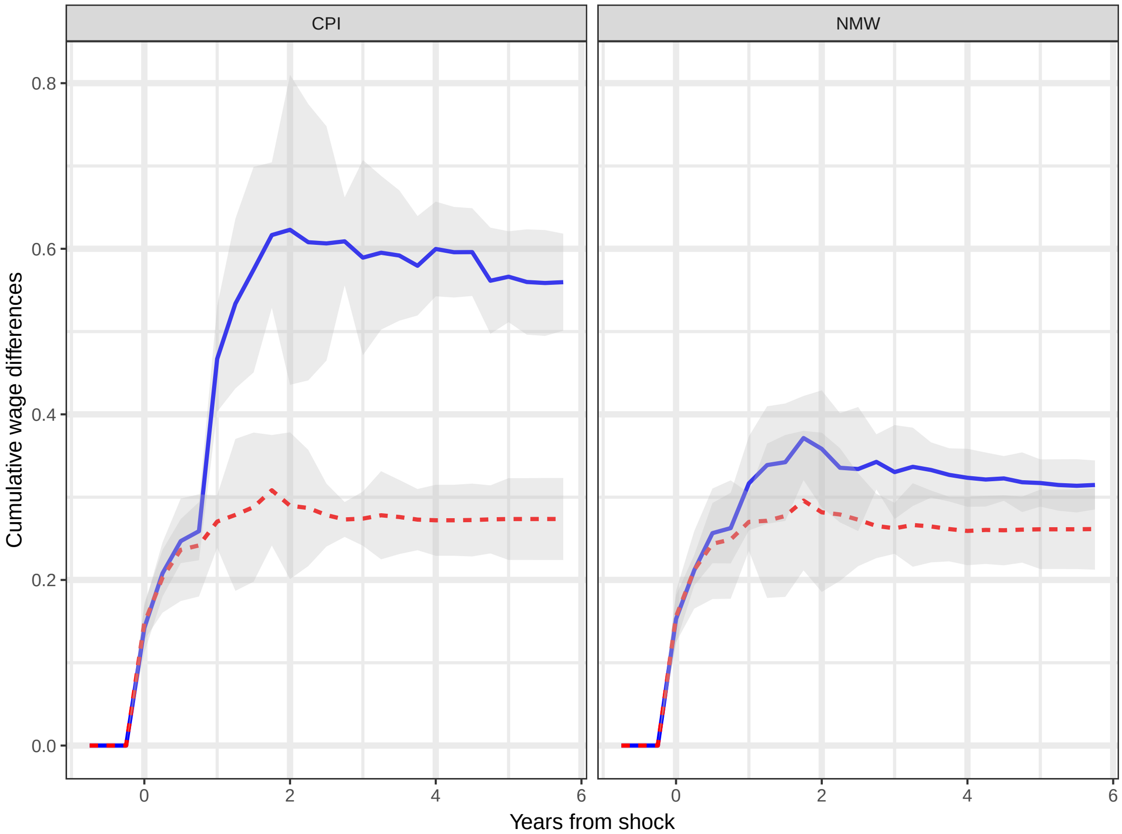
Table G: Firm-level Agreements: Probit Results

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

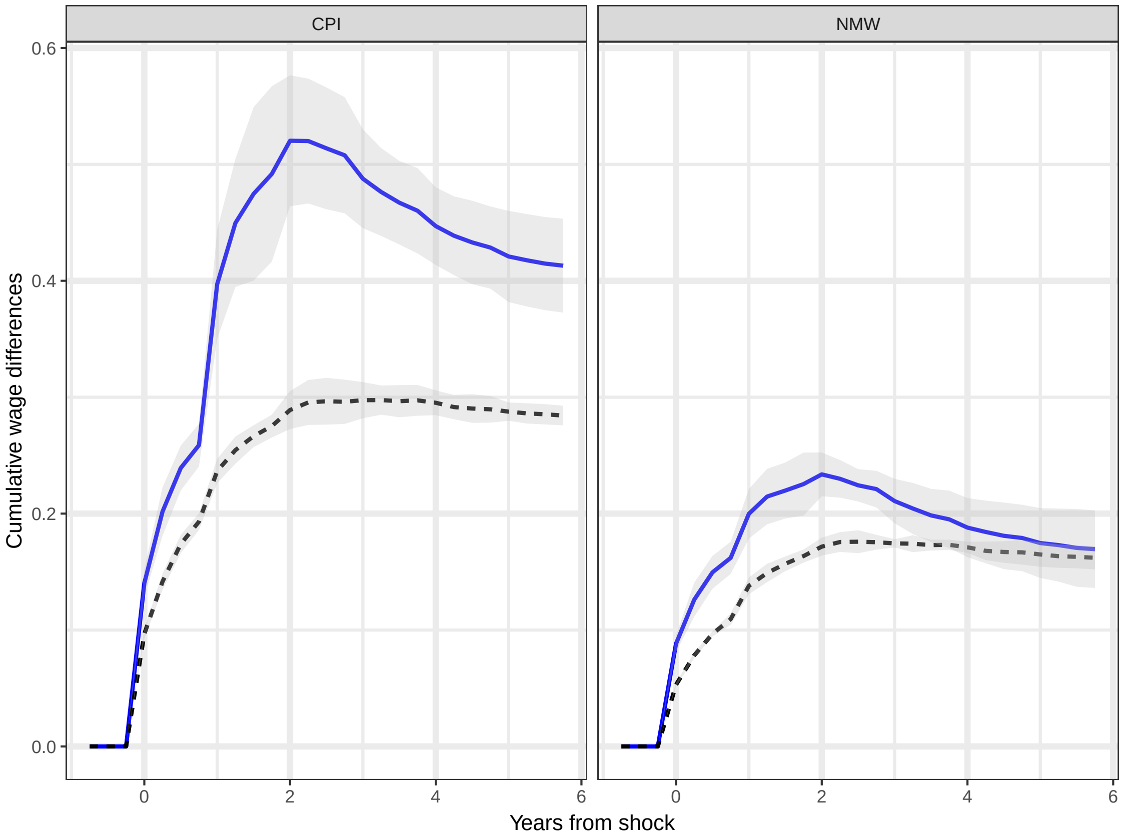
E Supplementary Simulation Results

Figure H: 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 feedback loop effects). We also report 95%-confidence intervals using bootstrap simulations.

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



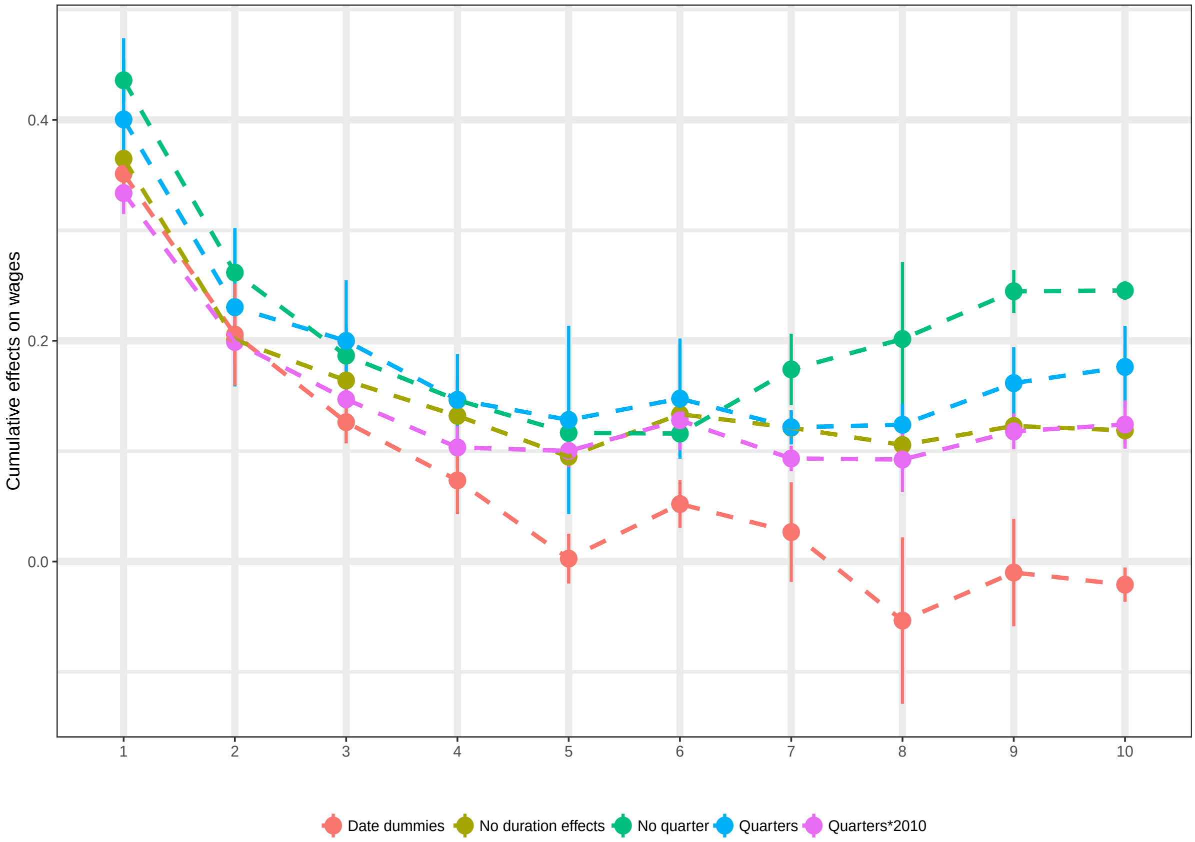
Note: We here report the results of our simulation exercize: using our estimated model, we simulate two groups of wage change trajectories, the first one with no shock and the second one with a 1%-increase in macro determinants. The shock is introduced in 2010Q1. We compute the average of all wage change trajectories by date and report the difference between the average with shock and the average with no shock. We also report 95%-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 H: 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 J: 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 brown, the estimates when we include only quarter dummies and no duration dummies, in light green, the estimates when we include no quarter dummies and only duration dummies, in red light we include date dummies, in purple, we include quarter dummies interacted with a dummy before/after 2010.

Table I: 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 5.1 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 J: 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

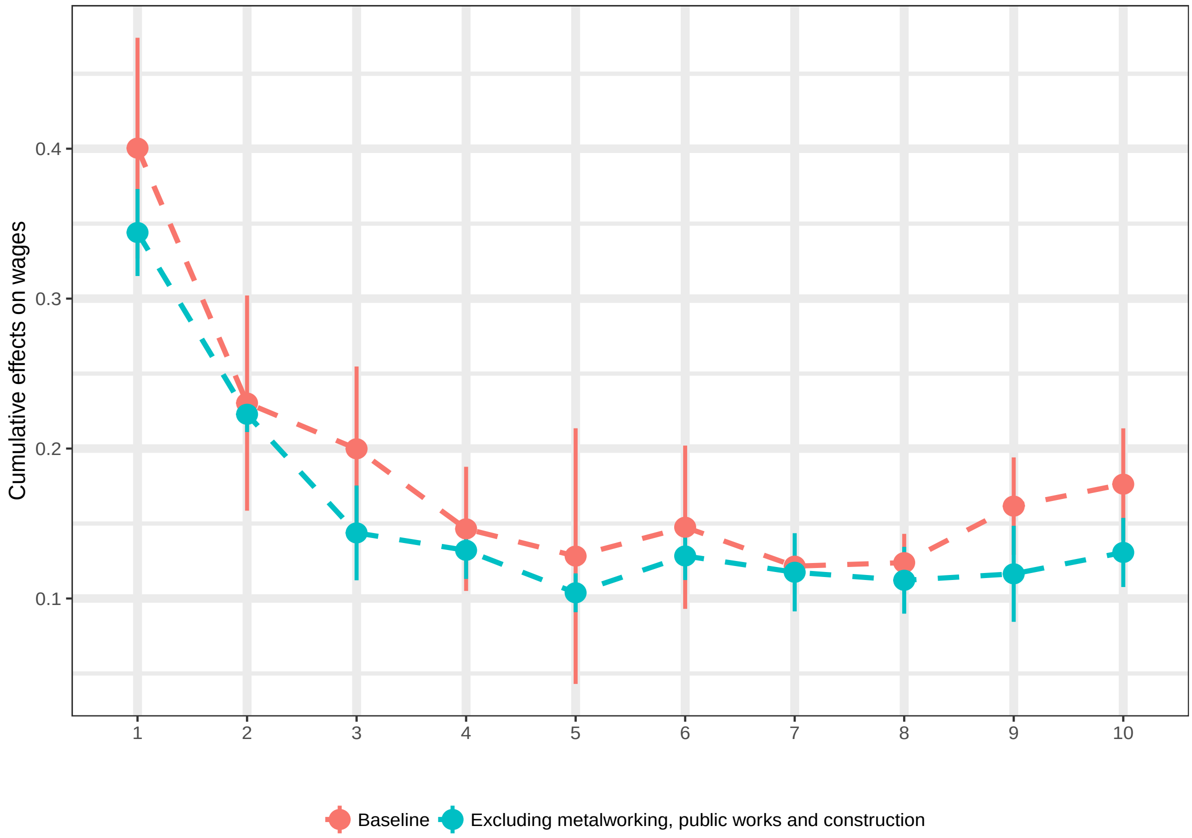
Note: this table reports results on the dynamic aggregate effect of a shock on wages. In the first three columns we report the number of quarters before the cumulative effect is equal to 90, 95 or 98% of the long term effect of a shock on aggregate wages. Our criterion is the following: the first date 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 K: 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)
No duration effects (only quarters)	0.123	0.160	0.161
	(0.003)	(0.003)	(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)
No duration effects (only quarters)	0.258	0.313	0.430
	(0.005)	(0.005)	(0.011)

Note: This table reports results from simulation exercise described in section 5.1 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. 95%-confidence interval are provided in brackets and are obtained using bootstrap simulations.

Figure K: 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 L: Direct and Indirect Effects of NMW on Wages

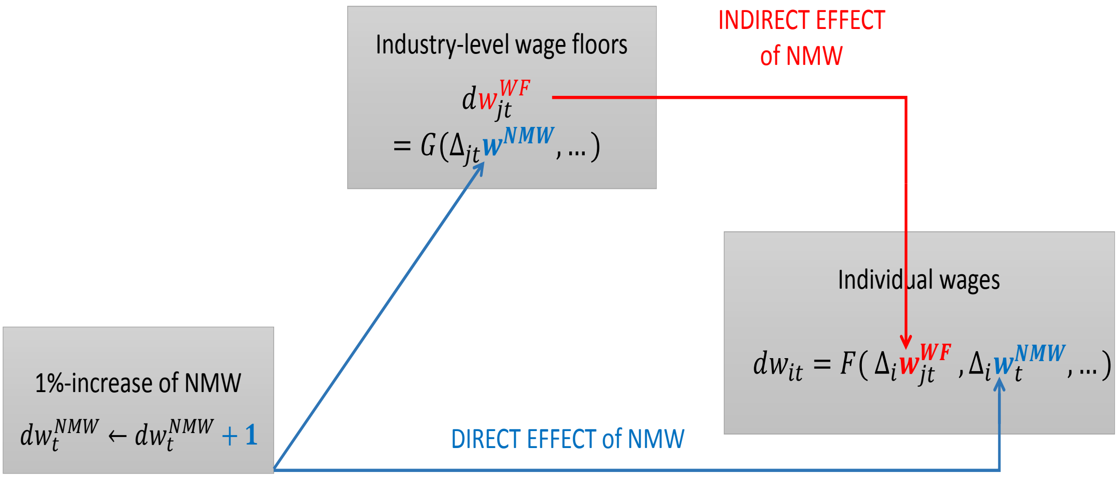
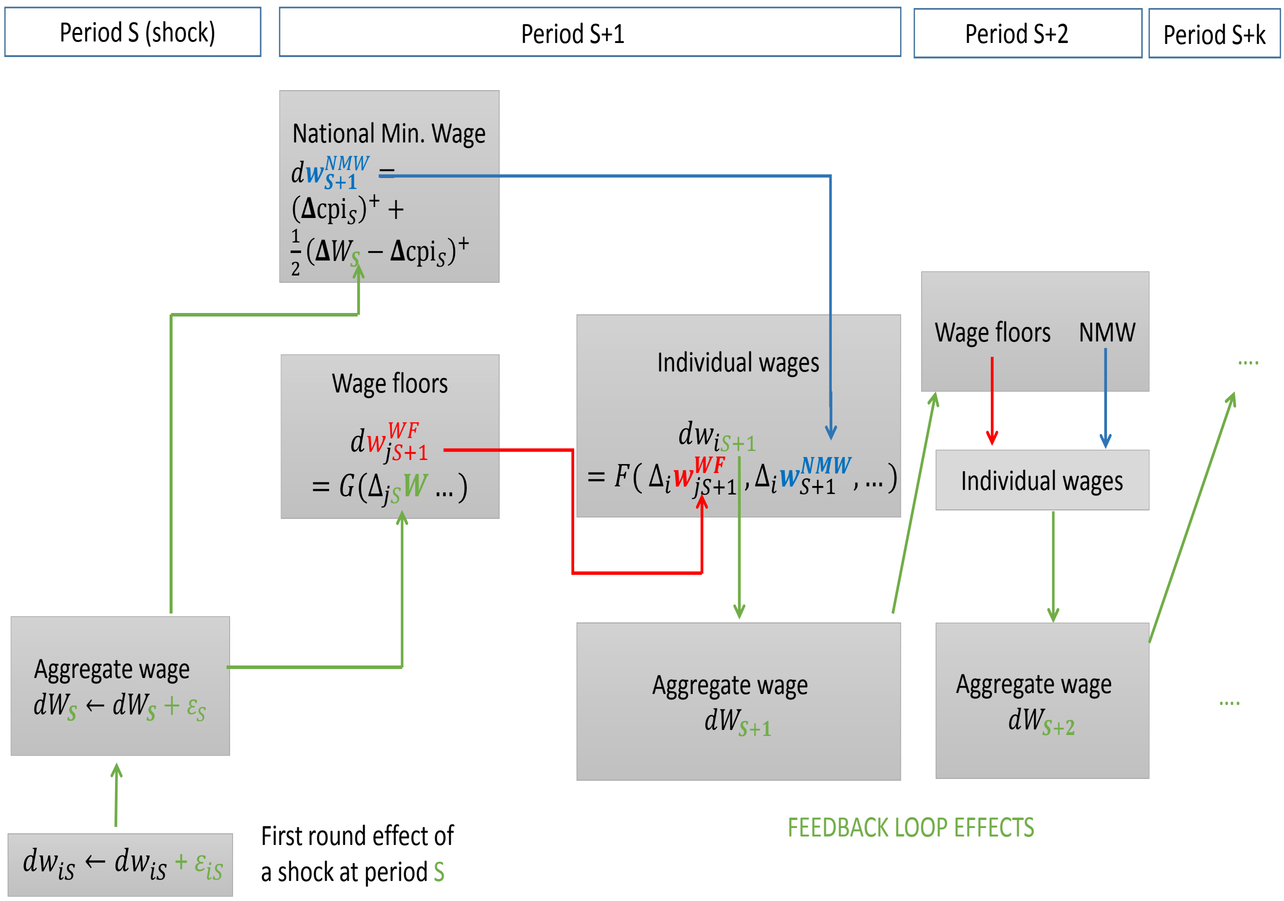


Figure M: Feedback Loop Effects of a Base Wage Increase



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[49]. 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.

[49]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: $\{dcpi_t\}_{1\le t\le T}$, 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 F 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:

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

We introduce a constant a in the wage change equation.[50] The shock appears in an individual trajectory i until the occurrence of a wage change after t_0 (then, $\tau^S_{it} \geq t_0$).

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

[50] 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.