Žymantas, Budrys; Porqueddu, Mario; Sokol, Andrej

**Book**

# Striking a bargain : narrative identification of wage bargaining shocks

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# Striking a Bargain: Narrative Identification of Wage Bargaining Shocks

## Working Paper Series

# Striking a Bargain: Narrative Identification of Wage Bargaining Shocks[*]

## Žymantas Budrys
(Bank of Lithuania and Vilnius University)

## Mario Porqueddu
(European Central Bank)

## Andrej Sokol
(Bloomberg LP)

## ABSTRACT

We quantify wage bargaining shocks' effects on macroeconomic aggregates in Germany using a structural vector auto-regression model. We identify exogenous variation in bargaining power from episodes of minimum wage introduction and industrial disputes. This disciplines the impulse responses of unemployment and output, and sharpens inference on the behaviour of other variables, which is consistent with theoretical predictions from search and matching models. We find that wage bargaining shocks are an important contributor to agregate fluctuations in unemployment and inflation, exhibit close to full pass-through to consumer prices, and imply plausible dynamics for the vacancy rate, firms' profits, and the labor share.

# 1  Introduction

Labour market developments play a fundamental role in the economy. On the one hand, they transmit macroeconomic disturbances associated, to name only a few, with technological change or monetary policy. On the other, policies affecting and outcomes arising from labour markets can themselves be important drivers of the business cycle. In this study, we revisit a specific distortion arising from the labour market: shifts in the relative bargaining power between workers and employers in wage negotiations. Our aim is to quantify the effects of wage bargaining shocks on macroeconomic aggregates and evaluate their importance for the business cycle.

Workers and employers bargain over the surplus generated by their relationship, and bargaining power determines how that surplus is split. However, bargaining power is an abstract concept in models capturing the essence of wage negotiations. It is unobserved and can be driven by many factors. We therefore propose to identify exogenous variation in bargaining power from the data by exploiting narrative information about key events relevant for wage negotiations.

Germany, the country we focus on in this paper, provides a number of historical events that arguably constitute wage bargaining shocks: a statutory minimum wage introduction in 2015, as well as a number of labour disputes led by the prominent union IG Metall. Both sets of events meaningfully affected wages for a large share of the workforce, and arguably also constituted exogenous variation in bargaining power: the wage floor was introduced mainly for political reasons close to a Federal election (Caliendo et al., 2019; WSI, 2013), while we rely on an event study to argue that our selected strikes were not fully anticipated by market participants.

The aim of a minimum wage policy is to improve conditions for low-paid workers by forcing employers to increase wages. The policy thus acts as a direct shift of bargaining power in favour of workers (Flinn, 2003). Previous studies found that the initial minimum wage introduction led to non-negligible hourly wage increases across the lower tier of the wage distribution (Caliendo et al., 2019, 2018; Mindestlohnkommission, 2018), which is confirmed by our own results. Collective bargaining rounds that involve the threat of, or actual, industrial strikes are also a device to boost workers' bargaining power. We document that in the aftermath of selected industrial disputes led by IG Metall, aggregate negotiated wages increased considerably by historical standards.

While Germany is a very interesting case study in its own right, our methods and findings are of broader applicability and relevance. Du Caju et al. (2009) show that wage bargaining institutions share important features across many economies, most notably some form of national minimum wage, high union coverage and a generally high degree of regulation of the wage-setting process. Against this background, recent debates about the national minimum wage in the United States (see for example Glover and Mustre-del Río, 2021), or ongoing wage bargaining rounds in many countries provide fertile ground for further research.[1]

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[1] See https://wageindicator.org/labour-laws/collective-bargaining.

## 1.1 Contribution

Our paper is the first to systematically exploit narrative information to identify wage bargaining shocks in a macroeconomic setting. To that end, we employ a structural vector-autoregressive model (SVAR) estimated with state-of-the-art techniques, including restrictions on its deterministic component (Giannone et al., 2019), and identified with a combination of sign and narrative restrictions (Antolín-Díaz and Rubio-Ramírez, 2018).

Our first contribution is to identify a small set of key events concerning the German labour market, showing their relevance for pinning down wage bargaining shocks and arguing for their exogeneity to cyclical developments. In terms of relevance, we find that over 99% of posterior parameter draws that satisfy uncontentious sign restrictions still violate narrative restrictions imposed when a minimum wage was first introduced in Germany and in periods featuring important strikes. Our results thus support Antolín-Díaz and Rubio-Ramírez (2018)'s claim that narrative restrictions can sharpen inference, and address some of the weak identification issues highlighted by Baumeister and Hamilton (2020). As for exogeneity, the argument comes in two parts: for the introduction of the minimum wage, we rely on established criteria (Romer and Romer, 2010) to classify the event as exogenous; for industrial actions, we conduct an event study and find that the abnormal returns of affected firms indicate that the strikes still constituted at least partly unanticipated events.

Our second contribution is to revisit the effects of wage bargaining shocks on aggregate fluctuations in light of our novel identification. We find that narrative identification disciplines the impulse responses to a wage bargaining shock of unemployment and output, on which we do not impose any sign restrictions. Wage bargaining shocks lead to adverse effects on the economy with higher unemployment and lower output. The response of unemployment is strikingly persistent, whereas output effects are comparatively short-lived, mostly fading within 3 years. Such effects are closely in line with the predictions of structural models with search frictions in labour markets or monopolistically competitive unions. We also find that bargaining shocks explain around a quarter of GDP deflator inflation and unemployment variability at longer horizons. The so-called pass-through of higher wages to prices following a wage bargaining shock is close to full, and provides a rationale for monetary policy-makers to monitor factors influencing wage bargaining outcomes. Focusing on the minimum wage introduction episode, we also show that estimated contributions of wage bargaining shocks to developments in unemployment, prices and nominal wages are in line with existing estimates from microeconometric studies.

## 1.2 Related literature

Our paper mainly relates to four literature strands. First, it speaks to the theoretical literature that studies the role of wage bargaining shocks in the macroeconomy (Christoffel et al., 2009; Galí et al., 2012; Gertler et al., 2008; Drautzburg et al., 2021; Hagedorn and Manovskii, 2008, among

others). Structural models differ in their underlying assumptions, often emphasizing a particular transmission channel to better fit specific features of the data. With that in mind, Chari et al. (2007) consider a prototype model encompassing a range of modelling frameworks, and suggest that frictions to the labour wedge can explain a sizeable share of business cycle variation. The labour wedge can capture both traditional and less common sources of variation, including shifts in wage bargaining power. Policy-oriented models, such as Smets and Wouters (2007) or Coenen et al. (2018) among others, typically capture this variation under the broad heading of 'wage markup shocks'. However, such models arguably lack sufficient detail to provide useful policy recommendations in this particular domain. Therefore, a plausible empirical identification of wage bargaining shocks can contribute to directing future modelling efforts and complement policy analyses of the labour market and the broader macroeconomy.

Second, it is related to other efforts to identify wage bargaining shocks (or more broadly, wage markup shocks) in macro data. Existing studies tend to rely on the implications of structural models to guide their identification strategy. For example, Galí and Gambetti (2019) identify a wage mark-up shock as the only shock that generates a positive co-movement between real wages and unemployment on impact. However, they do not study the macroeconomic implications of this particular shock. A similar approach for identification is taken by Foroni et al. (2018), who rely on sign restrictions implied by a New Keynesian model to disentangle labour supply from wage bargaining shocks. Finally, Bergholt et al. (2019), who mainly focus on the determinants of the labour share, find that wage markup shocks explain a large share of variation in wages and GDP. Relative to these studies, we shift the emphasis on narrative information about bargaining power, which we exploit to relax some of the more contentious identification restrictions imposed on the data, while at the same time sharpening inference.

Our paper thus also contributes to the growing literature that relies on narrative information for shock identification (Romer and Romer, 2004, 2010; Ramey, 2011; Cloyne, 2013; Mertens and Ravn, 2014; Gertler and Karadi, 2015; Antolín-Díaz and Rubio-Ramírez, 2018, among others). To date, only a handful of papers focused on labour markets: Duval et al. (2017), who evaluate the effects of job protection deregulation policies on employment and whether there are any asymmetries across business cycle states; and finally, Ciminelli et al. (2018) investigate whether employment protection reforms can explain the fall in the labour share in western countries.

The paper most closely related to ours is Drautzburg et al. (2021), who, among many other exercises, use a proxy VAR where variation in minimum wage policy in the United States is used as an instrument for wage bargaining shocks. While our results are largely consistent with theirs, there are some important methodological differences. Crucially, in our setting we only rely on one salient minimum wage episode, the introduction of a nationwide minimum wage, making allowance for the unclear timing of the event. But as wage bargaining is not solely related to minimum wages, we also examine industrial strikes as a further source of variation.

Finally, our paper also speaks to the literature studying the minimum wage introduction in Germany, which we review in more detail in Section 3 and relate to our results in Section 5. In this study, we explore different institutional properties and features of industrial relations in Germany. While we aim to provide a clear understanding of the main aspects, readers who are interested can refer to the footnotes and the latest informative summary provided by Jäger et al. (2022) for additional supporting arguments.

**Paper structure**   The rest of the paper is organized as follows. In Section 2 we briefly outline the role of wage bargaining shocks in a standard search-and-matching framework and why their macroeconomic implications are a priori ambiguous. In Section 3 we detail our identification strategy using narrative and sign restrictions. In Section 4 we present the data and estimation approach. In Section 5 we discuss our baseline results, and in Section 6 various extensions and robustness checks. In Section 7 we conclude. Additional results are reported in the Appendix.

## 2   Wage Bargaining in General Equilibrium

Bargaining power is unobserved, and represents an "umbrella" term for various factors, ranging from personal preferences to the extent of unionization to the sequencing of bargaining steps, that determine how the surplus of a work relationship is split between parties. In a canonical search and matching framework featuring Nash bargaining (Pissarides, 2000), bargaining power is controlled by a parameter that seeks to capture all factors determined outside the model.[2]

In such a framework, workers and vacancies cannot be matched immediately leading to flows in and out of the labour market, as summarised by the Beveridge curve (BC), a negative relationship between unemployment and vacancies (right panel in Figure 1). Firms post vacancies with the expectation of making a match, and a job-creation (JC) curve captures labour demand, a negative relationship between labour market tightness and wages. The value of the match for workers is the sum of the posted wage and the probability-weighted value of staying employed or becoming unemployed. Combined with a Nash bargaining solution, this gives rise to a wage curve (WC), a positive relationship between labour market tightness and wages, whose intersection pins down the equilibrium wage rate and labour market tightness (left panel of Figure 1). It also gives rise to a job creation locus in unemployment-vacancies space (right panel of Figure 1) that intersects the BC curve at the long-run equilibrium.

An increase in bargaining power leads to an upward shift in the wage curve ($WC_0$ to $WC_1$). Workers are able to obtain higher wages, resulting in the match value for firms to decrease and, therefore, a lower labour market tightness. On the right panel, the locus of job creation rotates clockwise, indicating that vacancies drop as firms are less willing to hire due to increased costs, and unemployment gradually increases.

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[2]For more technical details, see Appendix A.

**Figure 1** Illustrative effects of a wage bargaining shock in a canonical Diamond-Mortensen-Pissarides model
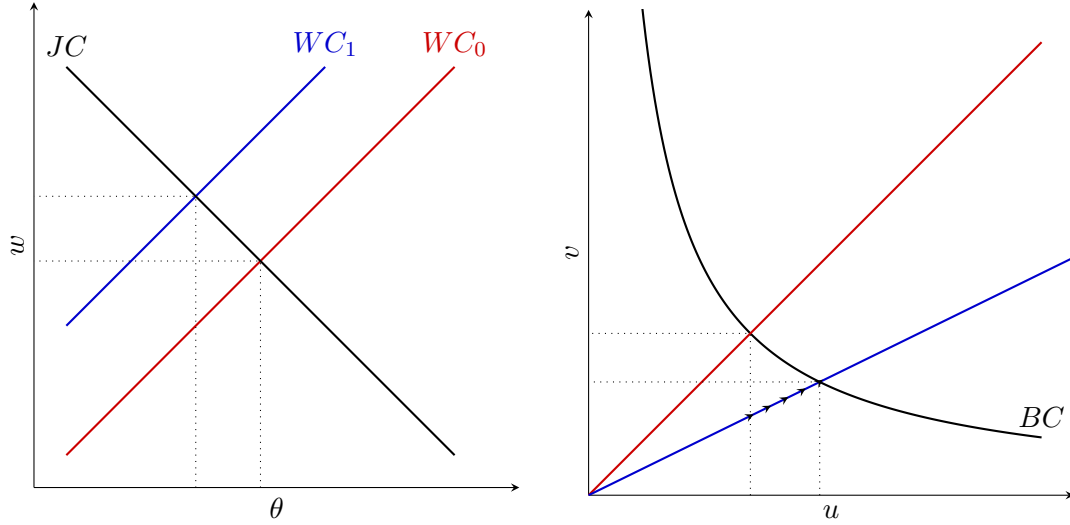


**Note:** BC stands for Beveridge curve; JC - job creation curve; WC - wage curve.

Crucially, such an outcome for unemployment very much depends on the specifics of the assumed model. A different bargaining framework, a more complex modelling setup or different parameter values can completely alter the conclusions, and with them any policy recommendations. We, therefore, seek to rely as little as possible on theory in our identification of wage bargaining shocks, and instead exploit information available from recent historical events.

## 3 Identification of wage bargaining shocks

Previous studies of wage bargaining shocks in a VAR setting (e.g. Foroni et al., 2018; Conti and Nobili, 2019; Galí and Gambetti, 2019) typically only relied upon sign restrictions on impulse responses, informed by a specific structural model, to achieve identification. However, when it comes to wage bargaining shocks, labour market models vary considerably in their structural assumptions and underlying mechanisms. For that reason, we relax some of the more contentious restrictions, those on unemployment or output, and instead exploit narrative information to pin down the dynamic responses of these variables.[3]

In addition, the sign restrictions are usually imposed on impact, suggesting that the transmission of structural shocks is immediate. But for wage bargaining shocks, especially those associated with more lasting changes to the labour market, such as fixing a minimum wage, legislative and transmission lags can be substantial, and assuming immediate effects may lead to a misleading chronology of structural shocks. In contrast, by relying on narrative restrictions, we can impose a chronology of events that regulates structural parameters and hence the timing of transmission.

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[3]In fact, we show in one of our robustness exercises that dispensing with sign restrictions altogether and solely relying on narrative information still yields very plausible dynamic responses, see Section H.2 in Appendix.

A further appealing feature of exploiting narrative information for identification is that with Antolín-Díaz and Rubio-Ramírez (2018)'s methodology, it is not required that a given event be completely exogenous and unpredictable, but simply that it signals the occurrence of a shock within a specified timeframe and with bounds on its economic significance.[4]

In what follows, we first review the narrative evidence that informs our identification restrictions. This comes in two parts: the first pertains to the introduction of a minimum wage in Germany, and the second to major industrial actions. In both parts, we argue that the events were relevant to wage dynamics, and also plausibly exogenous (at least partly) – two features that support their use to identify wage bargaining shocks. We then elaborate on the usefulness of also retaining some sign restrictions inherited from the existing literature.

## 3.1 Narrative restrictions

### 3.1.1 The introduction of a minimum wage floor

At the beginning of 2013, German political parties declared a shared intention to introduce a binding wage minimum. However, only after the general election of September 2013, the issue of a statutory minimum wage was revived. During coalition talks, political parties reached an agreement that included an aspiration for a minimum wage of 8.50 euros from 1 January 2015. Most details, such as the date of introduction, the minimum wage rate, provision period and terms for collectively agreed wages were pinned down by the coalition agreement and barely changed in the final legislation (WSI, 2013).[5] In April 2014 there was an agreement on the draft legislation, which was passed in July and came into force on 16 August 2014.

**Relevance and timing**    The initial minimum wage rate of 8.50 euros was sizeable. Compared to wage floors in other European countries, the initial level in Germany, adjusted for purchasing power, was the third largest, with a ratio of minimum-median wage of 52% (Caliendo et al., 2019; Link, 2019; Caliendo et al., 2018). Around 10.7% of the workforce (4 million employees) had wage rates below the new threshold and was eligible for the minimum wage rate, suggesting

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[4]There are of course limits to this. One of the reasons for not including the more far-reaching Hartz reforms – a series of extensive labour market reforms that represented a major shift in bargaining relations – as events in our analysis is that the reforms were extensively discussed in negotiation rounds, announced very much in advance, and implemented over several years, making it difficult to even approximately pinpoint the timing of a shock or series of shocks. In addition, the primary focus of the reforms was on reorganising unemployment benefits, which arguably reflects a change in workers' external options rather than a shift in bargaining power. Overall, the policies represented a lasting structural change with long-term effects on labour markets and the broader economy. Our interpretation is that they are likely to be better captured by the evolution of the deterministic components in our model, as opposed to the more transitory wage bargaining shocks that we examine in our study.

[5]The rate was set to be 8.50 from 2015 euro with a subsequent adjustment in two years' time. The pay rates agreed in collective agreements were allowed to stay below the national rate for a transition period ending in 2017. A minimum wage commission was established to determine future adjustments based on developments in the economy and changes negotiated in future collective agreements. Apprentices, volunteers, youth under 18 and interns, among others, were exempted from the minimum wage.

that the average wage increase was also sizeable, even without accounting for spillover effects on the rest of the wage distribution (Destatis, 2016). A number of micro studies subsequently found that there were significant hourly wage increases at the lower end of the wage distribution. The overall wage bill is estimated to have increased by 0.43% in 2015 (Mindestlohnkommission, 2018). Gross incomes rose more strongly than collectively-agreed pay for the first time in a number of years (Bundesbank, 2015b). And despite warnings of heavy employment losses, there were only small aggregate employment effects, mostly concentrated in mini-jobs and part-time work arrangements.[6] The adjustment of employment was more noticeable on the intensive margin, as contractual working hours fell (Caliendo et al., 2019, 2018). We provide further evidence of the policy's aggregate effects in Section 5.3 from the macroeconomic perspective.

The exact date of the policy shock is difficult to determine, as announcement, legislation and implementation are each two quarters apart, leaving the possibility of non-negligible anticipation effects. WSI (2015) and Bundesbank (2018) suggest that after the political agreement, a number of collective agreements in low-pay sectors were signed in 2014 to bring wages towards the national statutory rate and exploit the transition period until 2017. Bossler (2017) find that after the announcement, but prior to implementation, firms more exposed to minimum wage rate rises were more likely to report uncertain or worsened employment prospects and labour costs problems. Link (2019) suggests that affected companies were more likely to expect (realise) price changes for the treatment period of 2014m7-2016m6 (2014m10-2016m9). However, the extent to which wages were increased prior to 2015 is still debatable: Kubis et al. (2015); Bellmann et al. (2015) provide some evidence that wages were adjusted preemptively, whereas Caliendo et al. (2018) argue the opposite. We therefore opt not to take a stance on the exact timing of the shock, and instead, only require a positive contribution of wage bargaining shocks to real wages over the 2014q1 to 2015q1 period.

**Exogeneity** The reasoning behind the policy was to reduce inequality, protect the less-skilled and lower-paid, especially those not covered by any collective agreement, as well as to improve workers' rights and bargaining power in response to the ongoing decline in unionization rates and a number of "wage-dumping" scandals.[7] And although its introduction coincided with a period of favourable economic conditions in Germany, the policy only came into force one year after the announcement.[8] This suggests that the policy met the criteria – structural, long-run and ideological – proposed by Romer and Romer (2010) to define exogeneity to the business cycle.

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[6]In Germany, mini-jobs refers to part-time work arrangements or "marginal employment", for which workers earn less than 450 euros per month and are exempt from social security contributions.

[7]The policy reasoning is expounded in the coalition agreement (CDU, CSU und SPD, 2013) and supported by a number of political articles and commentators (Spiegel, 2013; Haufe, 2013; Reuters, 2012; The New York Times, 2013; The Local, 2013).

[8]Such implementation lags have been viewed before as circumstantial evidence of the policy not being cyclical in nature (see for example Drautzburg et al., 2017).

We thus interpret the introduction of a minimum wage as an unexpected wage bargaining shock that increased aggregate real wages over the 2014q1 to 2015q1 period. For that reason, we impose a narrative restriction such that the contribution of wage bargaining shocks to the historical decomposition of real wages over that period is positive.

**Restriction 1** *The contribution of wage bargaining shocks on real wages over the period from 2014q1 till 2015q1 is positive.*

### 3.1.2 Major industrial actions

We also treat major industrial disputes as events indicating the possible occurrence of wage bargaining shocks. Some early insights in this direction are provided by Hicks (1963), who viewed strikes and their outcomes as unpredictable by-products of failed negotiations, but also conjectured that since strikes are Pareto sub-optimal, they could also arise as a result of either private information or unions' effort to project a militant image. More recently, a number of bargaining models with strikes have been developed (see Cahuc and Zylberberg, 2004; Kennan, 1986; Kennan and Wilson, 1989, for comprehensive reviews). The exact definition of bargaining power is usually model-specific, but in general, and *ceteris paribus*, a union's greater bargaining power manifests itself in an increase in the incidence of strikes and in higher negotiated wages. For that reason, observing an above-average wage increase after a strike suggests that a wage bargaining shock may have occurred.[9]

We apply stringent criteria to select strikes suitable for our identification purposes. We focus on strikes where (1) a union is viewed as the winner of a negotiation round, and (2) anecdotal evidence suggests that wage increases, among other aspects of the negotiation, would have been much less favorable to workers in the absence of a strike (threat). These first two conditions are motivated by the aforementioned predictions of theoretical models of the bargaining process. Moreover, we require that (3) the strike is an economic strike, reflecting the union's aim to obtain higher wage increases or better working conditions. This criterion rules out strikes due to a union's reaction to unfavorable firm policies, which could be construed as an admission of weakness. We also choose (4) significant and costly strikes. In Germany, the legislative framework on strikes encourages unions to call warning strikes that are typically short and induce only minor production losses for the firm. Instead, we focus on full-day strikes. Finally, we only consider (5) major labour market conflicts involving IG Metall, the union representative for the metal and electricity industry. IG Metall is generally viewed as a trend-setter for wage bargaining activity in Germany, due to its significance in union coverage and historical dominance: the union

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[9]Shifts in bargaining power also relate to the institutional framework governing the ability to hold a strike and the credibility of its threat. Thus, legislative and institutional changes can potentially serve as alternatives to using strike events for narrative identification purposes. For example, a strike threat becomes less relevant if firms are allowed to employ strike-breakers or if workers are entitled to unemployment benefits during a stoppage, as opposed to relying on union finances. However, we ignore this angle in our study, mainly because the timing of such shocks would be less clear-cut due to legislative implementation lags and other complexities.

is the largest in Germany as well as in Europe, representing around 3.5-3.9 million employees (see Eurofound, 1999a; Bispinck, 1995).[10]

**Relevance and timing** We identify three events that fully match our criteria. These occurred in 1995q2, 2002q3 and 2018q2, respectively. We also include another event, in 1999q2, that, unlike the previous ones, did not result in a full-day strike, but instead ended with a compromise reached two hours after the deadline to authorize a strike. IG Metall led an end of wage restraint policy with above-average wage increases followed in other sectors (Eurofound, 1999a). A more detailed description of the events is provided in Appendix B.

We observe non-negligible wage increases after IG-Metall industrial disputes. Figure 2 shows nominal wage dynamics around our selected events.[11] The series of monthly growth rates, Basic Pay Rates (MoM), shows that there are spikes on the dates of IG Metall-negotiated wage increases.[12] We also note that the increases were above the $85^{th}$ percentile of wage increases over 1993 to 2020. The increase in May 1995 in particular constitutes an extreme outlier. Using a different measure of wages and salaries from national accounts we reach similar conclusions, though the spike may occur with a lag of one quarter due to the aggregation of the series to a quarterly frequency (see discussion below).

The effective dates of wage increases are a reasonable indicator to time our narrative restrictions.[13] Disputes and agreements take place one to two months prior to a pay increase, so there is little scope for anticipation effects using quarterly data. However, aggregation of monthly data plays a role, as becomes evident comparing the monthly, BPR (MoM), and quarterly, BPR (QoQ), versions of the same series in Figure 2: at a quarterly frequency, a wage increase lags by a quarter if the effective date is the last month of the quarter, as in 2002q2.[14] Our narrative

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[10]The coverage extends to the large part of employees in the metal and electricity industry, despite the fact that the union has over 2.2 million members and covers other sectors like textile and plastics. In Germany, bargaining agreements typically encompass all employees of the firms that have signed them, regardless of their union membership status (Jäger et al., 2022). Non-affiliated companies either choose individual agreements with the union or imitate sectoral agreements (Ellguth and Kohaut, 2020). The discretion to deviate seldom concerns wages but mostly concerns contractual benefits, such as leisure packages.

[11]Basic Pay Rates (BPR) is a monthly Bundesbank leading wage statistic that summarises developments in wages under collective agreements covering over half of the German workforce (Bundesbank, 2020). Wage agreements often also include a lump-sum payment to compensate for the period of re-negotiation. We do not consider those payments in our analysis as they constitute a one-off effect. For further comparison, we include wages and salaries per employee from national accounts statistics.

[12]We suspect that the delayed spike in 1999q2 was due to an agreed delay in wage increases for workers in Eastern Germany, (see Eurofound, 1998) as well as agreed pay increases in other sectors that followed the lead of IG-Metall to end the practise of wage moderation (Eurofound, 1999a).

[13]Note that the effective date of a wage increase differs from the effective date of a collective agreement, which in case of industrial action is back-dated to the end of the previous agreement.

[14]This happens mechanically as a result of the aggregation of cumulative variables such as BPR and wage and salaries from monthly growth rates into quarterly ones. Specifically, let the quarterly series be a cumulation of monthly series $y_t^q = y_t^m + y_{t-1}^m + y_{t-2}^m$. Then its quarterly differences will relate to its monthly differences as follows: $\Delta y_t^q = \Delta y_t^m + 2\Delta y_{t-1}^m + 3\Delta y_{t-2}^m + 2\Delta y_{t-3}^m + \Delta y_{t-4}^m$. A similar relationship holds for the transformation of quarterly averages. Of course, if (as here), the underlying series is in logs, this involves an approximation, which however is typically acceptable.

**Figure 2** Nominal wages around selected IG Metall industrial strikes



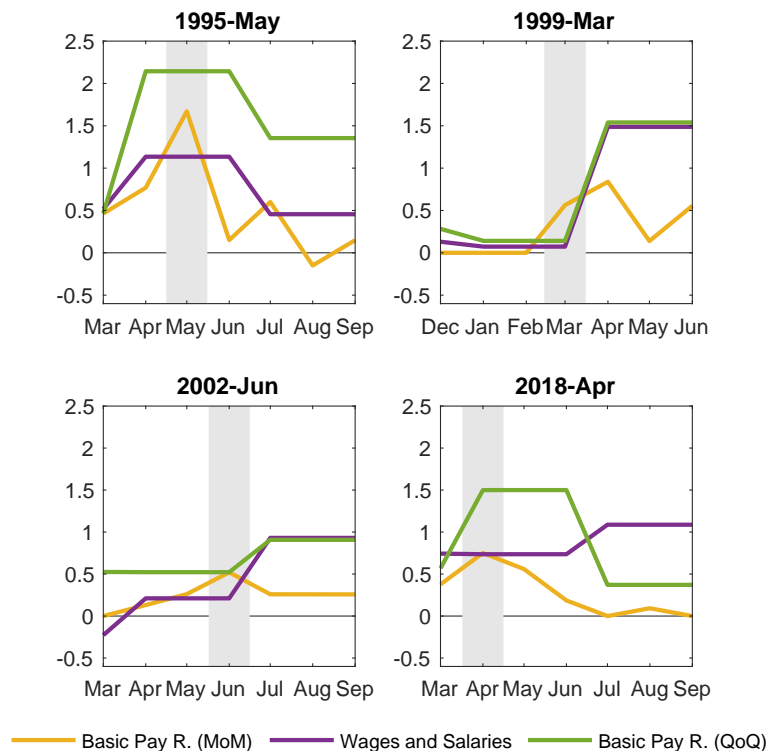**Note:** The grey area shows the month of the actual wage increase, agreed between IG Metall and the association of employers. Basic Pay Rates (BPR) is a monthly Bundesbank leading wage statistic that summarises developments in wages under collective agreements covering over half of the German workforce, excluding one-off payments and additional benefits (Bundesbank, 2020); BPR (MoM) is its monthly, BPR (QoQ) its quarterly growth rate. The series in purple is the quarterly growth rate of wages and salaries per employee from the national accounts.

restrictions are thus imposed for the same quarter if the effective date of a wage increase occurs in the first two months of that quarter, and otherwise, for the following one.[15]

**Exogeneity** Strikes do not represent completely exogenous events. In fact, calls for strikes and most negotiated wage increases typically reflect unions' endogenous reactions to improving economic conditions.[16] For example, historical sources emphasise that IG Metall reacted to past and expected developments in wages, low workers' purchasing power, a better economic situation and rising profitability (Gesamt Metall, 2018). However, as already pointed out by Hicks (1963), strikes are not entirely predictable either. For one thing, while the incidence of strikes may coincide and correlate with favorable economic conditions, industrial actions are still pretty rare, subject to legal barriers and usually viewed as a last resort option in wage negotiations, due to the potential unemployment and reputational costs for all social partners

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[15]The same timing assumption is used in other studies with narrative identification (e.g. Romer and Romer, 2010; Cloyne, 2013; Duval and Furceri, 2018).

[16]Industrial disputes tend to follow the business cycle. Among many other factors, high inflation and low unemployment correlate with increasingly militant union demands and a higher likelihood of strikes. Kennan (1986) provides an overview of the cyclicality of strikes.

involved.[17]

As a first step to probe the illustrative findings on the behaviour of wages in Figure 2, we estimate a set of wage Phillips curves to investigate whether wage dynamics can be adequately explained by macroeconomics developments for the quarters in which industrial disputes occur (see Appendix C for details). In our baseline specification, we find that quarterly wage growth is on average 0.7pp in excess of what macroeconomic factors would warrant for those quarters, suggesting that our selected events do indeed coincide with positive surprise effects and are economically relevant for wage dynamics.

Furthermore, we investigate the *predictability* of the full-day strikes discussed above by analysing in an event study the stock market performance of firms whose employees are represented by IG Metall, following Neumann (1980); Becker and Olson (1986); Kramer and Vasconcellos (1996) among others.[18] Strikes are harmful and costly for firms. Future profitability may suffer for a number of reasons, such as lost or delayed production due to stoppages or the expectation of a higher wage bill due to increased wage demands. Thus, strikes may reduce the valuation of a company, and if capital markets are efficient, the lower valuation should be reflected in the firm's stock price.

An event study allows us to compare observed stock market returns, $R_{i,t}$, to counterfactual normal returns in the absence of a strike, $R_{i,t}^e$.

$$AR_{i,t} = R_{i,t} - R_{i,t}^e \tag{1}$$

The difference constitutes abnormal returns, $AR_{i,t}$, that should be zero on average but may be significantly different from zero in case of particular events related to the firm's profitability. In our case, we would expect to observe significantly negative abnormal returns around the periods of industrial strikes. For the firm's normal returns, we use a basic market model that relates a company's returns to fluctuations in the overall stock market, reflecting the risk associated with investing in the company:

$$R_{i,t}^e = \alpha_i + \beta_i X_{m,t} \tag{2}$$

To quantify abnormal returns due to strikes, we first compute the model's parameters over at most 200 trading days, with the last day in the sample being 50 trading days prior to the beginning of a strike to avoid potential bias due to anticipation effects.[19] We then compute

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[17]In Germany, social partners and bargaining system assure tranquil and respectful industrial relationships. To illustrate, the average number of days not worked per 1000 employees due to industrial actions is one of the lowest among European Member States.

[18]These studies conclude that financial markets are able to anticipate strikes with the largest reaction one week before a strike, but only with limited foresight, as some surprise effect is observed following the announcement.

[19]Due to data availability or reduced market liquidity for some stocks, the estimation sample may be shorter than 200 trading days. If the sample is below 100 trading days, the stock is not traded often or is subject to severe liquidity issues, the company is dropped from the sample.

**Table 1** Cumulative Abnormal Returns around the beginning of a strike

| Window | 1995 | 2002 | 2018 | all |
|---|---|---|---|---|
| *using industrial and market index* | | | | |
| -4 : 0 | -1.62*** | -0.526 | -0.602 | -0.779* |
| -3 : 0 | -1.507** | -0.504 | -0.702 | -0.806** |
| -2 : 0 | -0.624 | -0.68 | -0.869* | -0.759** |
| -1 : 0 | -0.821* | -1.001 | -0.557 | -0.754* |
| 0 : 0 | -0.43 | -1.036 | -0.252 | -0.541 |
| Since Ann. | -0.821* | -0.68 | -0.869* | -0.799** |
| *using industrial index* | | | | |
| -4 : 0 | -1.697*** | -0.639 | -0.833 | -0.942** |
| -3 : 0 | -1.581*** | -0.581 | -0.804 | -0.894** |
| -2 : 0 | -0.659 | -0.828 | -1.024** | -0.887*** |
| -1 : 0 | -0.819 | -1.026 | -0.672 | -0.816** |
| 0 : 0 | -0.445 | -0.966 | -0.265 | -0.528 |
| Since Ann. | -0.819 | -0.828 | -1.024** | -0.92*** |
| *Obs:* | 19 | 29 | 44 | 92 |

**Note:** Statistical significance is based on the non-parametric generalised rank statistic of Kolari and Pynnonen (2011) adjusted for event clustering. Asterisks denote significance levels for a two-tailed test ( ***=1%, **=5%, *=10%). Results are also robust to an alternative parametric test statistic, 'ADJ-BMP' in Kolari and Pynnönen (2010), that also adjusts for the cross-correlation across firms in the event window.

out-of-sample abnormal returns starting five trading days before the beginning of a strike, aggregating abnormal returns across different stocks to obtain average and cumulative abnormal returns for each strike and across strike incidences.[20] Finally, we evaluate the statistical significance of abnormal returns using the nonparametric test statistic of Kolari and Pynnonen (2011), adjusted for event clustering. We use stock market returns for a list of companies whose workers are represented on supervisory boards by IG Metall and are listed on German stock exchanges (either Xetra or Frankfurt Stock Exchange). To control for market fluctuations, we use German total market and industrial indices or just the latter, as constructed in Datastream.[21]

The results are summarised in Table 1. For both specifications, we find that on average, stock returns fall by around 0.7-0.95% over the four days running up to and including the strike, which is within the range found in previous studies. On the day of a strike itself, the fall is around 0.5% but not significantly different from zero.[22] Cumulative abnormal returns are consistently negative across events and different horizons, although there is limited statistical significance for each incidence individually. But given that industrial disputes are not firm-specific and do not lead to economically significant devaluations, the power of the test for individual events is very limited and should be interpreted with a grain of salt. To isolate the

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[20]We set the event day to the beginning of a strike, but since market participants may anticipate the strike, or it may have been announced earlier, the effect on stock prices on the day may be understated. For that reason, we compute cumulative returns for recursive event windows leading to the start of a strike.

[21]Mnemonics: TOTMBKD and INDXFI, respectively.

[22]For the alternative one-tail hypothesis that the effect is below zero, we find that the effect is significantly different at the 10% significance level for both specifications (See Appendix D.1)

surprise component from a possible anticipation effect, we also present cumulative abnormal returns since the official announcement (row 'Since Ann.').[23] We observe that this effect on stock returns is around 0.8-0.9% and highly statistically significant. The results thus confirm that strikes are not fully anticipated and still constitute a surprising factor for stock market valuations, which also supports their use for narrative identification purposes.

Following the discussion of industrial disputes, we require that wage bargaining shocks in 1995q2, 1999q2, 2002q3 and 2018q2 be positive, i.e. increasing workers' bargaining power, and that the absolute contribution of wage bargaining shocks to the historical decomposition of real wages be the largest in 1995q2, 1999q2 and 2002q3.[24]

**Restriction 2** *The wage bargaining shocks in 1995q2, 1999q2, 2002q3 and 2018q2 are positive, i.e. increasing workers' bargaining power. The absolute contribution of wage bargaining shocks on real wages is the largest compared to other shocks in 1995q2, 1999q2 and 2002q3.*

## 3.2 Sign restrictions

While our main aim is to rely on narrative restrictions to identify wage bargaining shocks, we still find it useful to also impose a small set of sign restrictions in order to narrow down even further the set of admissible model specifications. Two uncontentious restrictions, on real wages and aggregate prices, are inherited from the existing literature, while a novel restriction on average hours is argued for on both theoretical and institutional grounds. As shown in Figure H.2 in the Appendix, our results remain largely intact if we drop the sign restrictions on the shock impact matrix altogether, provided that enough events are used for narrative identification.

Foroni et al. (2018), who rely on a New-Keynesian model with search and matching frictions in the labour market to derive a set of sign restrictions on aggregate variables, require that increased workers' bargaining power raises real wages, which, due to increased labour costs, then leads to an increase in prices and a reduction in employment, with output also dropping on impact.[25] The empirical literature on collective bargaining tends to agree that wages typically increase due to unions' actions (Cahuc and Zylberberg, 2004), so we retain the positive restrictions on wages and prices. However, we opt not to impose any restrictions on either unemployment or output, as their impact responses very much depend on the specifics of the underlying structural model.

Indeed, labour market models predict different effects on employment depending on what aspects of the employment contract social partners are bargaining over, the competitive structure as well

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[23]We define the announcement as an official and public declaration of a full-day strike by the union. The official announcement usually precedes by two or three trading days the beginning of a strike. In 1995 and 2002, the announcement followed a vote by union members to begin the strike. In 2018, the union unilaterally declared a 24-hour warning strike after a failed negotiation. If the announcement coincides with a non-trading day, the next trading day is selected as an announcement day.

[24]In the Appendix, we also show the effects of omitting the restrictions on the historical decomposition (Figure H.3).

[25]We show results applying this identification scheme in Figure H.1 in the Appendix.

as unions' and workers' preferences (Cahuc and Zylberberg, 2004). One example is minimum wage policy (Dolado et al., 1996; Card and Krueger, 1993; Caliendo et al., 2019): in that case, the labour market is usually characterised as either competitive or monopsonistic. Depending on which market structure is assumed, the minimum wage introduction can either decrease or increase the overall employment level in the economy.[26]

Instead, we opt to extend the baseline VAR specification of Foroni et al. (2018) with average hours per employee, because distinguishing between employment adjustment along the intensive and extensive margins can also be useful to correctly pin down wage bargaining shocks. In the Euro Area in general, the intensive margin tends to be more important for labour market adjustment than in the United States (Ohanian and Raffo, 2011; Bulligan et al., 2019). But especially in Germany, job-protection policies are quite stringent, making the hiring and firing of workers costly and time-consuming. Instead, firms have an incentive to adjust working hours: short-term working arrangements, open clauses in collective agreements and various subsidies ensure that the adjustment cost in terms of working hours is relatively lower.[27]

Following Kudoh et al. (2019), we estimate a variance decomposition of total hours worked into intensive and extensive margin contributions and find that average hours per employee can explain as much of the cyclical variation in total hours worked as fluctuations in the number of employees.[28] Historical evidence also corroborates this picture: on the back of the Great Financial Crisis, unemployment in Germany only increased marginally, but at the same time, firms reduced the number of hours worked for most employees, thus opting for short-term work arrangements rather than laying off their workforce (Burda and Hunt, 2011; Krugman, 2009).

The impact of wage bargaining shocks on average hours is not clear a priori. In a structural framework incorporating labour adjustment along both margins, the assumed bargaining structure determines whether average hours increase or decrease (Cahuc and Zylberberg, 2004). In the efficient bargaining case, where employers and employees negotiate both wages and hours worked, the marginal rate of substitution is equal to the marginal product of an additional hour, and following an increase in workers' bargaining power, labour market tightness decreases, employment and consumption fall, but average hours worked increase (Fang and Rogerson, 2007). Instead, in the right-to-manage model the parties negotiate wages but hours worked are solely determined by employers. In that case, the first-order condition equates the wage rate to the marginal product of an additional hour, and as a result, average hours worked fall following an increase in workers' bargaining power.[29]

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[26]Another classic example is a model with labour unions, which are bargaining with employers on behalf of workers. In this framework, the assumed bargaining framework determines the effect of changes in bargaining power on employment: if unions and employers are bargaining over wages and employment efficiently, the increase in unions' bargaining power leads to higher wages and employment. However, in the right-to-manage framework, where firms have full power to determine the employment level, lower employment follows.

[27]For more information, see http://www.oecd.org/employment/protection.

[28]For a more extensive description, see Appendix E.

[29]One conceptually appealing feature of the right-to-manage model is the direct transmission of wage increases

Empirically, Caliendo et al. (2019) and Mindestlohnkommission (2018) review a number of studies that find significant decreases in working hours following the introduction of minimum wage rate. Moreover, since employers react to higher labour costs by first adjusting the intensive margin, as changes in employment are both slower and costly, we also argue that the right-to-manage framework better captures some essential features of the German labour market. Most notably, working hours are rarely negotiated alongside wage increases within collective bargaining processes,[30] and employers can also rely on open clauses to deviate from any agreed level at the company level. Thus, we argue that following a surprise increase in workers' bargaining power, it is reasonable to expect a negative impact on average hours.[31]

Our identification thus relies on fewer impact restrictions, and at the same time is consistent with a wide range of structural models.

**Restriction 3** *A positive wage bargaining shock increases prices, and real wages but reduces hours per employee on impact.*

## 4 Model and data

We consider the structural vector autoregression model (VAR) given by

$$A_0 y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + \epsilon_t \tag{3}$$

where $y_t$ is a $n \times 1$ vector of endogenous variables, $c$ is a $n \times 1$ vector of constants, $A_i$ are $n \times n$ matrices of coefficients, $p$ is the number of lags, $\epsilon_t$ is a $n \times 1$ vector of i.i.d. structural shocks with identity covariance matrix. Our baseline specification includes five variables ($n = 5$) and four lags ($p = 4$).[32] The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE) and real GDP per capita (YERP). All variables except the GDP deflator (which is log-differenced) are in log-levels, save for the unemployment rate, which is in levels. All series are seasonally adjusted and enter the model at a quarterly frequency.[33] The sample is 1993q1 to 2019q2, providing 106 observations. For further details on the dataset, see Table 2.

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to inflation via changes in marginal cost (Trigari, 2006; Christoffel and Linzert, 2005; Krause and Lubik, 2007), a mechanism embedded in most macroeconomic models used to analyse monetary policy, including many that do not explicitly model the labour bargaining process.

[30]Calculations using Destatis data on agreed weekly working hours from collective agreements suggest that on average, only 3-4% of all subsectors had their working hours renegotiated in each year between 2010 and 2020.

[31]As a further check, we also compare our results to the impulse responses to a wage bargaining shock in the DSGE model of Christoffel et al. (2009). Their model features both intensive and extensive margins of labour adjustment, as well as wage and price rigidities, and is calibrated on Euro Area data. See Appendix F for details.

[32]Results remain very similar when increasing the numbers of lags.

[33]The unemployment rate is observed at monthly frequency. To transform it into a quarterly series, we take an average over the quarter.

**Table 2** Data sources and transformations

| Variable | Source | ID | Transformation |
|---|---|---|---|
| Wages and Salaries | Eurostat | WAGE | |
| Basic Pay Rates | Bundesbank | BPR | Averaged over the quarter |
| Total Hours worked by employees | Eurostat | HOURS | |
| Unemployment | Eurostat | URX | Averaged over the quarter |
| Nominal GDP | Eurostat | NYER | |
| Real GDP | Eurostat | YER | |
| Population | Eurostat | POP | |
| Total number of Employee | Eurostat | SAL | |
| Active population | Destatis | ACT | |
| Reported Vacancies | OECD | VAC | Averaged over the quarter |
| GDP deflator | Eurostat | YED | |
| Wages and Salaries per hour worked in manufacturing | Destatis | WAGEHman | |
| Gross operating surplus per capita | Eurostat | GOSP | ln(GOS/POP) |
| Real hourly wage | | RWAGEH | ln(WAGE/(HOURS*YED)) |
| Real GDP per capita | | YERP | ln(YER/POP) |
| Average hours worked | | HOURSE | ln(HOURS/SAL) |
| Vacancy Rate | | VACA | VAC/ACT |
| Real hourly wage in manufacturing | | RWAGEHman | ln(WAGEman/YED) |
| Real Basic Pay Rates | | RBPR | ln(BPR/YED) |

**Note:** The table summarises all variables used in the analysis, their sources and transformations.

We estimate the reduced-form counterpart of Equation 3 with Bayesian techniques. We use a standard Minnesota prior, shrinking non-stationary variables towards independent unit roots, and stationary ones towards white noise processes (see Litterman, 1986; Kadiyala and Karlsson, 1997; Bańbura et al., 2010, among others), supplemented with a long-run prior (Giannone et al., 2019). We opt to impose a long-run prior, preferring it to more traditional refinements to the Minnesota prior, to avoid over-fitting of the deterministic component by penalising initial observations. This is particularly important for Germany, where re-unification and a number of structural reforms in the early 2000s induced some trending behaviour for otherwise rather stationary variables, notably unemployment and average hours worked.

In terms of restrictions imposed through the long-run prior, we require that inflation ($\pi_t$), average hours worked ($h_t$) and unemployment ($u_t$) follow their own independent deterministic trends, whereas real wages ($w_t$) and output per capita ($y_t$) share a common trend and co-integrating relationship.[34] Following the notation of Giannone et al. (2019):

$$\tilde{y}_t = \underbrace{\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}}_{H} \underbrace{\begin{pmatrix} \pi_t \\ w_t \\ u_t \\ y_t \\ h_t \end{pmatrix}}_{y_t} \tag{4}$$

We use an invariant version of the prior, where we impose more shrinkage on the common trend of real wages and output per capita and on unemployment, which is very persistent. Hyperparameters are selected following the hierarchical approach suggested in the same paper.

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[34] According to augmented Engle and Granger (1987) and Johansen (1988) tests for cointegration, real hourly wages (RWAGEH) and output per capita (YERP) are cointegrated. The estimated cointegration vectors are [1.26 -1] and [-1.41 1], respectively, close to our ad-hoc long-run prior specification.

**Table 3** Probability of violating the narrative restrictions

|  | Restr. on sign of shock | Restr. on importance of shock | All Restrictions |
|---|---|---|---|
| MW (2014q1-2015q1) |  | 48% | 48% |
| 1995q2 | 14% | 70% | 70% |
| 1999q2 | 27% | 80% | 80% |
| 2002q3 | 20% | 79% | 79% |
| 2018q2 | 89% |  | 89% |
| All Events | 92% | 97% | 99.5% |

**Note:** The table shows the share of draws that satisfy sign restrictions but not narrative ones.

The resulting deterministic components are shown in Figure H.12 in the Appendix.

To recover the structural form of the VAR, we follow the algorithm of Antolín-Díaz and Rubio-Ramírez (2018), which combines sign/zero restrictions with narrative ones. Unlike traditional sign restrictions imposed on the impulse response function or the structural parameters themselves, narrative sign restrictions are imposed on the realised structural shocks, or on elements of the historical decomposition computed on their basis, and therefore require modifications to the standard algorithm (Rubio-Ramírez et al., 2010). As shown by the authors, they can be imposed by truncating the likelihood function of the VAR, which can be approximated using importance sampling. Our restrictions are discussed in the previous Section.[35]

In our application, we obtain around $10^6$ draws that satisfy the required sign restrictions, and then approximate importance weights using $10^6$ draws to obtain around 5000 posterior draws that also satisfy our narrative restrictions.

## 5 Results

### 5.1 Narrative restrictions and identifiability

We first show the importance of our selected events for identification. Table 3 shows the share of structural parameter draws that do not satisfy narrative restrictions, while satisfying the required sign restrictions. Around 89% of draws are rejected due to the restriction on the industrial action in 2018q2, suggesting it is essential to achieve good identification. When imposing a tighter restriction, namely that wage bargaining shocks be the largest contributor to the historical decomposition of real wages in 2018q2, we could not find any solution, suggesting that the data do not support it. On the other hand, we find that a weaker narrative restriction on the historical decomposition for the industrial dispute in 2018q2 is sufficient, by itself, to

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[35]Note that our narrative restrictions are likely to be rather mild compared to other approaches based on historical events. For example, in the context of the Great Financial Crisis, Ludvigson et al. (2015) require that the structural shocks be close to four standard deviations in size at some specific dates, which may be appropriate for that particular episode but would be difficult to both calibrate and convincingly defend in the case of strikes.

achieve good identification.[36]

Figure 3 shows the posterior distributions of wage bargaining shocks at restricted dates, comparing models with only sign restrictions imposed and including narrative restrictions, in grey and pink, respectively. Apart from the strike in 2018q2, the model only identified with sign restrictions tends to agree with our expected signs for structural shocks, as most of the posteriors' supports are positive, although usually more dispersed. When imposing narrative restrictions, the distributions of structural shocks have a positive support by construction. The restriction for 2018q2 seems to be the most binding one in that respect.

Figure 3 also provides some insights on the implications of our narrative restrictions on the chronology of shocks around the minimum wage introduction episode. As previously mentioned, the exact timing for this shock is hard to pin down, as the policy was announced and legislated far ahead of its actual implementation. For that reason, we required the contribution of wage bargaining shocks on real wages to be positive over the entire 2014q1 to 2015q1 period, which does however not imply a precise date for the shock. The estimated posterior distributions suggest that agents acted just after the announcement with a clearly positive wage bargaining shock in 2014q1, thus hinting at the importance of anticipation effects, possibly with some second-round effects on the effective introduction date in 2015q1.[37] However, this interpretation is only suggestive, as the timing coincides with a separate round of collective agreements in important sectors, and our framework is unable to distinguish between the two.[38]

## 5.2 Macroeconomic transmission of wage bargaining shocks

Figure 4 shows the impulse responses to a positive wage bargaining shock that increases workers' bargaining power. Responses for a model identified with sign restrictions only are shown in grey (with blue lines), those also supplemented with narrative ones are shown in red. Both are scaled to deliver one standard deviation shock to real wages. As expected, credible sets are generally narrower for the model with narrative restrictions as a result of smaller modelling uncertainty. But crucially, our narrative restrictions are also informative about the dynamic responses of variables with no sign restrictions imposed on them, that is, unemployment and output per capita. As discussed in Section 3, the responses of these variables depend on various modelling assumptions about labour market structure. Most notably, our results highlight that the effect of higher workers' bargaining power on unemployment is unambiguously increasing, in line with the implications of models with search and matching frictions or monopolistically competitive unions. With this in mind, for the rest of our discussion, we only focus on the model that also

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[36]In Appendix H.4, we include a specification with only one positive contribution restriction on the historical decomposition of real wages for 2018q2. The results for impulse responses are qualitatively similar to the baseline.

[37]Bundesbank (2015b) also report that for some specific sectors, which are not covered by a collective agreement, wages were increased once the statutory wage came in force.

[38]There were agreed wage settlements in the chemical, public and energy sectors starting around 2014 March (WSI, 2014)

**Figure 3** Posterior distribution of wage bargaining shocks.
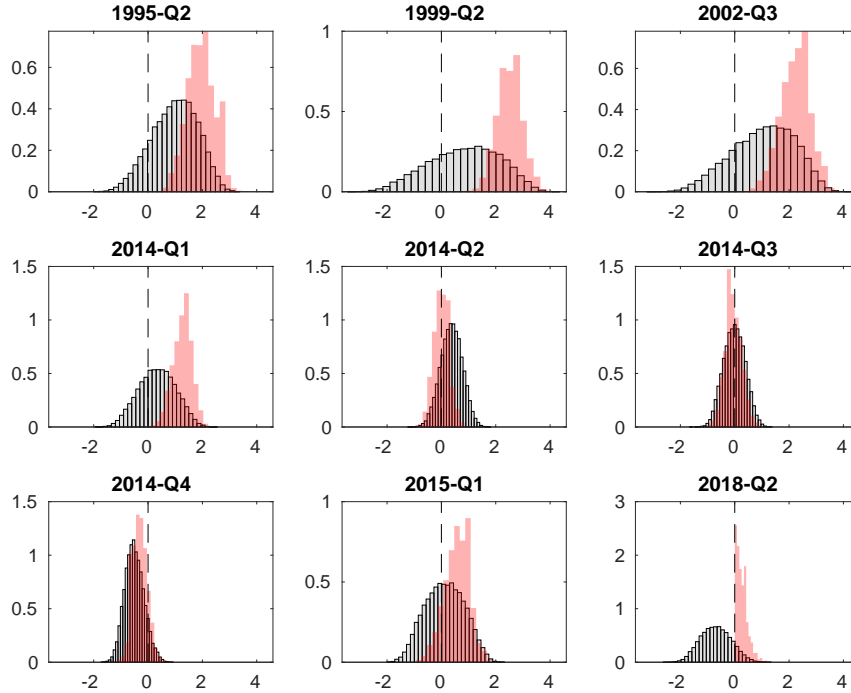


**Note:** The figure shows posterior distributions of wage bargaining shocks for the model with sign restrictions in grey and the specification including narrative restrictions in pink.

includes narrative restrictions.

The increase in real wages, of around 0.2 percentage points on impact, lasts for about two years following the initial shock. The pattern mostly reflects the dynamics of nominal wages, scaled by a slower-moving response of the GDP deflator. Indeed, the unexpected increase in the wage bill raises the price level by 0.15 percentage points on impact, which then remains above its steady state level for three to four years.[39] Average working hours fall by about 0.1 percentage points within two quarters after the shock, but then experience a highly persistent reversal that peaks at 0.1 percentage points above steady state after around three years, while the unemployment rate gradually picks up following the shock, reaching its peak of 0.15 percentage points after around two years, and with an even more gradual return to steady state. Output per capita falls on impact and troughs at around −0.4 percentage points after three quarters, then reverses to steady state within three years.

Overall, the pattern of impulse responses indicates that German firms first react to increased labour costs by adjusting prices and reducing average hours worked. With time, firms then also adjust their workforce and unemployment increases as a result, while those still in employment end up working longer hours. This is consistent with existing evidence about the relative importance of the intensive margin of adjustment in the Euro Area compared to the United States (see Ohanian and Raffo, 2011; Bulligan et al., 2019). Moreover, as already mentioned,

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[39]Note that the impulse response of the price level is inferred from the cumulative response of inflation.

**Figure 4** Impulse responses to a positive wage bargaining shock
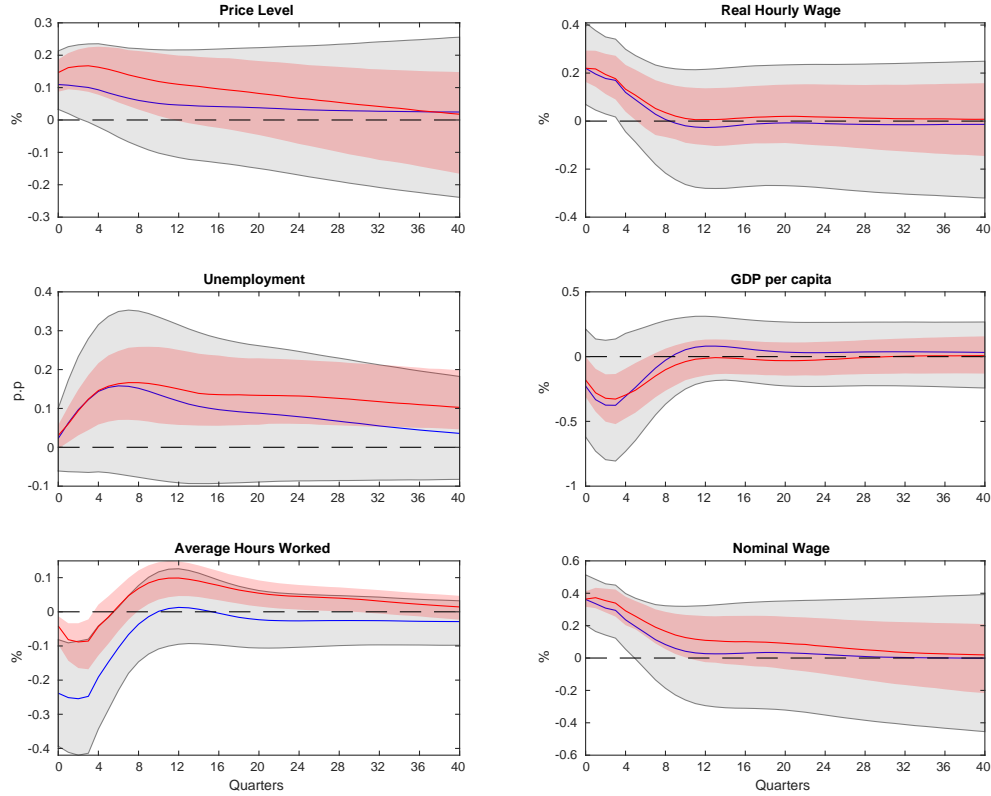


**Note:** The figure shows impulse responses to a positive wage bargaining shock for the baseline model. Bands show posterior 68% credible sets. The model with sign restrictions only is in grey, with blue lines for the median; the specification including narrative restrictions is in pink, with a red line for the median.

the impact signs of our estimated impulse responses on unemployment and output, although left unrestricted by our identification assumptions, do match the prescriptions of structural models with search frictions in labour markets. They are therefore, *a fortiori*, also consistent with the identification strategy proposed by Foroni et al. (2018), which entirely relies on sign restrictions inferred from such frameworks.

However, to highlight the advantages of our approach,[40] it is instructive to compare our results to a model that relies on their identification strategy (see Figure H.1 in the appendix). We find that while the broad pattern of responses is similar, our approach allows sharper inference, and, moreover, avoids some counter-intuitive, and theoretically difficult to explain, behaviour of nominal variables.[41]

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[40]Besides the fact that it provides an independent empirical validation of those restrictions.

[41]Note that for the United States, Foroni et al. (2018) find more pronounced effects on output and employment, but weaker responses of wages and prices. Besides any differences in identification strategies, this is likely to also reflect genuine differences across economies. In the United States, the bargaining framework and job protection legislation are relatively loose, and product competition is more fierce, so increased labour costs are more likely to lead to lay-offs in order to keep prices competitive. In Germany, both labour market institutions and collective bargaining tend to ensure job protection first, explaining a sizeable adjustment in prices that is not observed in the United States.

We also compute a forecast error variance decomposition to quantify the relative importance of wage bargaining shocks in explaining variation in our data. Table H.1 in the Appendix summarises the results for selected horizons. Around 16% of the contemporaneous variation in real wages is explained by the shock, decreasing to approximately 6% at the ten year horizon. The shock is an important driver of GDP deflator inflation, explaining almost a quarter of its variation at all horizons. In the long run, the shock similarly accounts for a fifth of the variation in the unemployment rate, while on impact, its contribution is minimal. For output and hours, the contributions are also non-negligible, but generally smaller at all horizons. Thus overall, wage bargaining shocks appear to be an important driver of the business cycle in Germany.

Finally, we calculate the wage pass-through to prices implied by a wage bargaining shock, defined as the ratio of the impulse responses of the GDP deflator and of nominal wages (both expressed in *log-levels*.[42] Pass-through thus defined represents an elasticity, namely the percent change in prices given a concomitant one percent increase in nominal wages. On impact, prices adjust only partially to the shock, roughly by 40% of the initial nominal wage response. Pass-through peaks at around 70% after three years, and gradually converges to a value of around 50% in the long run, within our range of estimates of the German labour share over our estimation sample.

## 5.3 Case study: the introduction of a national minimum wage floor

In this section, we use our framework to supplement the existing microeconometric evidence on the effects of the national minimum wage introduction in 2014. Figure 5 shows the contributions of wage bargaining shocks to aggregate variables from 2014q1 onwards, i.e. from the time of announcement but one year before the actual introduction [43]. Following the announcement and introduction of a minimum wage, wage bargaining shocks led to a persistent increase of around 0.25% in hourly real wages (RWAGEH), or roughly 0.5% in nominal terms, lasting until early 2016. This corroborates existing estimates of the resulting increase in the nominal wage bill, which range between 0.4 and 0.55% (Bundesbank, 2018; Mindestlohnkommission, 2018; Caliendo et al., 2019).

The impact of minimum wage changes on employment is also often debated in the literature. Existing studies of the German episode suggest that there were either small negative or negligible effects on regular employment (Caliendo et al., 2019), but a sizeable impact on marginal employment, the so-called 'mini-jobs', where studies found that around 100,000 to 200,000 jobs were affected: Mindestlohnkommission (2018) found that half of those transitioned into regular employment and another into unemployment or became inactive. In the previous Section, we showed that wage bargaining shocks lead to a higher unemployment rate. The historical decomposition reveals that the increase in unemployment due to shocks that occurred since 2014q1

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[42]An analogous definition is used in VAR applications to compute fiscal multipliers (Ramey, 2016), or to evaluate exchange rate effects on prices (Forbes et al., 2018), among many others.

[43]In the Appendix, we also present counterfactual series stripped of the contributions due to wage bargaining shocks, see Figure G.1.

**Figure 5** Contributions of wage bargaining shocks from 2014q1
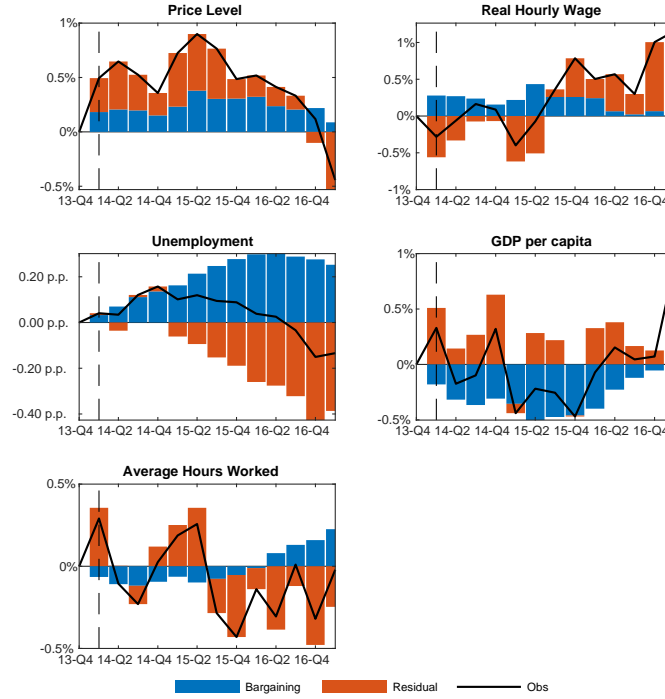


**Note:** The figure shows the contributions of wage bargaining shocks from 2014q1 until 2017q1. We use the posterior mean of the historical decomposition as our point estimate. The blue bars show the contributions of wage bargaining shocks, while the orange bars show the residual contributions of all other shocks. The solid black lines show the evolution of the data relative to 2013q4. All variables are expressed in levels or log-levels, including the GDP deflator (YED).

was of around 20 basis points in 2015q1, and 30 basis points at the peak in 2016q2. A back-of-the-envelope calculation thus suggests that wage bargaining shocks around the period when the minimum wage was introduced led to around 120,000 more unemployed people.[44] The concomitant effects on output per capita are also sizeable, with a (temporary) reduction in output that troughs at just below 0.5% in 2015Q2, but is fully unwound by early 2017.

The counterfactual exercise also highlights a non-negligible effect on the price level, which increases by 0.25% in 2015q1 and up to 0.33% in 2016q1, in line with existing estimates (Link, 2019; Mindestlohnkommission, 2018; Bundesbank, 2015a). Link (2019) also finds that the pass-through from wages to prices during the same episode was large and quick, as firms reacted in anticipation of higher labour costs and the adjustment in prices happened even before the minimum wage came into force.

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[44] After accounting for the effect of other concomitant shocks (shown in orange in Figure 5), overall there were negligible effects on aggregate unemployment during the entire episode.

**Figure 6** Impulse responses to a positive wage bargaining shock for additional variables
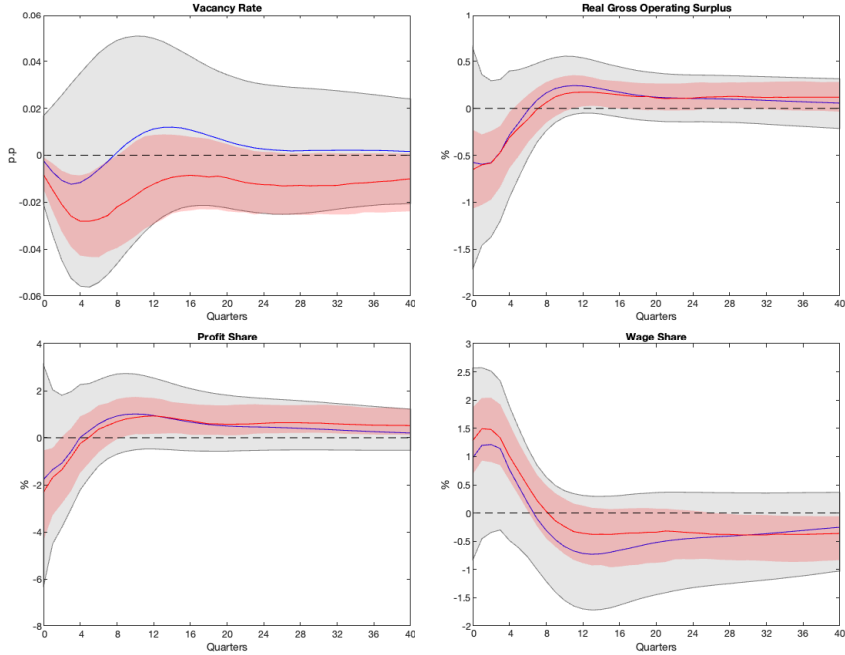


**Note:** The figure shows impulse responses to a positive wage bargaining shock for models with additional variables. Bands show posterior 68% credible sets. The model with sign restrictions only is in grey, with blue lines for the median; the specification including narrative restrictions is in pink, with a red line for the median.

## 6    Extensions and robustness

**Vacancies**    We estimate a specification that includes the vacancy rate as an additional variable (left unrestricted for identification purposes). The vacancy rate is the ratio between the number of reported vacancies and the labour force. Models with search frictions in labour markets predict that following a positive wage bargaining shock, firms should react to higher labour costs by creating fewer jobs, or in other words, by reducing the number of posted vacancies. The impulse response of the vacancy rate, shown in Figure 6, corroborates this prediction: the vacancy rate decreases with a trough of around -3 basis points, and remains persistently below a steady-state, mirroring the response of unemployment.[45]

Moreover, the results suggest that our narrative restrictions allow us to distinguish wage bargaining shocks from other labour market shocks typically studied in models with search frictions. Specifically, shocks to the separation rate as well as to matching efficiency shocks tend to induce a positive co-movement between unemployment and vacancies, while the responses of other variables are similar to the ones we find for a wage bargaining shock (Foroni et al., 2018; Furlanetto and Groshenny, 2016).

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[45]For the full set of impulse responses, see Figure H.6 in the Appendix.

**Profits and Labour Share** Wage bargaining shocks are often interpreted as leading to re-distribution between firms and workers, with workers obtaining a larger share of surplus at the expense of reduced profits. To assess the effect of wage bargaining shocks on profits, we add per capita real gross operating surplus to our baseline as a proxy for aggregate profits (again leaving it unrestricted for identification purposes).[46] Reassuringly, we find that real gross operating surplus falls in response to a positive wage bargaining shock (Figure 6).

We also investigate whether our wage bargaining shocks meaningfully contribute to variation in the labour share. In the spirit of Bergholt et al. (2019), we compute impulse responses for two different measures of labour share. First, using the same specification, we define the profit share as the (log) ratio of real gross operating surplus (RGOSP) to real GDP (YERP), which can also be viewed as the complement to the labour share:[47]

$$IRF_{Profit\ Share} = IRF_{RGOSP} - IRF_{YERP}$$

Second, we compute a wage share as the ratio between wages and salaries per employee and output divided by total employment, following the approach in the European Commission's AMECO database.[48] We substitute output per capita (YERP), used in the baseline model, with output over total employment (YERE).[49] The impulse response of the wage share can then be obtained as a linear combination of variables in the system:[50]

$$IRF_{Wage\ Share} = IRF_{RWAGEH} - (IRF_{YERE} - IRF_{HOURSE})$$

Impulse responses for the profit and wage shares thus obtained are shown in the two bottom panels of Figure 6. We find that an exogenous shock to wage bargaining significantly increases the labour share on impulse using both measures, in line with similar results found by Bergholt et al. (2019) for the US.[51] Results using both definitions provide similar implications also for the medium term. The positive effect is rather short-lived: by the second year following a shock, the labor share experiences a reversal and persistently remains below a steady state. The result questions to what extent changes in bargaining power can secure a higher share of

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[46]Gross operating surplus represents a balancing item in the national accounts under the income distribution approach. It is what's left of GDP after compensation of employees and taxes less subsidies on production and imports are subtracted. It is an imperfect proxy for aggregate profits in the economy as it does not account for all production costs, and mixes property income and some labour income. For more information, see https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Gross_operating_surplus_(GOS)_-_NA.

[47]This matches the Eurostat definition, see https://ec.europa.eu/eurostat/databrowser/view/teina520/default/table?lang=en.

[48]We slightly differ from the definition used in the European Commission's AMECO database, which uses a broader measure of workers' income that includes employers' social contributions in addition to wages and salaries. However, given that employers' contributions are very stable, the two measures are almost perfectly correlated.

[49]Note that total employment slightly differs from employment, although the two series are highly correlated.

[50]Specifically, as the (log) ratio of wages per hour to output per hour adjusted by the ratio of employment to total employment (or equivalently, of wages per employee to output over total employment).

[51]Note that rather than specifically identifying wage bargaining shocks, their study more generically identifies wage mark-up shocks that are assumed to be persistent.

surplus over longer horizons. Our results suggest that following a wage bargaining shock, real wages improve only for a few years, at the cost of persistently higher unemployment. The latter effect dominates in the medium term, suggesting that the lower labor share arises as a result of lower employment, as also evidenced by the behaviour of the vacancy rate (Figure 6).[52] To be sure, other labor market policies, notably those of a more structural nature, such as the Hartz reforms, may lead to different conclusions.

**Measurement of wages**   In our baseline, we use aggregate wages and salaries from the national accounts. However, our narrative contribution restrictions could potentially be ignoring compositional effects arising in other sectors not represented by IG Metall. For that reason, we estimate two alternative specifications, *adding* hourly wages and salaries in the manufacturing sector and basic pay rates, respectively, both deflated with the GDP deflator. The first measure should be more sensitive to the actions of IG Metall, given that the manufacturing sector is where the union has the most clout and that industrial disputes were mostly concentrated in the car industry. Basic pay rates summarise collectively-negotiated wages in the production sector including construction, and thus capture wage developments for the unionised portion of the economy.[53] In both cases, we impose narrative restrictions regarding industrial disputes on these alternative variables and leave the aggregate wages and salaries measure unrestricted.[54] Figures H.8 and H.9 show that impulse responses using these alternative measures are very similar to our baseline, suggesting that our narrative restrictions provide sufficient information to capture the dynamic effects of wage bargaining shocks.[55]

**Priors**   In our baseline, we follow Giannone et al. (2019) and employ long-run priors, optimally selecting the hyperparameters regulating the deterministic components in our estimates. We also estimate a version with flat priors. Figure H.11 shows that impulse responses remain broadly in line with our baseline results, the only noticeable difference being that real wages per hour exhibit a reversal following a wage bargaining shock, which we regard as a somewhat puzzling result. We also note that with flat priors, the implied deterministic components for real wages per hour and output per capita are projected to flatten, implying no growth, shortly after the end of our sample, unlike in our baseline (Figure H.12). This suggests that the specification with flat priors does not capture some relevant common trends between wages and output, which is

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[52]It might also reflect some distributional effects between unionised and non-unionised sectors following an aggregate shock, leading to an overall smaller labor share in the long-run, but our use of aggregate data doesn't allow us to pursue this conjecture any further.

[53]The statistic is often preferred when forecasting wage inflation developments (Nickel et al., 2019)

[54]We retain the narrative restriction concerning the minimum wage episode on the aggregate wage measure, since arguably the policy's aim was to improve conditions for all workers, including those not subject to any collective wage agreement.

[55]Results are also robust to using wages per employee instead of wages per hours worked for the aggregate measure. Results are omitted to conserve space.

at odds with both historical regularities and economic theory.[56]

**Additional shocks**    We also identify three more shocks with sign restrictions in addition to a wage bargaining shock: an aggregate demand, aggregate supply and a labour supply shock. We assume impact sign restrictions such that a positive demand shock raises output and inflation and reduces unemployment; a positive supply shock leads to higher wages and output but reduces inflation; a positive labour supply shock lead to lower inflation and wages but higher unemployment and output. Impulse responses are almost identical, with somewhat narrower credible bands, see Figure H.10. The results suggest that our wage bargaining shock is already well-identified by our restrictions.

# 7    Conclusion

We revisit the identification of wage bargaining shocks in a vector autoregression model using narrative information for Germany. We propose to use two sets of historical events, the introduction of a minimum wage as well as selected industrial disputes, which are both economically relevant for aggregate wage dynamics and plausibly attributable to exogenous variation in bargaining power. After establishing the suitability of these events for the purpose of narrative identification, we evaluate the effects of wage bargaining shocks on macroeconomic aggregates. Our restrictions discipline the impulse responses to a wage bargaining shock of unemployment and output, which are otherwise left unrestricted, in line with the implications of a broad class of structural models with labour market frictions. Our findings suggest that wage bargaining shocks are an important source of macroeconomic fluctuations, and our model's quantification of the impact of the minimum wage introduction in Germany is in line with and complements existing microeconometric evidence. Given the similarities in wage bargaining institutions shared by many economies, such as the existence of some form of national minimum wage, our methods and findings are of broader applicability and relevance.

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[56]We find that the problem also persists in a specification with a Minnesota prior complemented by a Single-Unit-Root prior. We omit the results to conserve space.

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# A    Wage bargaining in a search and matching framework

In a canonical search and matching framework featuring Nash bargaining (Pissarides, 2000), workers and employers agree on a wage rate, $w_t$, when bargaining over their respective surpluses, $S(w_t, \Phi_t)$ and $J(w_t, \Phi_t)$:

$$\arg\max_{w_t} S(w_t, \Phi_t)^{\eta_t} J(w_t, \Phi_t)^{1-\eta_t} \tag{A.1}$$

Bargaining power is summarized by the parameter $\eta_t$. It encompasses variation in all factors determined outside the model, including minimum wage policies and labor disputes – the two sources of variation that we exploit for identification.

Workers and vacancies cannot be matched immediately, leading to flows in and out of the labor market, as summarised by the Beveridge curve (BC), equation A.2.

$$\Delta u_t = \delta(1 - u_{t-1}) - q(\theta_t)v_t \tag{A.2}$$

Unemployment, $u_t$, increases with the number of employed people separated at the exogenous rate $\delta$, and falls with new matches, $q(\theta_t)v_t$. $v_t$ represents the number of vacancies posted by firms, and $q(\theta_t)$ is the endogenous probability to fill a vacancy at a given level of labor market tightness $\theta_t = \frac{v_t}{u_t}$.

The match value for the firm, $J_t$, corresponds to the marginal product of a worker, $z_t$, net of the wage rate, $w_t$, plus a discounted continuation value if the match survives, $(1-\delta)J_{t+1}$[57]. Firms post vacancies at a constant cost, $\kappa$, expecting to find a match. A continuum of firms can post vacancies, exhausting profitable opportunities such that the cost of an open vacancy over the expected duration, $\frac{\kappa}{q(\theta_t)}$, is equal to the expected discounted value of the match, $\beta E_t J_{t+1}$. The following equations capture the job-creation (JC) relationship between labor market tightness and wages

$$J_t = z_t - w_t + \beta E_t[(1-\delta)J_{t+1}] \tag{A.3}$$

$$\frac{\kappa}{q(\theta_t)} = \beta E_t J_{t+1}. \tag{A.4}$$

The value of the match to workers, $N_t$, is the sum of the wage rate, $w_t$, and the probability-weighted value of staying employed or becoming unemployed. Unemployed applicants receive a

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[57]Note that the risk-neutrality is assumed in our simplified exposition of the model.

benefit from home production, $b$, and expect to become employed with probability $p(\theta_t)$

$$N_t = w_t + \beta E_t \Big( \delta U_{t+1} + (1 - \delta) N_{t+1} \Big) \tag{A.5}$$

$$U_t = b + \beta E_t \Big( p(\theta_t) N_{t+1} + [1 - p(\theta_t)] U_{t+1} \Big). \tag{A.6}$$

Combining these value equations with a Nash bargaining solution yields the wage curve (WC):

$$w_t = (1 - \eta_t)b + \eta_t z_t + \frac{\kappa}{q(\theta_t)} \Big( \eta_t(1 - \delta) - (1 - \eta_t)[1 - \delta - p(\theta_t)] E_t \frac{\eta_{t+1}}{1 - \eta_{t+1}} \Big). \tag{A.7}$$

The bargaining parameter takes values between zero and one, which delimit the bargaining set for the parties. If $\eta_t = 1$, workers obtain the whole surplus, such that the firm is indifferent between closing down and accepting a match $\bar{w}_t = z_t + \frac{\kappa}{q(\theta_t)}(1 - \delta)$. On the other hand, for $\eta_t = 0$ workers receive the reservation wage $\underline{w_t} = b + [1 - \delta - p(\theta_t)] E_t(N_{t+1} - U_{t+1})$.

The model is summarised by four equations, (A.2, A.3, A.4 and A.7), and can also be illustrated graphically (Figure 1 in the main text). The left panel of Figure 1 pins down the equilibrium between labour market tightness and the wage rate, at the intersection of the wage (WC) and job-creation (JC) curves; the right panel shows the determination of vacancies and unemployment, at the intersection of the Beveridge curve (BC) and the job-creation locus in the unemployment-vacancies space. The effects of an exogenous shock to bargaining power, $\eta_t$, are discussed in the main text (Section 2).

## B    Additional material supporting the narrative restrictions

**The wage bargaining shock in 1995q2 was positive and its absolute contribution to real wages was the largest compared to other shocks.** At the beginning of 1995, IG Metall pressured employers for a wage increase of 6%, after wages had stagnated throughout the recession (New York Times, 1995; Bloomberg News, 1995). Following continued disagreements, on 23 February the union declared an industrial action in the region of Bavaria. The strike was restricted to around 20000 workers, mainly affecting smaller enterprises, and lasted for 12 days until an agreement was eventually reached. It included a lower wage increase of 3.4% and 3.6%, respectively, for the next two years, but also one less working hour per week. The agreement was considered a large win for workers, given the initial refusal by the employer federation of any pay increase or reduction in working time.

**The wage bargaining shock in 1999q2 was positive and its absolute contribution to real wages was the largest compared to other shocks.** After multiple rounds of negotiations, a collective agreement was reached in February 1999 (New York Times, 1999; Eurofound, 1999b). Workers were promised a 3.2% wage increase starting from March 1999.

Unlike the other industrial actions we consider, this bargaining round only featured warning strikes of short duration with around 1 million employees participating. However, an open-ended or full-day strike was only avoided at the last moment, when social partners reached a compromise two hours after the deadline for calling a strike. While union representatives were satisfied with the outcome, employers criticised the union's bargaining approach, emphasising the potential negative effects on employment and the possibility of firms to opt out from collective agreements. The bargaining round was viewed as an attempt to end a policy of wage restraint by both employers and employees (Eurofound, 1999a).

**The wage bargaining shock in 2002q3 was positive and its absolute contribution to real wages was the largest compared to other shocks.** In February 2002, social partners started another round of negotiations to reach a collective agreement. Following disagreements about wage increases, the union called for a ten-day strike, to which over 200000 employees participated.(Eurofound, 2002a) An agreement was signed on 15 May. This led to a pay rise of 4% from June 2002 and of 3.1% in 2003, lower than initially demanded, but high compared to historical wage increases.(New York Times, 2002; Eurofound, 2002b) Often viewed as one of the biggest strikes in the history of industrial actions in Germany, the negotiation process was heavily criticised by employers' associations and even the government.

**The wage bargaining shock in 2018q2 was positive.** Following favorable economic developments in Germany, in October 2017 IG Metall negotiated a large wage rise, as well as additional flexibility in working hours. (WSI, 2018; Eurofound, 2018b,a) After a failure to agree with employers' representatives, warning strikes were announced, mobilising 1.5 million members to act within a sector employing 3.9 million workers (around 11% of the total German labor force). A new collective agreement was reached on 6 February 2018 for the period covering January 2018 to March 2020, entailing a 4.3% increase in wages from April, a one-off fixed payment, and the possibility to opt for a reduced working time.[58] The agreement is considered to be a major achievement for workers, due to an above-average rise in wages and the considerable shift in working time policy.(WSI, 2018)

## C   Wage Phillips curve

To corroborate the illustrative findings of Figure 2, we estimate a set of wage Phillips curves to investigate whether wage dynamics can be adequately explained by macroeconomic developments for the quarters featuring industrial disputes. The wage Phillips curve represents a reduced-form relationship between aggregate wage dynamics and a number of economic activity factors (see for example Blanchard and Katz, 1999). In our specification, wage dynamics are captured by an autoregressive distributed lag model (Equation C.1), with the following variables:

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[58]For more details, see Gesamt Metall (2017).

lagged wage $\pi_t^w$ and price inflation $\pi_t^p$, labour productivity growth $\alpha_t$, inflation expectations $\mathbb{E}_{t+h}\pi_{t-1}^p$, as well as economic slack, captured by an unemployment gap $\hat{u}_t$. In addition, we include dummies $\mathbb{1}(strike_t)$ for the dates of industrial strikes, in order to control for the effect of industrial strikes on nominal wages.

$$
\begin{aligned}
\pi_t^w =& A(L)\pi_t^w + B_p(L)\pi_t^p \\
& + B_\alpha(L)\alpha_t + B_e(L)\mathbb{E}_{t+h}\pi_{t-1}^p + B_{\hat{u}}(L)\hat{u}_t + \mathbb{1}(strike_t) + \epsilon_t
\end{aligned}
\tag{C.1}
$$

We use quarterly log differences of wages and salaries per employee as our measure of wage inflation, and of the GDP deflator as our measure of price inflation. labour productivity growth is proxied by the log difference of real GDP divided by total number of employees. The unemployment gap is extracted with a Hodrick-Prescott filter on the unemployment rate. For inflation expectations, we use survey-based five-years-ahead inflation expectations for the euro area from Consensus Economics.[59]

The results are summarised in Table C.1. We find that in the quarters coinciding with industrial strikes, quarterly wage growth is on average 0.6 p.p. higher than implied by macroeconomic factors alone, suggesting that our selected events are relevant for aggregate wage dynamics[60]. In specifications 3 and 6, which feature individual dummies, we find that each event is associated with higher wage growth. A back-of-the-envelope calculation suggests that around 50 percent of the increases in nominal wages on strike dates can be attributed to the strike dummies. Of course, the estimated effects may be over-stated due to well-known issues with reduced-form estimates, but are nevertheless suggestive of the relevance of the selected events for our identification strategy.

---

[59]Results are robust to using alternative measures of observed and expected inflation, wage growth or economic slack. We also tried to add an error correction term capturing the labour share. However, the term was not stationary, as the labour share exhibit a trending behaviour over our sample. Results for these alternative specifications can be provided upon request.

[60]For the sake of brevity, we do not interpret the results for other variables, although they are in line with theoretical predictions and previous empirical results (Blanchard and Katz, 1999; Galí and Gambetti, 2019; Bulligan et al., 2019; Bundesbank, 2015a)

**Table C.1** Parameter estimates for selected wage Phillips curve specifications

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| GDP inflation t-1 | 0.191 | 0.250* | 0.232* | 0.203 | 0.273* | 0.253* | 0.176 | 0.204 |
| | (0.137) | (0.133) | (0.136) | (0.150) | (0.146) | (0.146) | (0.140) | (0.132) |
| Productivity t | 0.195*** | 0.183*** | 0.189*** | 0.196*** | 0.185*** | 0.190*** | 0.165*** | 0.162*** |
| | (0.0498) | (0.0528) | (0.0507) | (0.0486) | (0.0507) | (0.0490) | (0.0426) | (0.0467) |
| Unemp. Gap t | -0.295*** | -0.267** | -0.267** | -0.286*** | -0.250** | -0.250** | | |
| | (0.107) | (0.107) | (0.106) | (0.107) | (0.106) | (0.105) | | |
| EA 5y inflation exp. t-1 | | | | -0.0603 | -0.106 | -0.102 | | |
| | | | | (0.136) | (0.129) | (0.136) | | |
| Unemployment t | | | | | | | -0.101*** | |
| | | | | | | | (0.0129) | |
| Tightness (V/U) t | | | | | | | | 1.145*** |
| | | | | | | | | (0.263) |
| strike | | 0.592*** | | | 0.607*** | | 0.624*** | 0.612*** |
| | | (0.191) | | | (0.185) | | (0.203) | (0.215) |
| strike in 1995 | | | 0.568 | | | 0.638 | | |
| strike in 1999 | | | 1.052 | | | 1.04 | | |
| strike in 2002 | | | 0.35 | | | 0.354 | | |
| strike in 2018 | | | 0.377 | | | 0.373 | | |
| Constant | 0.342*** | 0.302*** | 0.3 | 0.458 | 0.503* | 0.496 | 1.113*** | 0.121 |
| | (0.0536) | (0.0683) | | (0.292) | (0.283) | | (0.109) | (0.0815) |
| | | | | | | | | |
| Observations | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 |
| $R^2$ | 0.267 | 0.331 | 0.346 | 0.268 | 0.335 | 0.350 | 0.452 | 0.361 |
| BIC | 119.1 | 114.2 | 107.1 | 123.6 | 118.2 | 111.2 | 93.40 | 109.5 |

**Note:** The table reports results of wage Phillips curve estimates with industrial strike dummies. Coefficients are only shown for either contemporaneous or first lag effects, with any further lags omitted to conserve space. Lag selection was performed by comparing BIC criteria across all possible lag permutations. Standard errors are adjusted for heteroscedasticity and autocorrelation, and shown in parentheses. Asterisks denote significance levels: *** $p < 0.01$, **$p < 0.05$, *$p < 0.1$. Note that for specifications (3) and (6), which feature individual dummies for each strike, standard errors for the continuous variables are computed by partialling out the industrial strike dummies and the constant. This ensures the full rank of the covariance matrix, but suppresses estimates of standard errors for the constant and dummies.

# D Event study

**Table D.1** Cumulative Abnormal Returns around the beginning of a strike (One-tail test)

| Window | 1995 | 2002 | 2018 | all |
|---|---|---|---|---|
| *using industrial and market index* | | | | |
| -4 : 0 | -1.62*** | -0.526 | -0.602 | -0.779** |
| -3 : 0 | -1.507*** | -0.504 | -0.702* | -0.806** |
| -2 : 0 | -0.624* | -0.68 | -0.869** | -0.759** |
| -1 : 0 | -0.821** | -1.001 | -0.557 | -0.754** |
| 0 : 0 | -0.43 | -1.036* | -0.252 | -0.541* |
| Since Ann. | -0.821** | -0.68 | -0.869** | -0.799** |
| *using industrial index* | | | | |
| -4 : 0 | -1.697*** | -0.639 | -0.833 | -0.942** |
| -3 : 0 | -1.581*** | -0.581 | -0.804* | -0.894*** |
| -2 : 0 | -0.659* | -0.828 | -1.024** | -0.887*** |
| -1 : 0 | -0.819* | -1.026 | -0.672 | -0.816** |
| 0 : 0 | -0.445 | -0.966 | -0.265 | -0.528* |
| Since Ann. | -0.819* | -0.828 | -1.024** | -0.92*** |
| *Obs:* | 19 | 29 | 44 | 92 |

**Note:** Statistical significance is based on the non-parametric generalised rank statistic of Kolari and Pynnonen (2011) adjusted for individual event clustering. Asterisks denote significance levels for a one-tail test ( ***=1%, **=5%, *=10%)[61].

# E   Intensive and extensive margins in Germany

**Figure E.1** Cyclical components of total hours, average hours and a number of employees over time
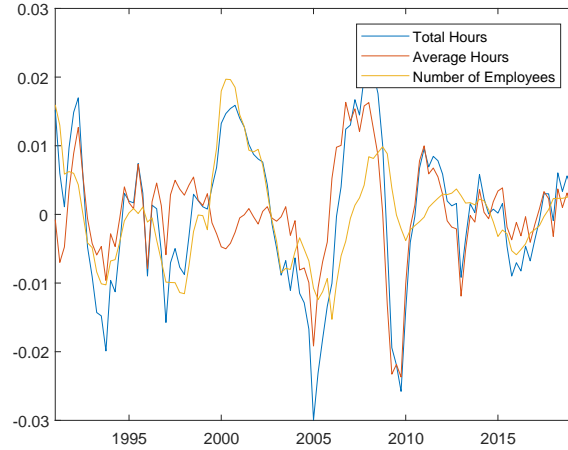


**Note:** The figure shows the cyclical components of total hours worked, average hours and the number of employees, adjusted for the the population trend and de-trended with a Hodrick-Prescott filter.

To evaluate the importance of the intensive and extensive margins of labour adjustment over the business cycle in Germany, we decompose the cyclical variation of total hours worked, $\hat{t}$, into the variation explained by average hours worked, $\hat{h}$ or the intensive margin, and by the number of employees, $\hat{n}$ or the extensive margin, following Kudoh et al. (2019). By definition, total hours worked is the product of average hours worked and the number of employees. We start from total hours worked and employment per capita, take logs and de-trend using a Hodrick-Prescott filter, yielding the following decomposition of the cyclical component of total hours worked:

$$\hat{t} = \hat{h} + \hat{n} \tag{E.1}$$

Figure E.1 shows the cyclical components of all three variables across time. From 2005 onwards, average and total hours move very much in tandem and have similar amplitudes, suggesting for example that the shock due to the Great Financial crisis was mainly transmitted along the intensive margin. Prior to 2005, the relationship was somewhat weaker, whereas the correlation between total hours and employment is stronger. The relative importance of the intensive and extensive margins thus appears to be time-varying, which could be explained by both a different prevalence of structural shocks over time or more secular trends, but goes beyond the scope of our paper.

Equation E.1 also implies the following variance decomposition of total hours:

$$var(\hat{t}) = cov(\hat{t}, \hat{h}) + cov(\hat{t}, \hat{n}) = var(\hat{h}) + var(\hat{n}) + 2cov(\hat{h}, \hat{n}) \tag{E.2}$$

Our estimates for the decomposition are summarised in Table E.1. For the full sample, half of the variation in total hours can be attributed to the covariance with the intensive margin

**Table E.1** Contributions of the intensive and extensive margins to the variation in total hours worked

| | $\frac{cov(\hat{t},\hat{h})}{var(\hat{t})}$ | $\frac{cov(\hat{t},\hat{n})}{var(\hat{t})}$ | $\frac{var(\hat{h})}{var(\hat{t})}$ | $\frac{var(\hat{n})}{var(\hat{t})}$ | $\frac{2cov(\hat{h},\hat{n})}{var(\hat{t})}$ |
|---|---|---|---|---|---|
| Full sample | 51% | 49% | 47% | 46% | 6% |
| Up to 2008 | 41% | 59% | 37% | 55% | 8% |
| Post-2008 | 79% | 21% | 75% | 17% | 8% |

**Table E.2** Contributions of the intensive margin, employment rate and participation rate to the variation in total hours worked

| | $\frac{cov(\hat{t},\hat{h})}{var(\hat{t})}$ | $\frac{cov(\hat{t},\hat{e})}{var(\hat{t})}$ | $\frac{cov(\hat{t},\hat{p})}{var(\hat{t})}$ |
|---|---|---|---|
| Full sample | 47% | 47% | 6% |
| Up to 2008 | 37% | 58% | 5% |
| Post-2008 | 64% | 30% | 6% |

(alternatively, based on the second identity, the variance of average hours worked explains just short of 50% of the variance of total hours worked). This is in stark contrast to the US, where estimates vary from 17% to 33% (Cacciatore et al., 2016; Bulligan et al., 2019), and suggests that in Germany the intensive margin is as important as the extensive one and cannot be neglected when analysing cyclical fluctuations. However, the relationship is not stable over time. Prior to the Great Financial Crisis, the extensive margin was more prominent, while the opposite is true for the later period. This can be explained by the working time policies enacted in Germany during the crisis to avoid high unemployment (Burda and Hunt, 2011; Krugman, 2009).

The variation in employment can in turn capture changes in both labour supply and labour participation. For the sake of completeness, we also decompose employment per capita into an employment rate $\hat{e}$ and a participation rate $\hat{p}$. This decomposition is shown in Table E.2[62]. over the full sample, the results adjusting for participation confirm that the intensive and extensive margins are both important drivers of the variation in total hours.

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[62]Note that for this exercise we use working-age population (15-74) instead of total civilian population. For that reason, the covariances in the two tables do not match exactly.

# F   Theory-robust sign restrictions

To further support our identifying assumptions, we show by means of a simple Monte Carlo exercise that the sign restrictions we impose on the responses of real wages, average hours worked and inflation to a wage bargaining shock are consistent with a prototypical medium-size DSGE model featuring search frictions in labor markets (Christoffel et al., 2009), and hold for a broad range of parameter values. As a corollary, we also show that our baseline results for unemployment and output, as well as additional variables such as the vacancy rate and the labour share, which we leave unrestricted, are consistent with the behaviour predicted by the DSGE model for the same range of parameter values.

Christoffel et al. (2009) represents a useful framework for our purposes for a number of reasons. First, the model was developed to analyse to what extent various exogenous shocks arising in labor markets, including wage bargaining shocks, are important for business cycle fluctuations. A wage bargaining shock represents an exogenous change to a Nash bargaining parameter that governs the distribution of employment surplus between employers and workers. Second, it features involuntary unemployment and labour adjustment along both the intensive and extensive margin. As shown in Appendix E, average hours worked account for around half of the cyclical variation in total hours worked in Germany, indicating that this margin should not be neglected. Third, bargaining is of the 'right-to-manage' type, where it is entirely up to employers to set hours worked by employees given the agreed wage. This framework arguably captures a salient feature of bargaining on the German labour market, as discussed in the main text.

We follow Canova and Paustian (2011) and first take independent draws ($10^4$ in total) from uniform distributions for selected model parameters. We then solve the model using each parameter draw and compute an impulse response.[63]. Table F.1 shows the parameter ranges used for the exercise. The bounds are fairly wide, allowing for conventional values as well as rather unrealistic calibrations. Nevertheless, on impact, the signs of the dynamic responses of most variables to a wage bargaining shock are robust, as shown in Figure F.1.

The shock leads to an increase in real wages. Due to the associated higher costs, firms reduce the amount of hours worked for each employee, but also increase prices. These three features are in line with the only sign restrictions we impose in our VAR. In addition, since now workers obtain a higher share of the surplus, employers post less vacancies, leading to a lower probability of finding a job, and thus to higher unemployment and output under most parameter values. Similarly, the net effect on the labor share is typically positive. Our baseline results and additional exercises including the vacancy rate and labour share corroborate these predictions.

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[63]Foroni et al. (2018) do a similar exercise, using a slightly smaller model that allows for an additional labor participation decision instead of an intensive margin of adjustment within firms.

**Table F.1** Parameters and ranges for the Monte Carlo exercise

| Description | Parameter | Range |
|---|---|---|
| Interest rate smoothing coefficient | $\gamma_R$ | [0 1] |
| Response to inflation | $\gamma_\pi$ | [1 3] |
| Response to output gap | $\gamma_y$ | [0 1] |
| Response to output growth | $\gamma_{dy}$ | [0 0.2] |
| Markup in the wholesale sector | $\epsilon$ | [6 12] |
| Inverse of Frisch elasticity | $\varphi$ | [1 5] |
| Risk aversion | $\sigma$ | [1 3] |
| External habit persistence | $\varrho$ | [0 0.6] |
| Calvo stickiness of prices | $\omega$ | [0.5 0.8] |
| Degree of price indexation | $\xi_p$ | [0 0.2] |
| Elasticity of matches w.r.t. unemployment | $\xi$ | [0.5 0.7] |
| Bargaining power of workers | $\eta$ | [0.01 0.99] |
| Calvo wage stickiness | $\gamma$ | [0 0.9] |
| Wage indexation | $\xi_w$ | [0 0.5] |
| Labor elasticity of production | $\alpha$ | [0.5 1] |
| Autocorrelation of bargaining shock | $\rho_\eta$ | [0 0.99] |
| Steady state unemployment rate | $\bar{u}$ | [0.03 0.1] |
| Replacement rate | $\frac{b}{wh}$ | [0.2 0.95] |

**Note:** The table lists the parameters drawn in the Monte Carlo exercise and the corresponding ranges. The notation follows Christoffel et al. (2009).

**Figure F.1** Impact impulse responses to a wage bargaining shock in the Christoffel et al. (2009) model under different parameterisations
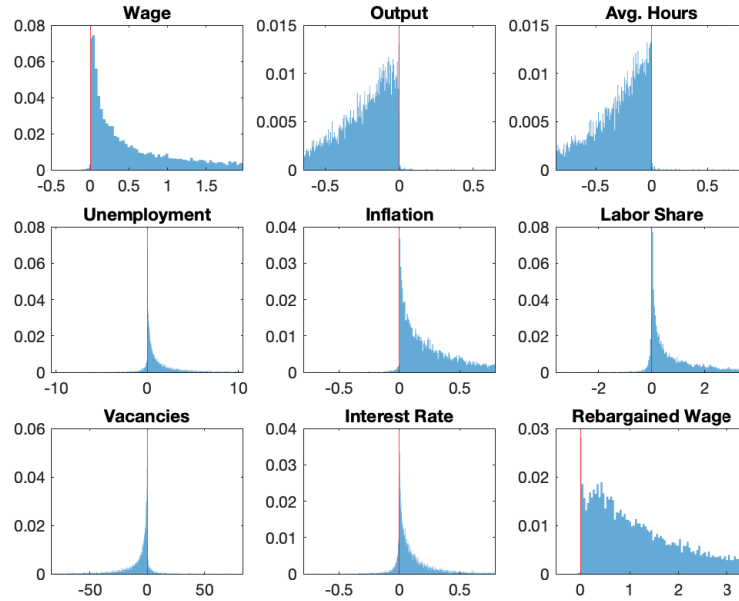


**Note:** The histograms show impact impulse responses to a positive wage bargaining shock, which increases workers' share of the surplus, for $10^4$ different parameterisations.

# G    Minimum wage introduction episode: counterfactual series

**Figure G.1** Counterfactual macroeconomic variables simulated without wage bargaining shocks
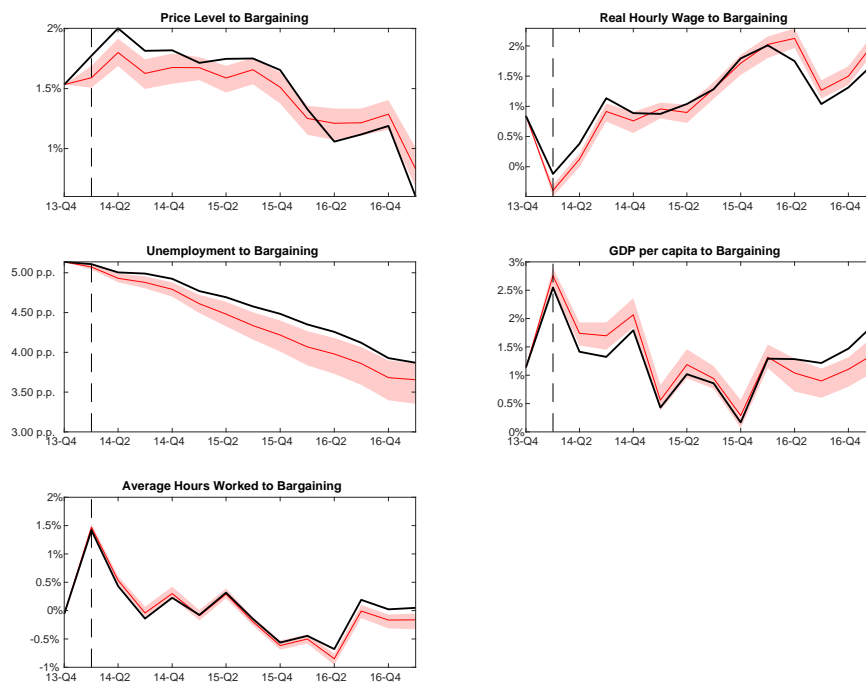


**Note:** The figure shows counterfactual series, computed excluding wage bargaining shocks. Median estimates are shown in pink, bands are posterior 68% credible sets, and outturns are shown in black. Unemployment (URX) is shown in percentage points, all other variables in year-on-year growth rates. The solid black lines show the actual data.

# H   Robustness and extensions

**Table H.1** Share of forecast error variance attributed to wage bargaining shocks for the baseline and alternative specifications.

| | | GDP deflator inflation | Real Wages and Salaries | Unemployment | Output per capita | Average hours worked |
|---|---|---|---|---|---|---|
| Baseline | h=0 | 24% | 16% | 6% | 6% | 1% |
| | h=4 | 24% | 17% | 14% | 12% | 3% |
| | h=8 | 23% | 12% | 16% | 12% | 5% |
| | h=40 | 23% | 6% | 21% | 8% | 10% |
| Sign Restrictions as in Foroni et al. (2018) | h=0 | 25% | 16% | 8% | 8% | 1% |
| | h=4 | 25% | 17% | 18% | 17% | 5% |
| | h=8 | 24% | 10% | 23% | 16% | 6% |
| | h=40 | 25% | 5% | 28% | 10% | 13% |
| Only Narrative Restrictions | h=0 | 16% | 15% | 2% | 3% | 2% |
| | h=4 | 16% | 16% | 5% | 4% | 2% |
| | h=8 | 16% | 13% | 7% | 4% | 5% |
| | h=40 | 17% | 7% | 12% | 5% | 11% |
| No contribution restrictions | h=0 | 19% | 9% | 13% | 14% | 2% |
| | h=4 | 19% | 9% | 21% | 20% | 6% |
| | h=8 | 19% | 8% | 24% | 19% | 7% |
| | h=40 | 20% | 7% | 28% | 14% | 13% |
| Narrative restriction for 2018q2 only | h=0 | 13% | 4% | 21% | 18% | 2% |
| | h=4 | 14% | 5% | 29% | 26% | 6% |
| | h=8 | 14% | 7% | 31% | 25% | 7% |
| | h=40 | 16% | 10% | 34% | 17% | 13% |
| Vacancy rate | h=0 | 20% | 16% | 5% | 6% | 1% |
| | h=4 | 19% | 16% | 14% | 13% | 5% |
| | h=8 | 19% | 11% | 17% | 12% | 5% |
| | h=40 | 20% | 5% | 18% | 8% | 12% |
| Real Gross Operating Surplus | h=0 | 21% | 14% | 6% | 5% | 1% |
| | h=4 | 20% | 15% | 16% | 13% | 4% |
| | h=8 | 20% | 10% | 18% | 12% | 5% |
| | h=40 | 20% | 5% | 20% | 8% | 9% |
| Narrative restrictions on Wages in Manufacturing | h=0 | 25% | 16% | 9% | 4% | 1% |
| | h=4 | 24% | 13% | 12% | 6% | 3% |
| | h=8 | 23% | 10% | 11% | 6% | 4% |
| | h=40 | 23% | 7% | 12% | 6% | 7% |
| Narrative restrictions on Basic Pay rates | h=0 | 18% | 16% | 4% | 4% | 4% |
| | h=4 | 17% | 19% | 12% | 9% | 7% |
| | h=8 | 17% | 13% | 15% | 8% | 6% |
| | h=40 | 17% | 7% | 17% | 9% | 10% |
| Additional Shocks | h=0 | 20% | 18% | 10% | 5% | 1% |
| | h=4 | 20% | 17% | 21% | 12% | 4% |
| | h=8 | 20% | 12% | 23% | 12% | 5% |
| | h=40 | 20% | 6% | 28% | 8% | 10% |

**Note:** The table reports posterior median values of forecast error variance decompositions for the baseline and a number of alternative specifications.

## H.1  Comparison with Foroni et al. (2018)

Sign restrictions on unemployment and output are added, as in Foroni et al. (2018), to the model identified with sign restrictions only.

**Figure H.1** Impulse responses to a wage bargaining shock as in Foroni et al. (2018)
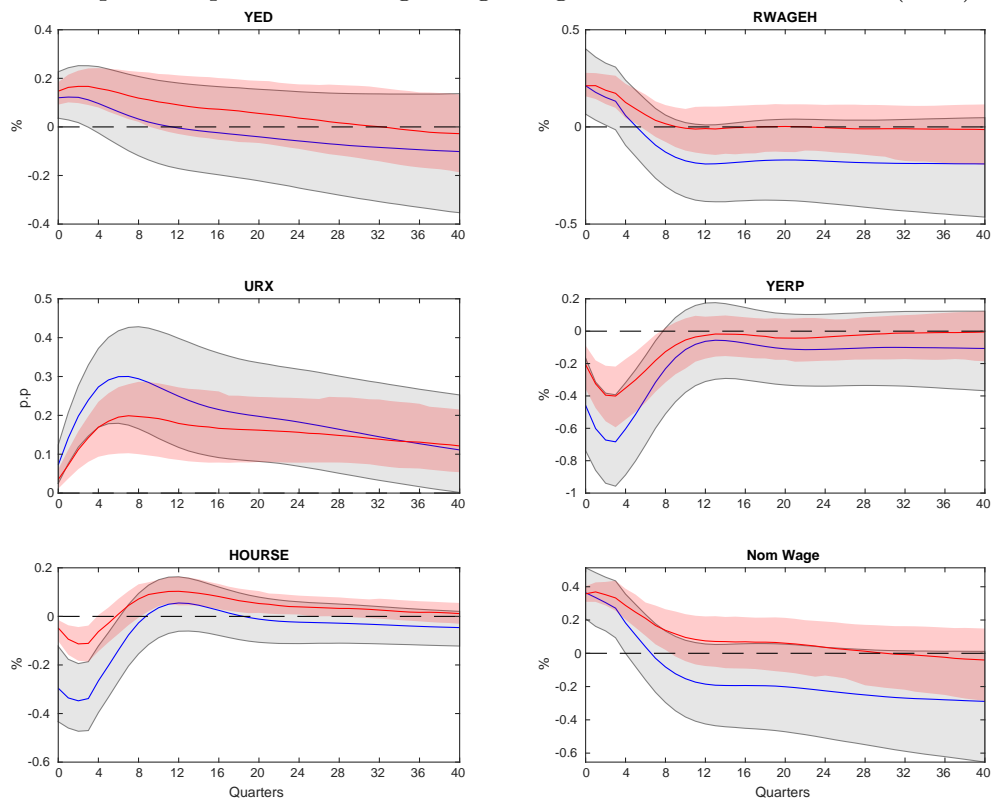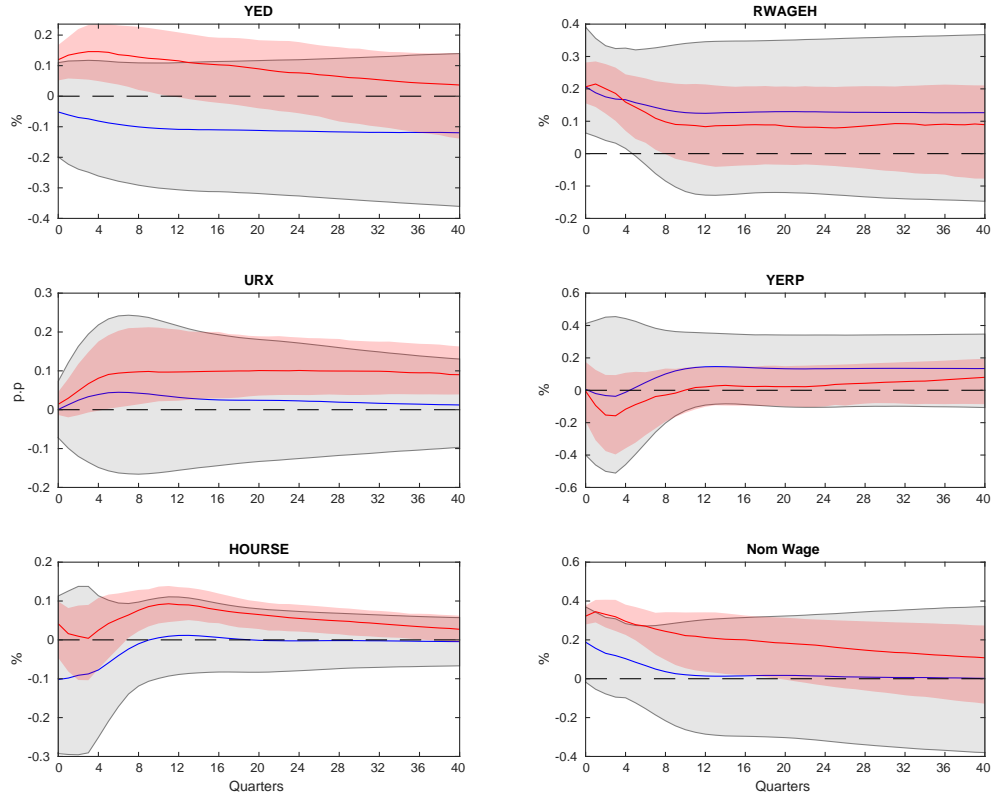


**Note:** The figure shows 68% credible bands for the impulse responses to a positive wage bargaining shock for the model with sign restrictions as in Foroni et al. (2018) (in grey, median in blue), and for our baseline specification (in pink, median in red). The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE); real GDP per capita (YERP) and nominal wages and salaries per hour (Nom wage).

## H.2 Only narrative restrictions

The sign restrictions on average hours worked and inflation are relaxed but all narrative restrictions are maintained.

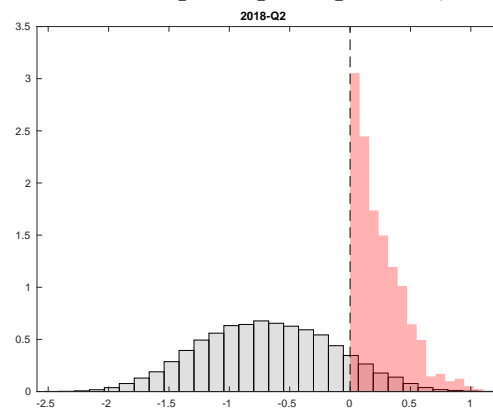**Figure H.2** Impulse responses to a positive wage bargaining shock, only narrative restrictions.



**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink. The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE); real GDP per capita (YERP) and nominal wages and salaries per hour (Nom wage).

## H.3 No contribution restrictions

All narrative restrictions on the *contributions* of wage bargaining shocks to the historical decomposition are dropped.

**Figure H.3** Impulse responses to a wage bargaining shock without narrative contribution restrictions.
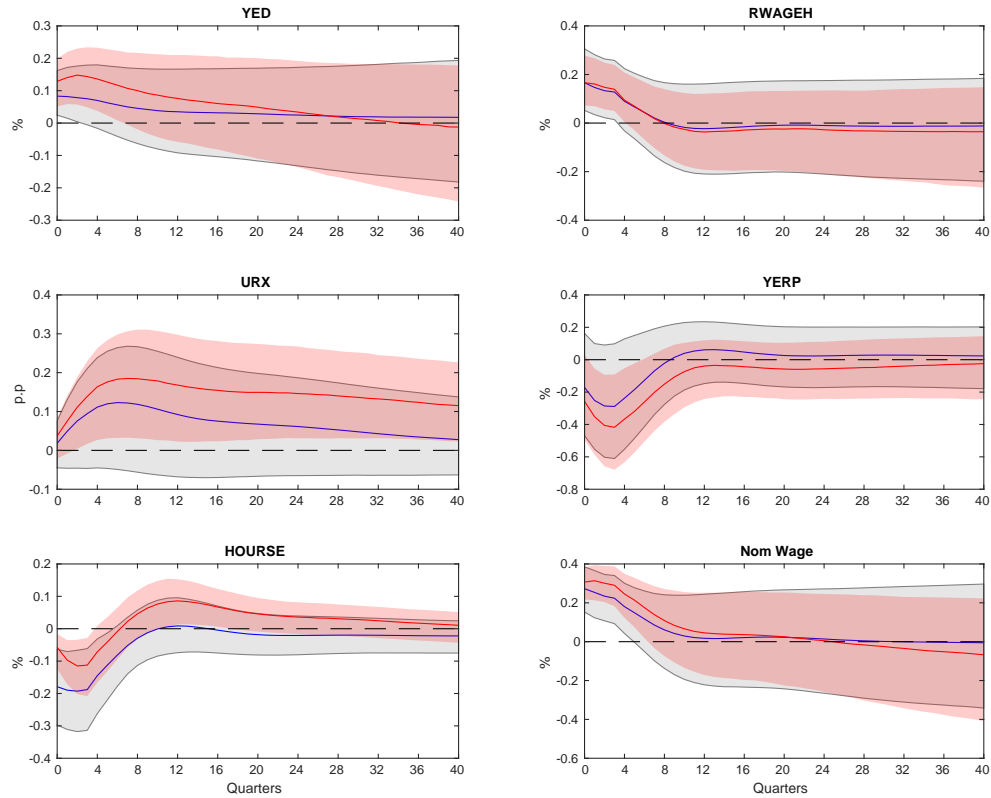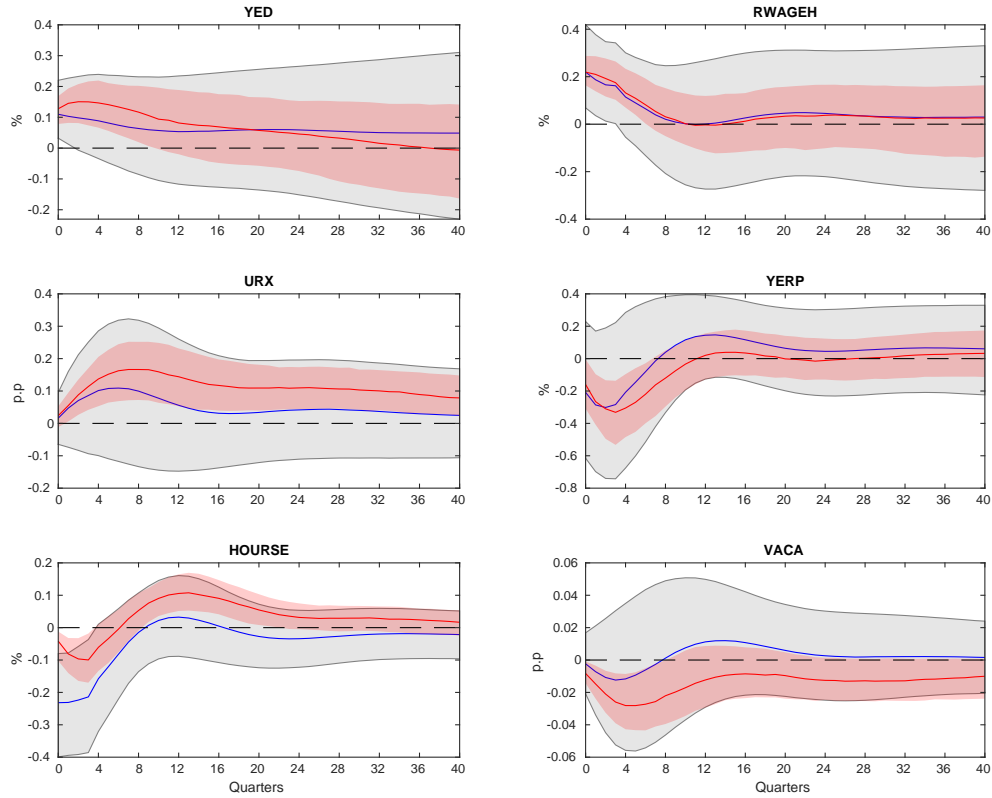


**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink. The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE); real GDP per capita (YERP) and nominal wages and salaries per hour (Nom wage).

## H.4 Narrative restriction for 2018q2 only

Only one narrative restriction, requiring that the wage bargaining shock was positive in 2018q2, is imposed alongside sign restrictions.

**Figure H.4** Posterior distribution of wage bargaining shocks, 2018q2 restriction only.



**Note:** The figure shows posterior distributions of wage bargaining shocks for the model with sign restrictions in grey and the specification including narrative restrictions in pink.

**Figure H.5** Impulse responses to a positive wage bargaining shock, 2018q2 restriction only.
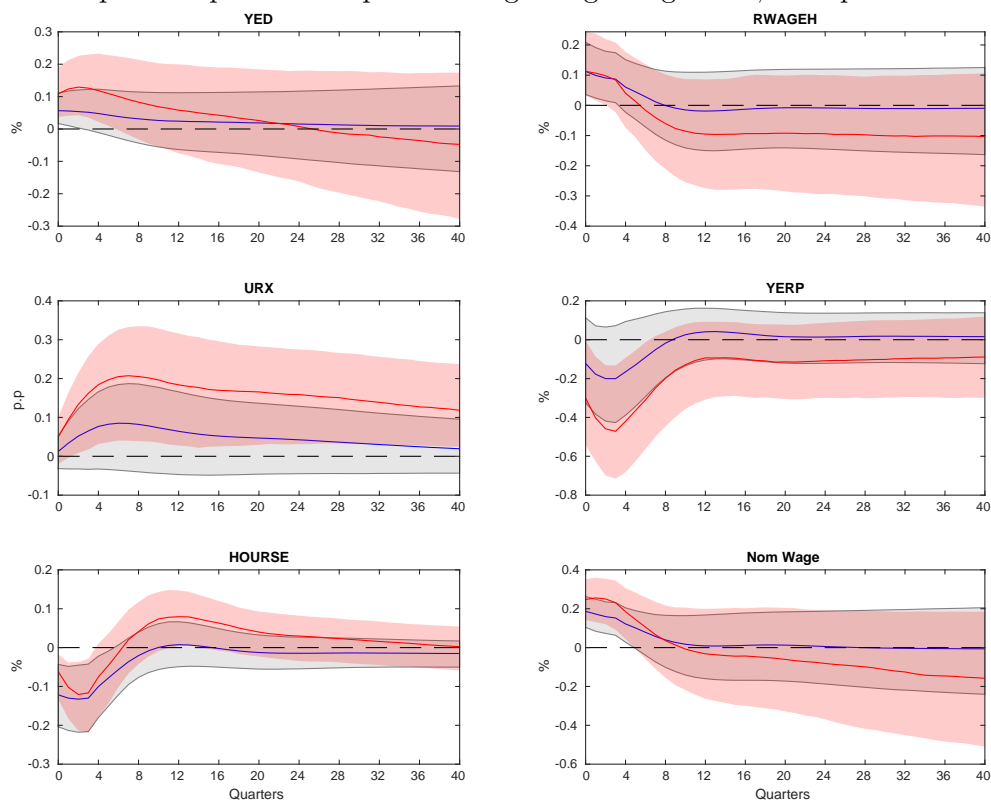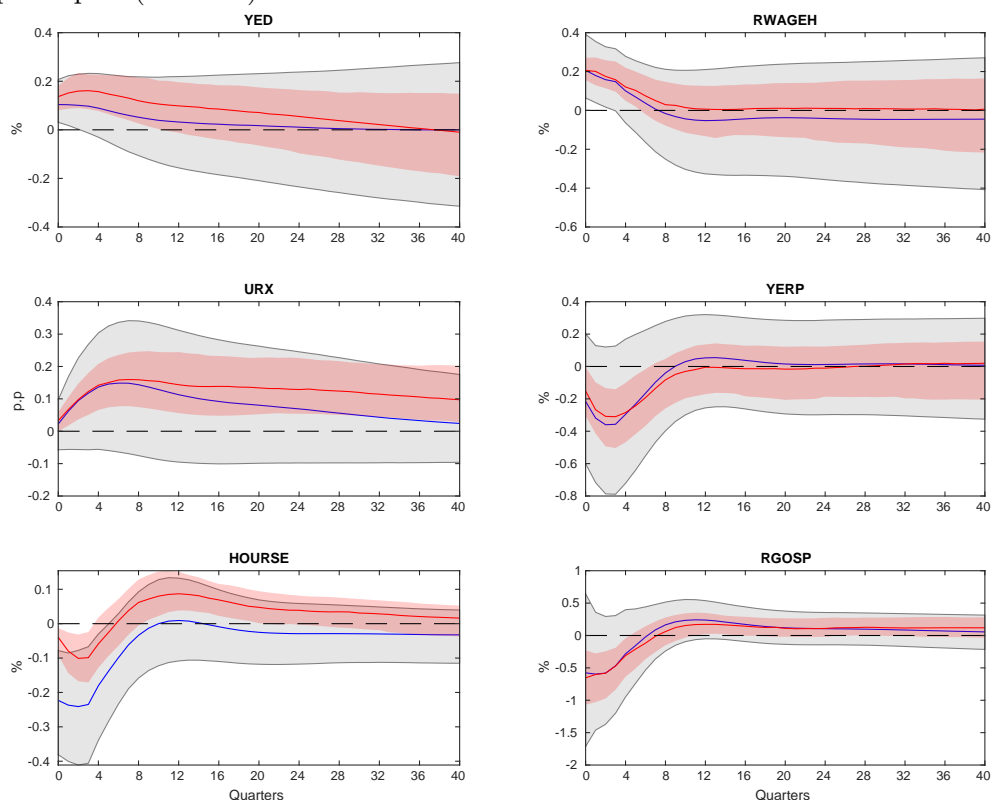


**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink. The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE); real GDP per capita (YERP) and nominal wages and salaries per hour (Nom wage).

## H.5 Vacancy rate

Includes the vacancy rate as an additional (unrestricted) variable.

**Figure H.6** Impulse responses to a positive wage bargaining shock, with vacancy rate.
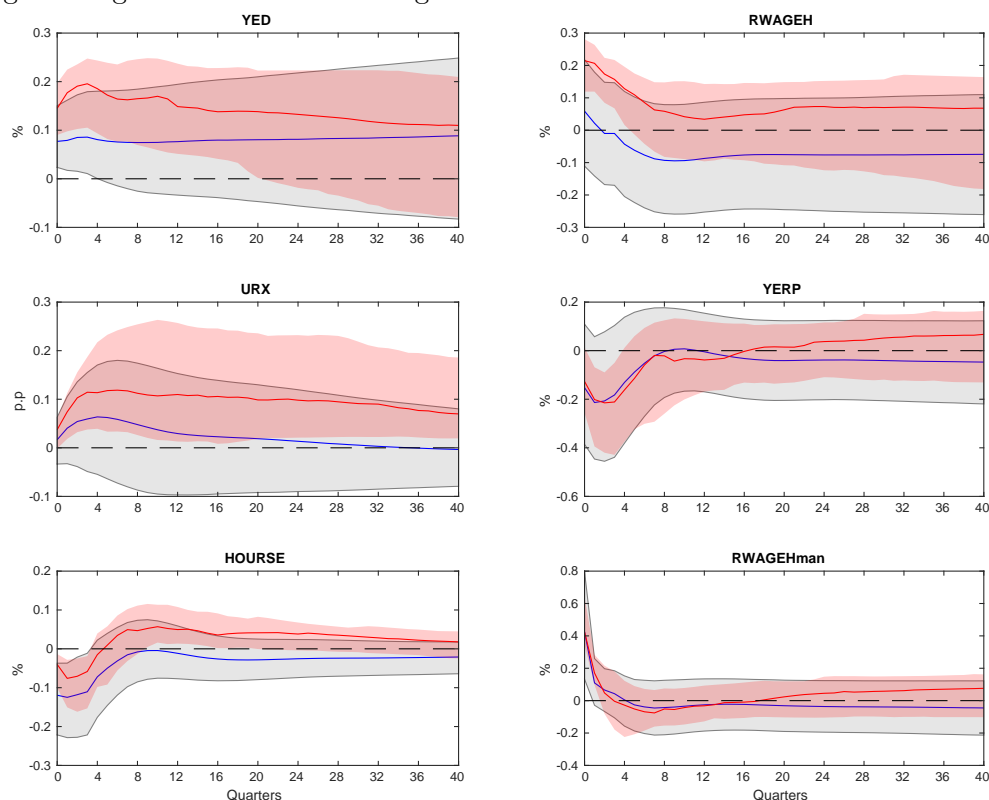


**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink. The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE); real GDP per capita (YERP) and vacancy rate (VACA).

## H.6    Gross operating surplus

Includes the gross operating surplus per capita as an additional (unrestricted) variable.

**Figure H.7** Impulse responses to a positive wage bargaining shock, with real gross operating surplus per capita (RGOSP)



**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink.The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE); real GDP per capita (YERP) and real gross operating surplus per capita (RGOSP).
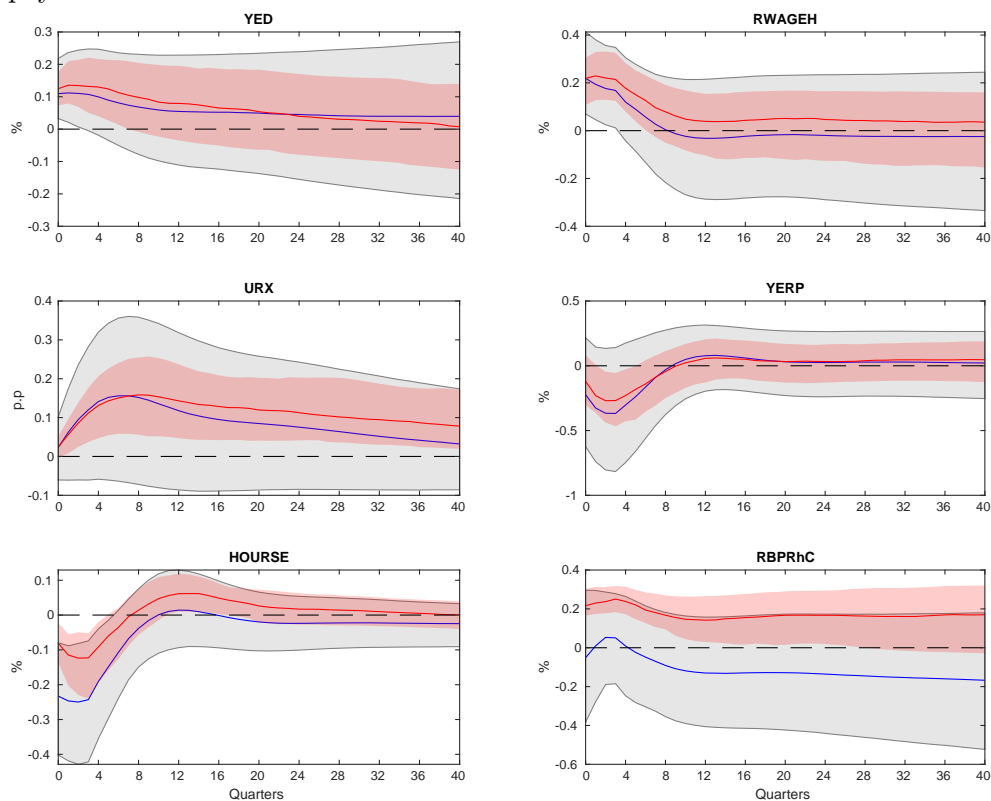
## H.7    Alternative wage measures

Narrative contribution restrictions are imposed on alternative measures of wages.

**Figure H.8** Impulse responses to a positive wage bargaining shock with narrative restrictions on aggregates wages in the manufacturing sector



**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink. The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE); real GDP per capita (YERP) and real wages and salaries per hour in the manufacturing sector, deflated using the GDP deflator (RWAGEHman).

**Figure H.9** Impulse responses to a positive wage bargaining shock with narrative restrictions on basic pay rates
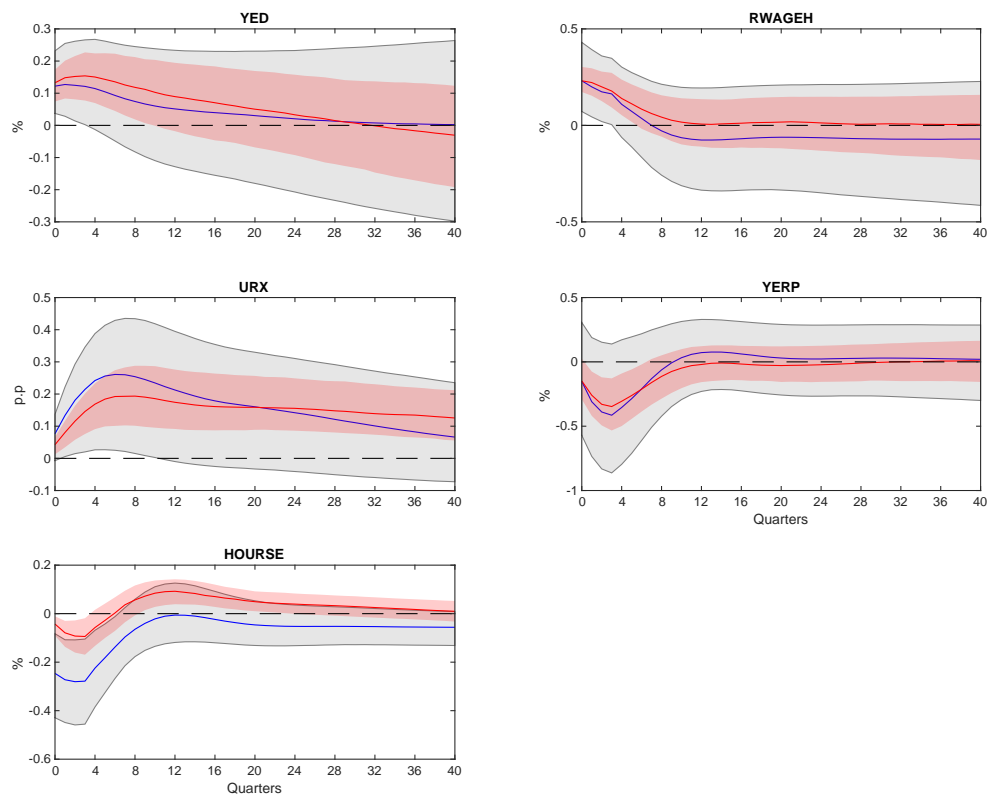


**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink. The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE); real GDP per capita (YERP) and basic pay rates, deflated using the GDP deflator (RBPRhC).

## H.8    Identifying additional shocks

The remaining shocks are identified with sign restrictions.

**Figure H.10** Impulse responses to a positive wage bargaining shock, additional shocks identified
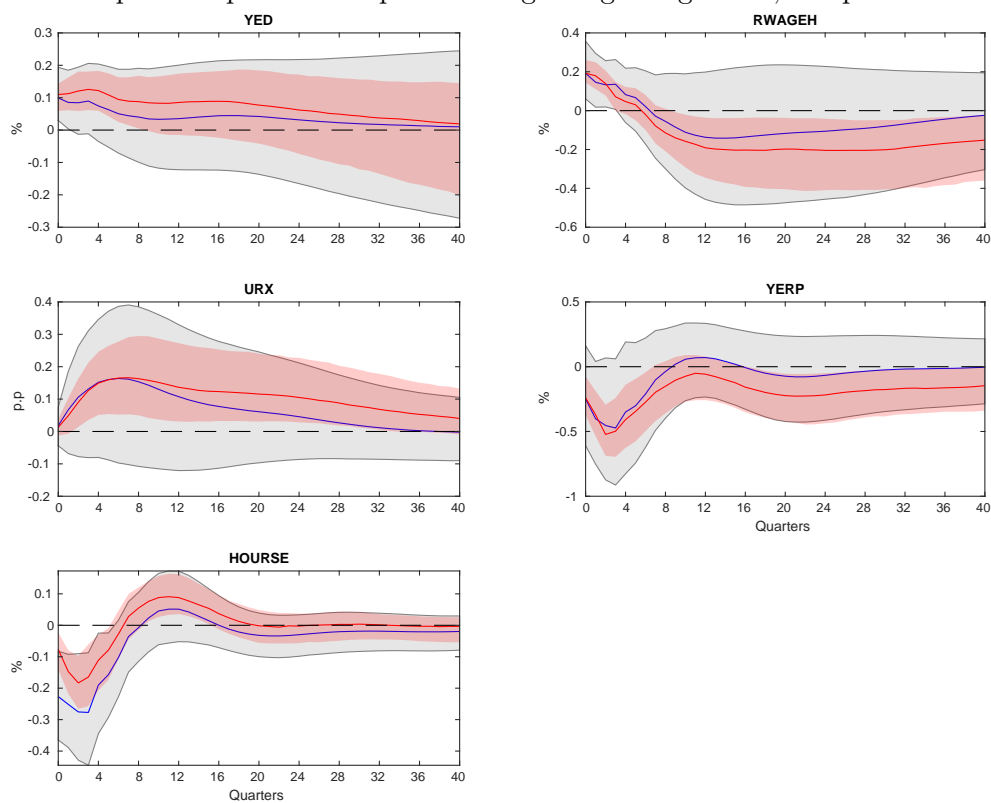


**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink. The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE) and real GDP per capita (YERP).
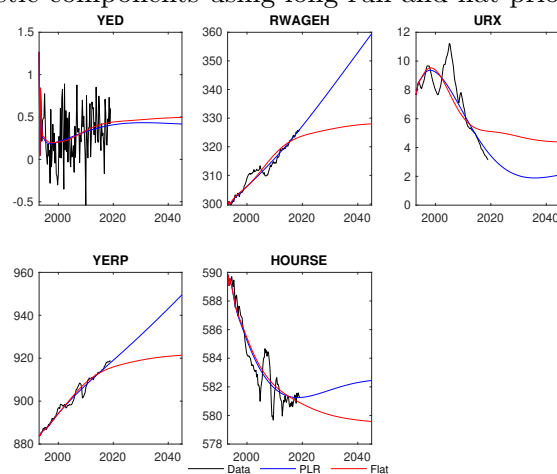
## H.9 Flat priors

Flat rather than informative priors are imposed.

**Figure H.11** Impulse responses to a positive wage bargaining shock, flat priors.



**Note:** The figure shows impulse responses to a positive wage bargaining shock. Solid lines stand for the posterior median as a point estimate and bands are posterior 68% credible sets. The model with sign restrictions is in grey; the specification including narrative restrictions is in pink. The variables are: the GDP deflator (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE) and real GDP per capita (YERP).

**Figure H.12** Deterministic components using long-run and flat priors



**Note:** The figure plots data and deterministic components using long-run (PLR) and flat priors (Flat). The variables are: the GDP deflator in log-differences (YED); real wages and salaries per hour, deflated using the GDP deflator (RWAGEH); the unemployment rate (URX); hours worked per employee (HOURSE) and real GDP per capita (YERP).

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