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SHORT-TERM MACROECONOMIC EVALUATION OF THE GERMAN MINIMUM WAGE WITH A VAR/VECM

Alexander Herzog-Stein¹, Camille Logeay²

ABSTRACT

The German minimum wage was introduced in January 2015. This paper investigates the short-term macroeconomic impacts of its introduction. Therefore, an estimated VAR/VECM is used to perform forecasts that are interpreted as counterfactual to the introduction of the minimum wage and compared to actual developments of six key macroeconomic variables. The deviations are interpreted as minimum wage effects. Robustness checks as well as a comparison with descriptive empirical results are performed to assess the validity of the results. Overall, small positive price effects, significant positive wage effects, and positive employment effects although not robustly estimated in their magnitude are found.

¹ Macroeconomic Policy Institute (IMK) Düsseldorf and University of Koblenz-Landau.

² Hochschule für Technik und Wirtschaft (HTW) Berlin and senior research fellow at IMK Düsseldorf.

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* Macroeconomic Policy Institute (IMK) Düsseldorf and University of Koblenz-Landau.

** HTW Berlin and senior research fellow at IMK Düsseldorf.

1. Introduction¹

Before the introduction of the national minimum wage in Germany. There was a fierce debate about the potential employment effects of a possible minimum wage. A lot of economists predicted marked employment losses in the short and long run. The German Council of Economic Experts even deliberated in 2014 shortly before the minimum wage law came into force that the minimum wage might have a negative impact on firms' investment decisions due to the *expected* higher wage cost induced by the minimum wage (GCEE 2014: p 8). Furthermore, with respect to its economic forecast for 2015 it assumed that in 2015 around 140 000 jobs less would be created as a consequence of the introduction of the minimum wage (CCEE 2014: p 110).

The German national minimum wage was introduced in January 2015 (8.50 Euro per hour), increased in January 2017 (8.84 Euro per hour) and again in 2019 (9.15 Euro per hour). A further increase is scheduled in 2020 (9.35 Euro per hour). Undoubtedly such a far reaching institutional change like the introduction of a national minimum wage should impact on the macroeconomic performance of an economy. The open questions are however in which way and to which extend does the introduction of a national minimum influence macroeconomic outcomes already in the short run. To our knowledge so far there is no other study who attempted to answer these questions empirically.

The aim of this paper is to fill this gap in the literature and estimate the macroeconomic impact of the minimum wage on key economic variables. There is a vast choice of models to evaluate such a far-reaching policy as the introduction of a minimum wage. After Clements/Mizon (1991), economists face a trade-off between empirical and theoretical coherence in dealing with macroeconomic modelling. VAR models, the one extreme, stand at the opposite to the structural models as DSGE-models, the other extreme. VAR models are commonly used for forecasting

¹ This paper is based on research done as part of the research project No. 526652 “ Macroeconomic effects of minimum wage in a Keynesian economic framework“ commissioned by the German Minimum Wage Commission (see Herr et al. 2017 and Herzog-Stein et al. 2018). Despite the name of the report the research presented here was done without imposing a theoretical framework. The intention within the commissioned research project was to provide the IMK Keynesian macroeconometric model with proper actual inputs for its medium-term simulations. Those simulations are however not part of this paper.

purposes (see ECB 2016) for the reason that they show a high empirical coherence (Pagan 2003: p 68). In this paper, the strategy is to let the data speak freely and incorporate their observed interdependencies to produce a counterfactual (what would be without minimum wage). This is done within a VAR-forecast-exercise. Those forecast-counterfactuals are then compared to the actual developments immediately after January 2015. The difference or forecast error is then attributed to the minimum wage (see Pesaran et al. 2007 or Logeay/Schreiber 2006 for similar strategies).

The limits of the method are well-known. Ideally there would be no forecast error, at least not a systematic one, for the forecast period. Since this cannot be assessed by usual means, to address the validity of the interpretation of the forecast error as very probable minimum wage effect, an extensive descriptive statistical analysis is made to provide a plausible range of the effect on the main macroeconomic variables. This is related to international and German literature on the minimum wage effects. In this way we are able to gauge the minimum wage effect from two sides, both not theoretically driven.

The structure of the paper is as follows: in the next section the evidence from descriptive statistics on prices, employment and wages is presented. Section 3 describes the dataset used for the VAR analysis. Section 4 justifies the estimation of the VAR/VECM with the usual diagnostic tests. Section 5 presents the results of the VAR analysis and discusses these results in perspective of the evidence presented in Section 2. The final Section concludes.

2. Descriptive statistics: expected effects and observed effects

Prices

The empirical literature on the price effects of the minimum wage is not very numerous. For Germany, the Minimum Wage Commission (2016: p 118) points out that no reliable microeconomic sectoral analyses of the price effects could be carried out. At least, results from the IAB

Establishment Panel 2015 show for Germany that for establishments the increase in sales prices is one of the preferred reported reactions to the minimum wage (Bellmann et al. 2016).

There are however several international studies, in particular from the United States and the United Kingdom. In a review of the existing literature on the price effects of minimum wages Lemos (2008: p 196) comes to the conclusion that macroeconomic price effects are difficult to find, and that across all studies the magnitude of the price effect of a rise in the minimum by 10% is a price increase of around 0.2 %. In a recent study Arpaia et al. (2017: pp 26-27) examine the minimum wage effect on consumer prices in 20 EU countries. They come to the conclusion that a 10 percent increase in the minimum wage leads to a rise in consumer prices by a total of 0.4 to 0.6 %, with the effect of the minimum wage varying greatly depending on the product category (Arpaia et al. 2017: pp 26-27). Overall, they conclude that an increase in the minimum wage has only a small effect on prices in the EU countries with minimum wages.

Looking at price developments in Germany around the time of the introduction of the minimum wage, the following calculations provide some evidence on the impact of the minimum wage on prices: The Minimum Wage Commission (2016) presents in its first report in Tab. 12 (p 119) the price development of 17 goods and services (merged into 15) from sectors highly affected by the statutory minimum wage. If the weight of these goods and services in the calculation of the CPI is taken into account – their combined weight is about 11% –, and multiplied with the price increases shown by the corresponding good or service, this adds up to an overall contribution of 0.22 percentage points for 2015 out of the total price increase of 0.3% in this year (Tab. T1). Therefore, thanks to the price increases induced by the minimum wage Germany did not experience deflation in 2015. This range of order was confirmed by the second report of the Minimum Wage Commission (2018: p 137).

Table T1: Price effects

	2013	2014	2015
CPI, all Index, yoy-growth rate in %	1,54	0,85	0,28
Contribution of 15 products to Inflation rate in pp	0,36	0,26	0,22

Remark: the 15 products are: CC0111 , CC0113 , CC0724 , CC0732 , CC0734 , CC081 , CC0941 , CC0942 , CC0943, CC0951 , CC0952 , CC0953 , CC1111 , CC1112 , CC112.

Sources: Minimum Wage Commission (2016, Tab. 12: p 119); Destatis (Fachserie 17 Reihe 7) and Destatis (2013); Own calculations after Herr et al. (2017).

Wages

The minimum wage triggers two effects on the wage structure. On the one hand a minimum wage draws a downward limit, which results in a compression effect that reduces the wage structure from below leading to a more egalitarian wage distribution. At the same time, this compression effect may be attenuated if the minimum wage introduction or increase also leads to increases in wages above the minimum wage level. This latter spillover effect counteracts the compression effect.

In the minimum wage research, there is a broad consensus that spillover effects are present. It can be explained by the will of firms and workers to maintain the existing wage hierarchy and therefore to counteract to some extent the compression effect of the minimum wage (Belman/Wolfson 2014: pp 236f.).

In contrast to the analysis of employment effects, empirical research on spillover and compression effects of the minimum wage is more limited. Empirical studies (see Tab. T2) have been carried out in the USA, UK, and France (see also the literature reported in Horn et al. 2008: p 10). The different results reported by empirical studies indicate that the presence and magnitude of spillover effects depends on a number of specific factors and can also be very different over time. First, the magnitude of the price effect depends of the magnitude of the minimum wage increases. Second, the institutional framework of wage determination influences certainly the spillover effect, but this remains largely unexplored. This should particularly apply in Germany regarding the relationship between minimum wages and collectively agreed wages.

Table T2: Selected research studies to spillover effects in USA, UK and France

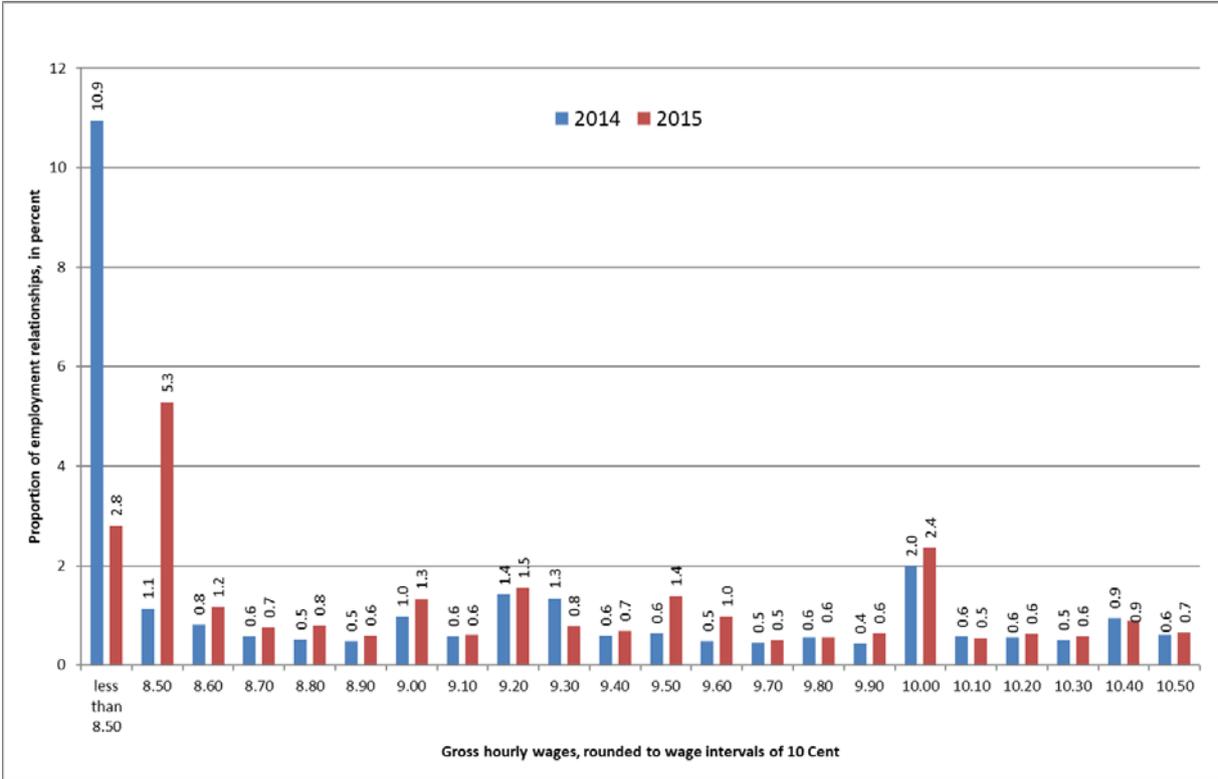
Study	Country	Results
Belman/Wolfson (2014), meta-study	USA/UK	USA: Clear spillover effects. Depending of the studies, it reaches from just over the MW to the 3 rd wage decile. UK: various results from none (by the introduction of the MW) to significant spillover effects (later increases).
Neumark/Wascher (2008)	USA	Increases of the MW influence wages that lie up to 20% over the MW. This effect is strongest near the MW-level.
Card/Krueger (1995)	USA	MW increases of 1990-1991: Clear spillover effect at the 5 th to 10 th wage percentiles.
Autor et al. (2016)	USA	MW increases between 1979-2012: Decreasing spillover effects till the 25 th wage percentile.
Dickens/Manning (2004)	UK	Introduction of MW 1999: Very small spillover effects by workers in residential homes for elderly.
Stewart (2012)	UK	MW increases since introduction: no systematic spillover effects.
Butcher et al. (2012)	UK	MW between 1998-2010: Spillover effects till the 25 th wage percentile.
CSERC (1999), meta-study	France	Clear spillover effects till a wage level of 1,5xMW. The spillover effects did significantly decrease in the 90's. They affect workers differently depending on their sex, age and professional position.
Goarant/Muller (2011)	France	MW increases 2006-2009 (after the working time reduction): Decreasing spillover effects till a wage level of 3xMW.
Aeberhardt et al. (2016)	France	MW increases between 2003-2005 (during the adjustment phase to the working time reduction): Spillover effects till the 7 th wage decile for men and 5 th wage decile for women. Here too, the effects are decreasing with the wage level.
Arpaia/van Herck (2017)	France	MW increases between 2007-2012: Spillover effects till the 8 th wage decile, with decreasing effects with the wage level.

Source: Herr et al. 2017, Tab. 2: p 36. Own adjustments.

The effects of introducing the minimum wage of 8.50 euros per hour on 1 January 2015 can be examined on the basis of the Structure of Earnings Survey 2014 (VSE 2014) and the Earnings Survey 2015 (VE 2015) (Fig. F1; see also Minimum Wage Commission 2016: pp 49-59). Accordingly, the proportion of employees earning less than 8.50 per hour has fallen sharply, so that the minimum wage is associated with a significant compression effect. In addition, it can be shown that not only the group earning exactly 8.50 euros per hour, but also the wage groups earning up to an hourly wage of 10.00 euros increased markedly, which speaks for noticeable spillover effects. From an hourly wage of 10.00 euros onwards, on the other hand, hardly any changes in the wage structure

are discernible. One exception is eastern Germany, where both the compression and spillover effects are even more pronounced (Minimum Wage Commission 2016: p 57).

Figure F1: Distribution of gross hourly wages in April 2014 and April 2015



Sources: VSE 2014, VE 2015; Own calculations.

On the basis of the observations described above, it seems appropriate to calculate the spillover effect of the introduction of the minimum wage only up to a gross wage level of 10.00 euro per hour. Based on the data from VSE 2014 and VE 2015 – adjusted for both the macroeconomic employment increase as well as the average wage increase compared to the previous year (see Annex A1) – the overall spillover effect has a magnitude of around 5.4 billion euros or slightly more than 0.4 % of gross wages of 2014. It is therefore in the same order as the direct (compression) effect calculated by the Minimum wage Commission (2016: p 116, footnote 50). Overall the effect of the minimum wage 2015 would have increased the wage bill by 0.4% directly (i.e. wage rises of the minimum wage earners still working) and by further 0.4% indirectly (wage increases of workers earning a wage above the minimum wage). Hence the total effect was 0.8% of the gross wage bill.

It should be noted that a parallel project to ours, funded equally by the Minimum Wage Commission (Burauel et al. 2018) and using other data, comes to the conclusion that the direct wage effect and the spillover effect are of a much smaller magnitude and insignificant compared to those calculated from the here used official VSE/VE-data.

Employment

In the research on minimum wages, no other relationship was examined so intensively as the one between the minimum wage and employment. The overview of the state of research in the first report of the Minimum Wage Commission is illustrating on this point (Minimum Wage Commission 2016: pp 22-25). Nevertheless, though there are plenty of studies, this remains a very controversial debate. However, it seems that a sort of consensus emerges since several meta-studies came to similar conclusions: Hardly any significant employment effects from minimum wages can be identified (OECD 2015, Tab. 1.3: p 47). Specific to Germany, the previously available research results on the sectoral minimum wages confirmed these international findings, too (see the brief overview in Minimum Wage Commission 2016: p 24).

For Germany, the evidence gathered by the Minimum Wage Commission (2016: pp 75ff and pp 105ff) as well as the actual data up to 2018 show that the development of employment was robust. However, there is a shift from minijobs to employment subject to social insurance contributions (vom Berge/Weber 2017). As can be seen from various data analyses, the introduction of the minimum wage has led both to a substitution of minijobs for employees subject to social insurance contributions (IAB-Arbeitsmarktspiegel) and to a probable change in working hours in the various categories of employment, which in total indicate a reduction in individual hours worked.² Other studies (Bossler/Garner 2016; Bellmann et al. 2016; Garloff 2017) show that firms had several strategies to adjust for the minimum wage. But on the whole, the effect on employment figures should have been very limited till positive, confirming again the international evidence. The effect on

² This is our interpretation from Frentzen and Günther (2017: p 56 and Tab. 10). Another project, commissioned by the minimum wage commission, comes to the same conclusion (Bonin et al. 2018).

working time is much more difficult to establish because of data problems but seems to point to a slight decrease (Wanger/Weber 2016; Minimum Wage Commission 2016: 105ff; Frentzen/Günther 2017). Overall the effects on the total volume of work from the change in the working time and shifts between minijobs and jobs subject to social insurance contributions is likely to be very small (Herzog-Stein et al. 2018, Tab. 1: p 6).

On the whole, the magnitude of order of the employment effect is small, the direction is not that clear. The working time might have declined but in magnitudes that are certainly not relevant at the aggregated level. Therefore, the effect on the volume of work should be also very limited. This means also that the overall effect on the wage bill can be interpreted as an effect on the wage rate.

Summary of the descriptive evidence

From literature and statistics, the take-aways are: The effects on overall consumer price inflation should be modest of around 0.2 percentage points stemming from products and services where the minimum wage has a high incidence.

The effects on total employment should be positive but very small and not significant, in line with the international literature. Especially the decrease of the minijobs seems to have been overcompensated by the increase in employment subject to social insurance contributions. It will be therefore important to control for business cycle effects in the VAR-part to prevent mixing positive employment effects from good overall economic environment and from the minimum wage. The findings on working time and therefore the volume of work is depending on very uncertain data. Therefore, the conclusions are to be taken cautiously. Eventual negative effects with respect to working hours can be inferred from the shift from minijobs to employment subject to social insurance contributions. Overall the effect on the volume of work should have been modest, too.

The wage effect has so far been estimated at 0.8% of the gross wage bill (0.4% as direct effect and further 0.4% spillover effects). If the employment effects are merely zero then this effect can be mirrored fully into the wage rate.

3. Dataset

Sources

Seasonally adjusted (partly also working day adjusted) time series are used from national accounts on a quarterly basis. For reasons of consistency, only national accounts data (Destatis, Fachserie 18 Reihe 1.3, publication date 25 August 2017) are considered, except for the oil price, which is taken from US databases.

The quality of national accounts data is reported in detail by Destatis (see the quality reports and methodological papers on seasonal adjustment on the Destatis website under National Accounts). National accounts data are more or less revised every quarter. The last major revision took place at the end of 2016 (see Fig. A1 and Tab. A2 in Annex A2). From 2017q1 to 2017q2, however, there are still noticeable revisions for 2016. Of particular relevance for this study are the revisions in working time and work volume, both of which have been sharply reduced by 0.4% compared with the previous publication. Real GDP has also been revised (+0.4%), with the latter consistently also for previous years, so that growth rates hardly changed. It should therefore be emphasised here that the forecasts presented are contingent on the status of national accounts as published at the end of August 2017, a well-known problem in the forecast literature (cf. Croushore/Stark 2003).

It should also be mentioned that variables of interest for the study, such as employment subject to social insurance contributions (SVB) and low-wage employment (minijobs), cannot be taken from the national accounts on a quarterly basis. SVB and minijobs time series are only available on a quarterly basis from the Federal Employment Agency from 1999q2 onwards. Older data for the SVB are available but lead to a statistical break when linked to the new data. Estimates for minijobs from other sources such as the SOEP (DIW) or the microcensus (Destatis) are only available on an annual basis before 1999 and, lead to a discontinuity in the time series when linked to the official data of the Federal Employment Agency. For this reason, a more detailed breakdown of employment cannot be used for the VAR estimate.

The period extends from 1991q1 to 2017q2 (T=108). For the first descriptive analyses, the largest possible period is considered. In the VAR estimation, on the other hand, the minimum wage years (2015q1-2017q2, T=96) are excluded in order to rule out any minimum wage effects influencing the estimated coefficients.

Variables used

The theoretical background of the VAR includes the wage and price-setting curves, as well as at least real GDP for the aggregated demand curve. An aggregated (vertical) labour supply curve in the sense of the labour force could also be taken into account. However, this figure shows few fluctuations. A time trend in the VAR should capture the demographic component and real GDP the behavioural component, so that explicit consideration of the labour force is not considered necessary. Therefore, in addition to a wage variable, at least one employment variable and real GDP should be included in the VAR.

Employment variables: Because the minimum wage is at the centre of the study, the focus is on wage-dependent employees. As was explained before, the introduction of the minimum wage has led both to a substitution of minijobs for employees subject to social insurance contributions and to a probable change in working hours in the various categories of employment, which in total indicate a reduction in working time. This makes it interesting to look at both persons and hours and two of the following three variables should be included in the VAR: Wage earners (=employees), working time of employees, volume of hours worked of employees (=volume of work).

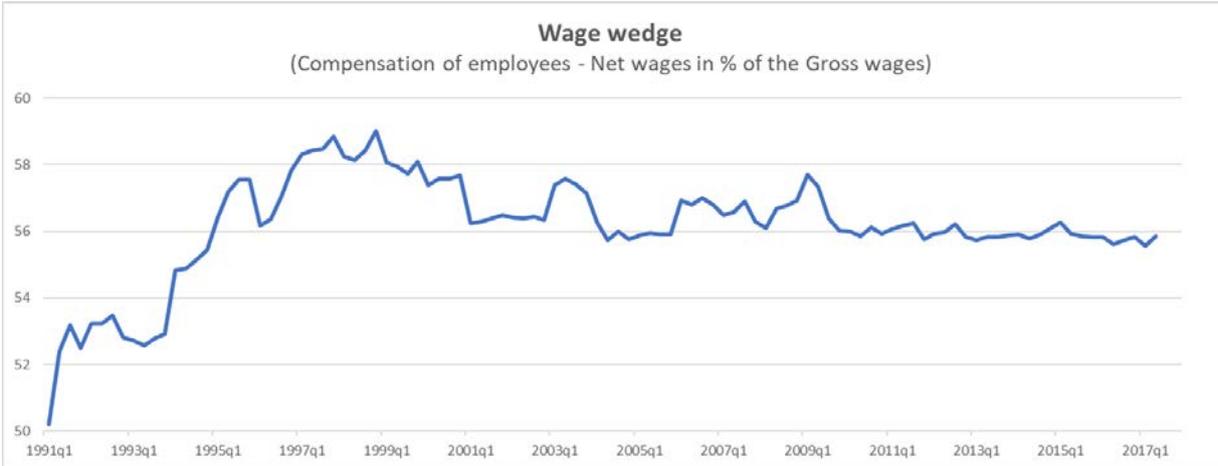
Often the unemployment rate is modelled as a determinant of the aggregated wage-setting curve, a strategy that is also pursued here, as in the macroeconomic textbook of Blanchard/Illing (2014: pp 195 and pp 199-200) or Bowles et al. (2017, Unit 9).

Wage measures: The wage can be defined along three dimensions: which tax/contributions is excluded, which underlying employment measure is considered and whether price corrections are done. Since the minimum wage is defined as the (gross) hourly wage, it seems more sensible to

consider an hourly gross wage in the VAR. The wage wedge (tax and social contribution share in % of gross wages) increased sharply in the 1990s, so that the choice between wage costs, gross wages or net wages could lead to different results. For the relevant period 2015 to 2017 and for the decade before, however, there is hardly any movement in the wage wedge (see Fig. F2).

From the employer's point of view, price adjustment is best done with the GDP deflator, from the employee's point of view with the consumption deflator. The price wedge (difference between the deflators of GDP and private consumption) is subject to more fluctuations at the end of the period (see Fig. F3). However, these are not significant in quantitative terms (four index points). Since the effect of the minimum wage on consumer prices is particularly interesting, only the consumption deflator is considered here.

Figure F2: Wage wedge (Germany, 1991-2017)



Source: own calculations from NA-statistics (Destatis, FS18 R1.3)

Since the deflator of private consumption is used, it was found in the course of the estimates that oil price fluctuations considerably improve the model quality, in particular the price equation. Therefore, the oil price (UK-Brent in Euro/Barrel) was included as an exogenous variable in the model.

Figure F3: Price wedge (Germany, 1991-2017)



Source: own calculations from NA-statistics (Destatis, FS18 R1.3)

The variables included in the VAR are therefore the following (see Tab. T3 and Fig. F4):

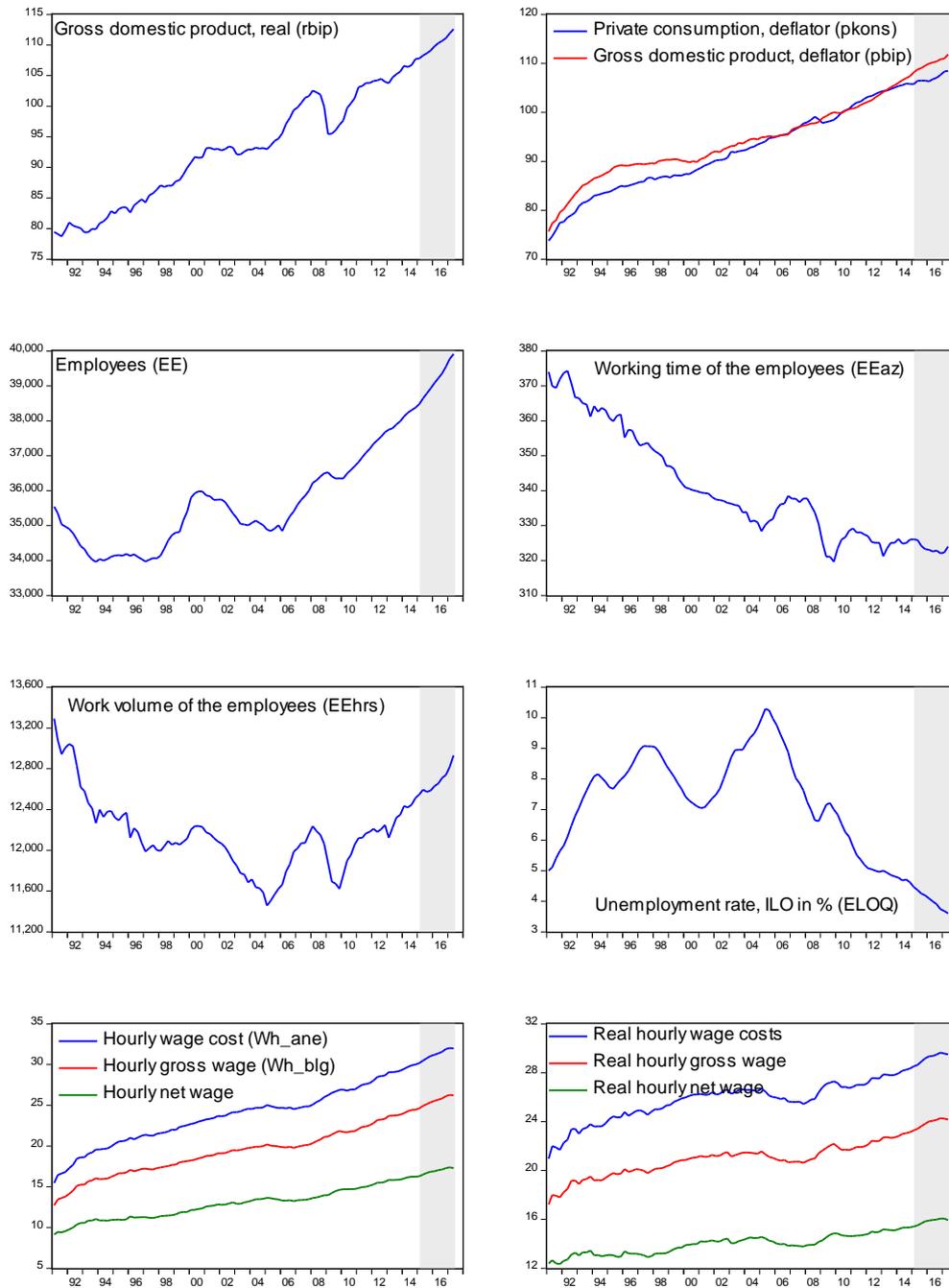
Table T3: Variables list (Germany, 1991q1-2017q2)

Name	Variable	Unit
rBIP	Gross Domestic Product, real	2010=100
pKONS	Private Consumption, Deflator	2010=100
ELOQ	Unemployment Rate (ILO-Definition)	%
EE	Employees (domestic concept)	Th. Persons
EEhrs	Hours Worked by Employees	Mill. Hours
EEaz	Average hours worked per employee	Hours/Quarter
Wh_blg	Average Gross Hourly Wage	EUR/Hours
oileur	Oil Price (UK-Brent)	EUR/Barrel

Sources: Time series and own calculations from NA-statistics (Destatis, FS18 R1.3), FRED and EIEA (oil Price and exchange rate).

All variables are expressed in logarithm except the unemployment rate. This is a common procedure in macroeconomic analysis. This data transformation mostly solves problems of heteroscedastic residuals (i.e. whose variance is not constant over time, leading to inefficient estimators) and makes the interpretation of differentiated variables as approximated growth rates straightforward.

Figure F4: Variables of the VAR (Germany, 1991-2017, Grey Areas=2015q1-2017q2).



Sources: Time series and own calculations from NA-statistics (Destatis, FS18 R1.3).

ADF-Stationarity test (Augmented Dickey-Fuller)

As can be seen from Fig. F4 (this also applies to the oil price which is not shown), all ADF tests have to include a linear trend (Model III), except for the unemployment rate (Model II). In regard to working

hours and employees, both ADF test variants are considered since the trend feature is not so obvious.

The results are presented in Tab. T4. All variables are considered as I(1), as expected, since macroeconomic variables are often found and considered to be I(1) (Nelson/Plosser 1982; Juselius 1999: pp 264-266). A different choice of lag lengths, based on short-term t-statistics, resulted in a clear I(1) conclusion for logarithmic deflators and average hourly wages

Table T4: Results of the ADF-Tests (p-values, H0: unit root)

Name	Variable	Trans-formation	Level, ADF-p-value		Difference, ADF-p-value		
			Model III (constant and trend)	Model II (constant)	Model III (constant and trend)	Model II (constant)	Model I (no Det.)
rBIP	Gross domestic product, real	log	5.5%	90.3%	0.0%	0.0%	0.0%
pBIP	Gross domestic product, deflator	log	0.0%	1.4%	0.0%	0.4%	0.5%
pKONS	Private consumption, Deflator	log	0.0%	0.3%	0.0%	0.0%	0.0%
ELOQ	Unemployment rate	none	53.1%	79.1%	1.2%	0.6%	0.0%
EE	Employees (domestic concept)	log	81.0%	99.6%	0.0%	0.0%	0.1%
EEhrs	Work volume of employees	log	89.2%	56.9%	0.0%	0.0%	0.0%
EEAZ	Working time of employees	log	75.9%	26.1%	0.0%	0.0%	0.0%
Wh_ane	Hourly wage costs	log	0.0%	0.1%	0.0%	0.0%	0.5%
Wh_blg	Hourly gross wage	log	0.0%	0.6%	0.0%	0.0%	0.5%
oileur	Oil price in EUR (UK Brent)	log	35.9%	65.8%	0.0%	0.0%	0.0%

Remark: The lag length was chosen with the Schwarz information criterion.

Thus, the possibility of cointegration must be considered in the VAR: The VAR with lag length **p** and **k** endogenous variables is estimated either in first difference or as VECM for the estimation period $t=1...T$ (cf. Johansen 1995, from equation 2.1: p 11 to equation 4.1: p 45):

Vector autoregressive Model, VAR-Form:
$$X_t = \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \dots + \Pi_p X_{t-p} + \Psi D_t + \varepsilon_t$$

Vector error correction model, VECM-Form:
$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Psi D_t + \varepsilon_t$$

With **X** the (T,k) variable vector, **D** the (T,m) matrix of the deterministics (constant, trend, dummies and logged oil price). The rank of the Π -matrix (**r**) provides information about the number of cointegration relationships and thus controls whether the VAR must be estimated in initial differences or in VECM form. The matrix is written as the product of two (k,r) vectors $\alpha\beta^T$, where α

contains the loading coefficients (control the speed at which deviations from the long-term cointegration relationships are corrected) and β the coefficients of the cointegration relationships (express the long-term or equilibrium relationships).

The modelling of the deterministic components can be influential. In almost all statistical programs, including EViews used here, Johansen (1995: pp 80-81) is followed and 5 variants are offered. Variant 3 (H1(r): linear trend allowed in the data, but not in the cointegration relationship) was chosen because it fits best with the data. The 4th variant (H*(r): the linear trend cannot be eliminated from the cointegration relationships) was also tested, but it was not convincing, because the linear trend dominates implausibly. The other variants are not pursued because they obviously do not describe the data of Fig. F4 (quadratic trends for the 5th variant or no trend in variants 1 and 2).

4. VAR/VECM-Estimation

The estimation period is 1993q1 to 2014q4 (T= 88): the minimum wage years are excluded and the initial values are set to 1993q1 in order to compare the different VAR models on a uniform basis. The **X**-variable vector is defined as $(I_rBIP, I_pKONS, I_Wh_blg, I_EE, I_EEhrs, ELOQ)^T$ (k=6). All variables except the unemployment rate are in logs (the prefix I_ stands for this). A trend and a constant are included in the model, as well as the log of the oil price (**D**-matrix).

Choice of the VAR-Model (lag length p=2 or p=6)

The VAR length (p) is selected based on the usual information criteria (Lütkepohl 1993, Section 4.3, with focus on forecast quality or good in-sample properties). Accordingly, p=2 (Final Prediction error, Schwarz and Hannan-Quinn) or p=6 (Likelihood Ratio and Akaike) is recommended.

Diagnostic tests (Autocorrelation, Normality und Homoskedasticity)

Diagnostic tests (Tab. T5) on the two estimated VARs are performed: a visual check of the autocorrelation functions and the Lagrange multiplier autocorrelation tests (up to the 8th lag, LM)

indicate no significant autocorrelations, neither for $p=2$ nor for $p=6$, with the individual estimated autocorrelations at $p=6$ being more clearly within the 95% confidence bands.

For both lag lengths the normality of the residuals is first rejected by Jarque-Bera tests (JB) for the GDP and employment equations at the 1% level, for $p=6$ also for the price equation at the 10% level. A visual check of the individual residuals shows some outliers³: In the variant with 2 lags, the sharp economic slump in 2009 is absorbed by two impulse dummies (2009q1 and 2008q4). The GDP equation now shows normally distributed residuals. The residuals of the employment equations show three outliers which are absorbed by three impulse dummies (2006q1, 2000q1 and 1999q3). In the model variant with 6 lags, the outlier problem is solved with three impulse dummies (2009q1, 2006q1, 2003q1).

The White heteroskedasticity tests on these augmented models indicate homoskedastic residuals.

Table T5: p-values of the diagnostic tests (in-sample) for the two VAR ($p=2$ and $p=6$), 1993q1-2014q4

Lag-length	p=2		p=6			p=2		p=6	
	w/o	with	w/o	with		w/o	with	w/o	with
LM1	25%	19%	14%	21%	White	49%	94%	40%	44%
LM2	56%	38%	87%	95%	JB-rBIP	0%	23%	1%	34%
LM3	63%	71%	14%	14%	JB-pKONS	22%	9%	6%	19%
LM4	68%	67%	12%	7%	JB-Wh_blg	49%	21%	71%	31%
LM5	87%	94%	15%	16%	JB-EE	0%	48%	0%	26%
LM6	12%	9.5%	39%	69%	JB-EEhrs	25%	11%	85%	71%
LM7	69%	87%	91%	97%	JB-ELOQ	39%	59%	88%	78%
LM8	11%	27%	64%	88%					

Remark: $p=2$ (with Impulse-Dummies: i2009q1, i2008q4, i2006q1, i2000q1, i1999q3) and $p=6$ (2009q1, 2006q1, 2003q1).

Cointegration tests (Johansen and Choice of cointegration rank)

Since all variables of the VAR can be regarded as $I(1)$, they must now be differentiated. If cointegration relationships exist, the specification must take this into account. This is found out with the Johansen test (Johansen 1995). The mentioned variant 3 of EViews (H1(r)) is preferred. The

³ See for example Hendry/Mizon (2011) on consequences of and solutions for outliers in co-integrated VAR.

impulse dummies and the oil price are differentiated and left unrestricted in the VAR (Johansen 1995: p 84).

Tab. T6 shows the test results and points to 2 cointegration relationships ($p=2$), since both test statistics show clear jumps from $r=1$ to $r=2$. At $p=6$ the test results are less clear, but here too the test statistics points to $r=2$.

Since the purpose of this analysis is to do forecasts and nothing else, it is neither relevant here to explain the number of cointegration relationships theoretically, nor to interpret them. Therefore, the in-sample model quality is further investigated, now with a VECM ($p=2$ or $p=6$ and $r=2$), on which in addition to the trend restrictions discussed earlier (variant 3 or $H_1(r)$) no further restrictions are imposed.

Table T6: Johansen tests ($H_1(r)$) for the two VAR ($p=2$ and $p=6$), 1993q1-2014q4

<i>p=2 (diff. Dummies, trend in the data, not in the cointegration)</i>					
<i>Null-Hypothesis: nb of coint.-relationships</i>	<i>Eigen value</i>	<i>Trace</i>		<i>Max-Eigen value</i>	
		<i>Statistic</i>	<i>p-value</i>	<i>Statistic</i>	<i>p-value</i>
<i>none</i>	<i>0.41</i>	<i>118.90</i>	<i>0%</i>	<i>45.88</i>	<i>1%</i>
<i>At most 1</i>	<i>0.31</i>	<i>73.01</i>	<i>3%</i>	<i>33.01</i>	<i>6%</i>
<i>At most 2</i>	<i>0.19</i>	<i>40.00</i>	<i>22%</i>	<i>18.56</i>	<i>45%</i>
<i>At most 3</i>	<i>0.16</i>	<i>21.44</i>	<i>33%</i>	<i>15.66</i>	<i>25%</i>
<i>At most 4</i>	<i>0.06</i>	<i>5.79</i>	<i>72%</i>	<i>5.78</i>	<i>64%</i>
<i>At most 5</i>	<i>0.00</i>	<i>0.01</i>	<i>92%</i>	<i>0.01</i>	<i>92%</i>
<i>p=6 (diff. Dummies, trend in the data, not in the cointegration)</i>					
<i>Null-Hypothesis: nb of coint.-relationships</i>	<i>Eigen value</i>	<i>Trace</i>		<i>Max-Eigen value</i>	
		<i>Statistic</i>	<i>p-value</i>	<i>Statistic</i>	<i>Statistic</i>
<i>none</i>	<i>0.45</i>	<i>127.26</i>	<i>0%</i>	<i>53.45</i>	<i>0%</i>
<i>At most 1</i>	<i>0.29</i>	<i>73.81</i>	<i>2%</i>	<i>31.16</i>	<i>10%</i>
<i>At most 2</i>	<i>0.21</i>	<i>42.65</i>	<i>14%</i>	<i>21.42</i>	<i>25%</i>
<i>At most 3</i>	<i>0.16</i>	<i>21.23</i>	<i>34%</i>	<i>16.14</i>	<i>22%</i>
<i>At most 4</i>	<i>0.05</i>	<i>5.09</i>	<i>80%</i>	<i>5.08</i>	<i>73%</i>
<i>At most 5</i>	<i>0.00</i>	<i>0.01</i>	<i>93%</i>	<i>0.01</i>	<i>93%</i>

Remark: p=2 (with differenced Impulse-Dummies: i2009q1, i2008q4, i2006q1, i2000q1, i1999q3) and p=6 (with differenced Impulse-Dummies: i2009q1, i2006q1, i2003q1). The log of the oil price was also differenced.

Stability tests

Since a large number of coefficients is estimated (for $p=2$, 102 coefficients are estimated and for $p=6$, 268), the usual stability tests can hardly be regarded as meaningful (e.g. the three Chow stability tests for the VECM with $p=r=2$, which are implemented in JMulti, contradict each other) and partly ($p=6$) cannot be calculated due to too low degrees of freedom. In JMulti, besides the mentioned contradictory stability tests, recursive estimates of the eigenvalues for the period 2004-2014 could also be carried out and no anomalies could be found.

5. Out-of-Sample Forecasts (Counterfactuals)

2015q1-2017q2

The minimum wage became effective at 8.50 Euro per hour on 1 January 2015 and out-of-sample forecasts are expected to start in the first quarter of 2015. The VECM confidence bands are usually very broad in such multivariate unrestricted estimation and are therefore often presented with 68% instead of the usual 90 to 99% (see e.g. Bobeica/Jarociński 2017). The 68% and 95% confidence intervals are both shown in the following. The VECM forecasts for 2015/2016 (Fig. F5, Tab. T7) are compared with the actual developments. This comparison is interpreted as the minimum wage effect, because the VECM forecasts transfer the previous development without shock into the future, taking into account the mutual variable dependencies.

Actual developments, with the exception of wage developments, lie within the confidence bands. Statistically speaking, therefore, all differences commented on here (with the exception of wages) should not be regarded as statistically significant at the 5% or 33% level. Despite the predictions of substantial employment losses (cf. Müller 2009, Tab. 1 for an overview of ex-ante studies), which were based on substantial wage effects (also the only significant effects in these estimation

exercises), the macroeconomic effects are not statistically significant. This does not mean that they are not economically significant, but that they are smaller than the estimated uncertainties.⁴

Table T7: Comparison of the out-of-Sample VECM-Forecasts ($p=r=2$) with the actual developments (Stand = NA-statistics of 2017q2)

	GDP	Deflator Priv. Cons.	Hourly Gross Wage	Employees. (Th. Pers.)	Work volume.	Unempl. Rate
2015	0.2%	-0.2%	-0.7%	-147	-0.2%	0.0 pp
2016	-0.5%	-0.1%	-1.6%	-426	-0.8%	0.0 pp

Remark: positive values mean that the forecasts lie over the actual developments.

The VECM overestimates the good economic situation by 0.2% in 2015. In 2016 the VECM is clearly worse, predicting 0.5% too little real GDP. This is undoubtedly due to the inability of this small model to capture the better global economy in 2016, which means that the interpretations of the other 2016 numbers can no longer be identified as a minimum wage effect alone. For this reason together with the aforementioned data quality issue of national accounts (revision) at the end of the sample we restrict ourselves therefore in our analysis to the year 2015.

The consumption price is underestimated by the VECM by 0.2% in 2015 (by 0.1% in 2016), despite an optimistic GDP forecast. This fits very well interpretatively with the positive minimum wage effect found in Section 2 on prices, which is noticeable in the heavily affected sectors but is modest at the aggregated level. It should be remembered here that the oil price is taken into account in the model as exogenous and thus cannot provide an explanation for the deviation between actual and forecast values.

The hourly gross wage is clearly underestimated by 0.7% in 2015 and 1.6% in 2016. This is the clearest effect measured in all variants (alternative trend restrictions and $p=6$, not shown here) and can therefore be regarded as the most resilient. This 2015 effect fits with the estimated direct effect

⁴ On the difference between statistical and economic significance, reference is made to the contribution by Hirschauer et al. (2016), which provides a good overview of the correct understanding of p-values and implicitly also of confidence intervals.

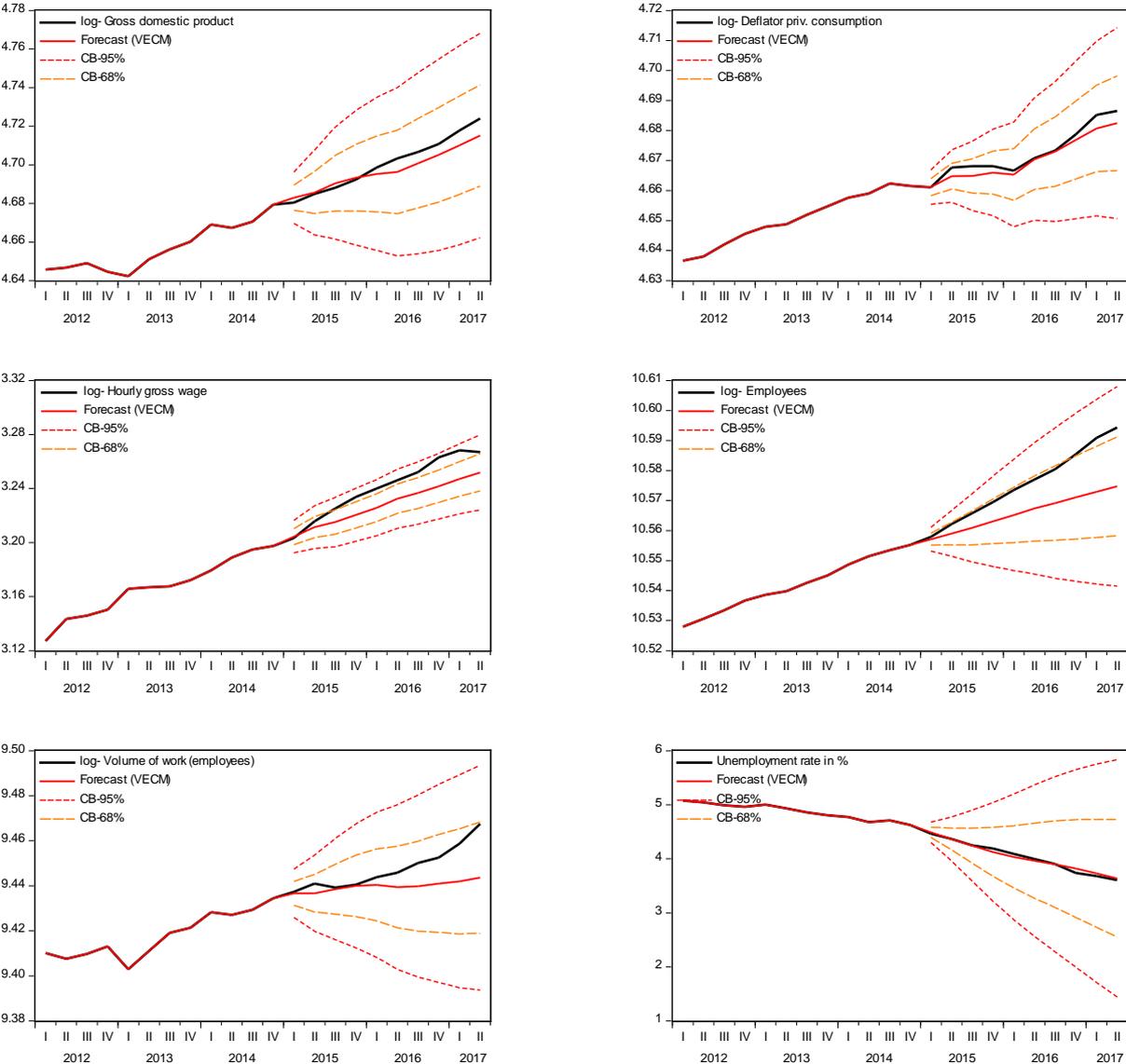
(Minimum Wage Commission 2016: p 116, footnote 50) of 0.4 to 0.5% on the gross wage and salary total, without any significant direct work volume effect (which is also seen here: the forecasts underestimate the volume of work by 0.2% in 2015 only slightly). This would mean that the spillover effect of the minimum wage would be about as high as the direct effect. This was also found in Section 2. By contrast, the volume of work is clearly underestimated in 2016, which could be explained by the underestimated GDP dynamic.

Also interesting is the almost perfectly forecasted unemployment rate in 2015 (and 2016), which is in line with the previously observed absence of any effects.

On the other hand, the employment forecast is not easy to interpret: The forecast of 0.4% (approx. 150 thousand pers.) clearly underestimates the actual development in 2015 (also in 2016 with 1.1% or approx. 425 thousand pers.), which cannot be explained by the optimistic GDP forecasts in this dimension. Nor can the previous findings that the substitution of minijobs for regular employment would lead to a (slight) decline in employment in line with the other trend be discerned here. Since a changed GDP structure - e.g. the share of construction in gross value added is rising steadily again after a low average of 3.8% before the crisis -, for which there is no control here, could still provide an explanation⁵, the interpretation is rather cautious: the very negative employment forecasts made in the time before the introduction of the minimum wage cannot be confirmed. To what extent the extraordinary good employment development is related to the minimum wage cannot be answered well by the results of the VECM.

⁵ See Anderton et al. (2014) for an investigation of the influence of the composition of the use of GDP in the Okun estimation context.

Figure F5: VECM-Forecasts 2015q1-2017q2 ($p=2, r=2$, no restrictions for the deterministics and the oil price)



Robustness checks with other variants

The other variants of the VECM with the 6 variables discussed above (trend explicitly in the cointegration relationships, different number of cointegration relations and $p=6$) provided much

worse forecast results and are therefore not commented on any further, as forecast errors⁶ certainly dominate the picture here.

An alternative version of the VECM with working time instead of dependent employment as endogenous variable ($p=2$, $r=2$, oil price as exogenous and only i2009q1 as impulse dummy) provided very similar forecasts (Tab. T8). The real GDP is very well forecasted for 2015, the price effect is modest at the aggregate level (0.2%), the wage effect is pronounced (0.6%, statistically significant), working time and the unemployment rate are very well forecasted, while the volume of work is underestimated somewhat more strongly (0.3%). Overall, this variant confirms the 2015 results of Fig. F5: no significant effects on real GDP, very small price effects, larger wage effects, positive employment effects.

Table T8: Comparison of the out-of-Sample VECM-Forecasts ($p=r=2$) with the actual developments (Stand = NA-statistics of 2017q2)

	GDP	Deflator of priv. Cons.	Hourly gross wage	Working time (Employees)	Volume of work (employees)	Unemplo. Rate in %
2015	0.1%	-0.2%	-0.6%	0.1%	-0.3%	0.0 pp
2016	-0.8%	-0.1%	-1.5%	0.1%	-1.1%	0.1 pp

Remark: positive values mean that the forecasts lie over the actual developments.

For the robustness check, the time period was also varied. The idea here is to exclude possible anticipated effects. Since the law was passed in July 2014, but was intensively discussed in advance, anticipated effects could have already occurred before the third quarter of 2014. The choice of the first forecast quarter was even placed conservatively on the 1st quarter of 2014 in order to exclude any anticipated effects. Moreover, the GDP forecast quality proves to be superior with this quarter compared to 2014q3, so that in the discussion there is far less confusion between forecast errors (related to the economy) and anticipated effects.

⁶ For forecasting purposes, it is often argued that shorter models perform better (see for example Lütkepohl/Xu 2011), which would be confirmed here.

The following conclusions can be drawn from Fig. F6 and Tab. T9: real GDP is estimated relatively accurately for 2014 and 2015, so that misinterpretation of economic developments is not an argument that be used to interpret the deviations between actual and forecast values for the other variables. It also confirms the assumption that the 2016 economic cycle will be measurably influenced by external effects.

Price developments in 2014 (0.2%) and 2015 (0.3%) are forecast to be somewhat too low, so that conclusions can be drawn similar to those drawn previously: the minimum wage has had a very small, barely measurable increasing effect on aggregate consumer prices.

Gross hourly wages were very well forecast for 2014 (0.3% too little) and significantly underestimated for 2015 (-1.0%), which would again identify a minimum wage effect of at least 0.7%. This confirms that the wage effect can be considered as the most resilient.

The unemployment rate is now underestimated by 0.3 percentage points for 2014 and 0.4 percentage points for 2015, which can be seen as a slight underestimation.

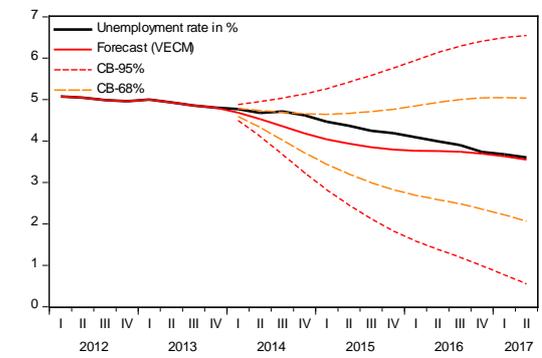
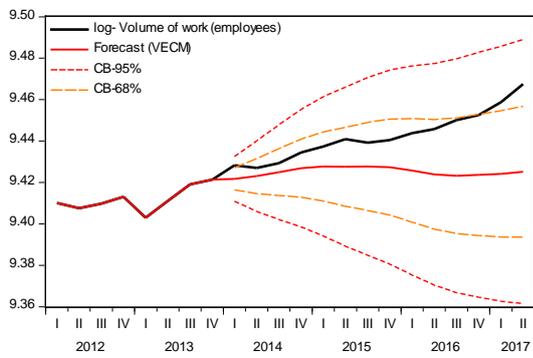
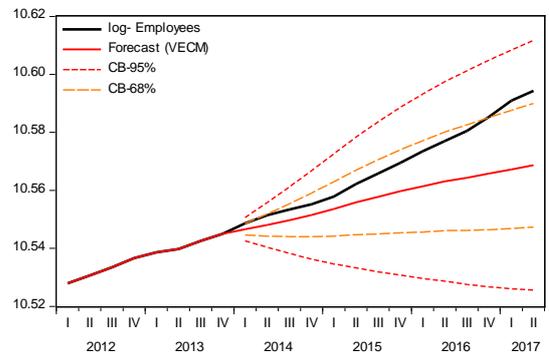
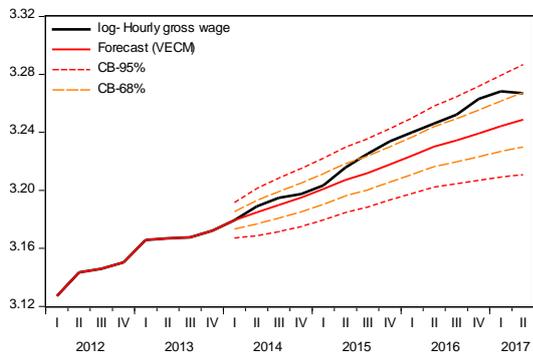
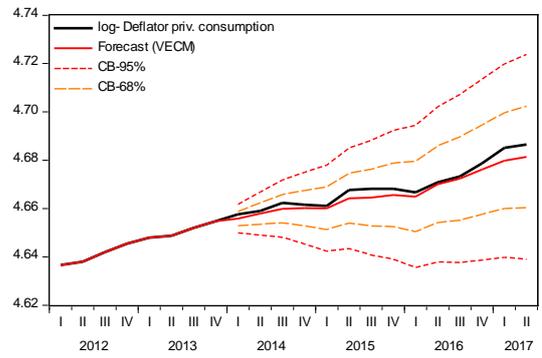
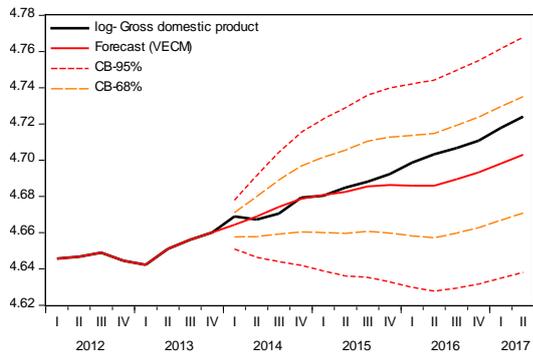
The two problematic variables are now the volume of work, which is already clearly underestimated at 0.6% in 2014, an error that doubles to 1.2% in 2015 and employment, which is also clearly underestimated first by 0.3% and then by 0.7%. At least from these comparisons it is confirmed that the minimum wage had no negative effects on aggregate employment, regardless of whether measured in heads or hours.

Table T9: Comparison of the out-of-Sample VECM-Forecasts (2014q1-2017q2, p=r=2) with the actual developments (Stand = NA-statistics of 2017q2)

	GDP	Defl. of priv. Cons.	Hourly gross wage	Employees (Th. Pers.)	Volume of work (employees).	Unempl. rate
2014	0.0%	-0.2%	-0.3%	-123 th.p.	-0.6%	-0.3 pp
2015	-0.3%	-0.3%	-1.0%	-275 th.p.	-1.2%	-0.4 pp

Remark: positive values mean that the forecasts lie over the actual developments.

Figure F6: VECM-Forecasts 2014q1-2017q2 (p=2, r=2)



6. Conclusions

This study estimated a small multivariate VECM model for 1991q1 to 2014q4, the period before the introduction of the minimum wage, based on national accounts data. The model and its variants were specified according to the econometric textbook standards. Subsequently, out-of-sample forecasts for the period after the introduction of the minimum wage (2015q1 to 2017q2) were done. These reflect the continuation of the trends including interdependencies between the variables used in the model. A comparison with the actual developments of these economic variables was then carried out and interpreted as a possible minimum wage effect. Robustness checks and statistical significance tests confirmed the resilience of the results.

The results are additionally put in comparison to figures obtained from official statistics on prices, wages and employment. The VECM-estimated departure between forecasts and actual trends, interpreted as minimum wage effects, are quite in line with the measured effects of the minimum wage. This can be viewed as an additional external validity test.

The resilient results are limited to the year 2015. The year 2016 seems to be influenced by a positive external impulse, which the small model cannot capture. For the year of the minimum wage introduction, the model forecasts the economy very well, so that the deviations between forecast and actual values for the other variables cannot be attributed to this.

The observed positive wage effect of 0.5 to 0.7% can be considered robust. As expected, very small positive effects are observed in aggregate consumer prices. The employment figures - working hours, dependent employees and volume of work - point to an extraordinarily positive employment trend. The results are not very robust as far as their magnitude is concerned. But the (robustly estimated) positive signs of the effect clearly contradict the negative ex-ante predictions of many studies.

References

Aeberhardt, R, Givord, P, Marbot, C (2016), Spillover effect of the Minimum Wage in France: An Unconditional Quantile Regression. CREST-Working Papers n°2016-05.

Anderton, R, Aranki, T, Bonthuis, B, Jarvis, V (2014), Disaggregating Okun's Law. Decomposing the Impact of the Expenditure Components of GDP on Euro Area Unemployment. ECB-Working Paper n°1747.

Arpaia, A, Cardoso, P, Kiss, A, van Herck, K, Vandeplass, A (2017), Statutory Minimum Wages in the EU: Institutional Settings and Macroeconomic Implications. IZA Policy Paper n°124.

Arpaia, A, van Herck, K (2017), Wage distribution spill-overs from minimum wage increases in France. European Commission Analytical Web Note 1/2017. The European Union, Luxembourg.

Autor, D H, Manning, A, Smith, C L (2016), The Contribution of the Minimum Wage to US Wage Inequality over Three Decades: A Reassessment. Applied Economics, 8(1), 58-99.

Burauel, P, Grabka, M M, Schröder, C, Caliendo, M, Obst, C, Preuss, M (2018), Auswirkungen des gesetzlichen Mindestlohns auf die Lohnstruktur. Abschlussbericht (Vergabe-n°525549) für die Mindestlohnkommission 31.1.2018.

https://www.mindestlohn-kommission.de/DE/Forschung/Projekte/pdf/Bericht-Mindestlohn-Lohnstruktur.pdf?__blob=publicationFile&v=4 [12.04.2019]

Bellmann, L, Bossler, M, Dütsch, M, Gerner, H D, Ohlert, C (2016), Folgen des Mindestlohns in Deutschland: Betriebe regieren nur selten mit Entlassungen. IAB-Kurzbericht n°18.

Belman, L, Wolfson, P (2014), What Does the Minimum Wage Do? W.E. Upjohn Institute for Employment Research, Kalamazoo, Michigan.

Blanchard, O, Illing, G (2014), Makroökonomie. 6th edition. Pearson, Hallbergmoos.

Bobeica, E, Jarociński, M (2017), Missing disinflation and missing inflation: the puzzles that aren't. ECB Working paper n°2000.

Bonin, H, Isphording, I, Krause, A, Lichter, A, Pestel, N, Rinne, U, Caliendo, M, Obst, C, Preuss, M, Schröder, C, Grabka, M (2018), Auswirkungen des gesetzlichen Mindestlohns auf Beschäftigung, Arbeitszeit und Arbeitslosigkeit. . Abschlussbericht (Vergabe-n°525576) für die Mindestlohnkommission 31.1.2018.

https://www.mindestlohn-kommission.de/DE/Forschung/Projekte/pdf/Bericht-Mindestlohn-Beschaeftigung-Arbeitszeit.pdf?__blob=publicationFile&v=5 [12.04.2019]

Bossler, M., Gerner, H. D. (2016), Employment Effects of the New German Minimum Wage. Evidence from Establishment-Level Micro Data. IAB Discussion Paper n°10.

Bowles, S, Carlin, W, Stevens, M (2017, main contributors). The CORE project, The Economy. Unit 9 (The labour market: Wages, profits, and unemployment), Oxford university press, Oxford.

Butcher, T, Dickens, R , Manning (2012), Minimum Wages and Wage Inequality: Some Theory and an Application to the UK. CEP Discussion Paper n°1177.

Card, D, Krueger, A (1995), Myth and Measurement. The New Economics of the Minimum Wage. Princeton University Press, Princeton.

Clements, M P, Mizon, G E (1991), Empirical Analysis of Macroeconomics Time Series. VAR and structural models. European Economic Review, 35(4), 887-917.

Croushore, D, Stark, T (2003), A real-time data set for macroeconomists: Does the data vintage matter?. The Review of Economics and Statistics, 85(3), 605-617.

CSERC (1999), Le Smic: Salaire Minimum de Croissance, Rapport du Conseil Supérieur de l'Emploi, des Revenus et des Coûts. La Documentation Française, Paris.

Destatis (2013), Preise – Verbraucherpreisindex für Deutschland. Wägungsschema für das Jahr 2010, Wiesbaden (published: 20.02.2013).

https://www.destatis.de/Migration/DE/ZahlenFakten/GesamtwirtschaftUmwelt/Preise/Verbraucherpreisindizes/WarenkorbWaegungsschema/Waegungsschema.pdf?__blob=publicationFile&v=2
[02.05.2019]

Dickens, R, Manning, A (2004), Spikes and Spill-Overs. The Impact of the National Minimum Wage on the Wage Distribution in a Low-Wage Sector. *Economic Journal*, 114(494), 95-101.

ECB (2016), “A guide to the Eurosystem/ECB staff macroeconomic projection exercises. <https://www.ecb.europa.eu/pub/pdf/other/staffprojectionsguide201607.en.pdf> [02.05.2019]

Frentzen, K, Günther, R (2017), Verdiensterhebung 2015 - Abschlussbericht einer Erhebung über die Wirkung des gesetzlichen Mindestlohns auf die Verdienste und Arbeitszeiten der abhängig Beschäftigten. Statistisches Bundesamt, Wiesbaden.

https://www.destatis.de/DE/Themen/Arbeit/Verdienste/Mindestloehne/Publikationen/Downloads-Mindestloehne/verdiensterhebung-mindestlohn-5611112159004.pdf?__blob=publicationFile&v=3
[02.05.2019].

Garloff, A (2017), Der Mindestlohn ist kein Jobkiller. IAB-Forum, 30.06.2017, <https://www.iab-forum.de/der-mindestlohn-ist-kein-jobkiller> [13.9.2018].

German Council of Economic Experts (GCEE 2014), Mehr Vertrauen in Marktprozesse. Jahresgutachten 2014/15. Bonifatius GmbH Buch-Druck-Verlag, Paderborn.

Goarant, C, Muller, L (2011), Les effets des hausses du SMIC sur les salaires mensuels dans les entreprises de 10 salariés ou plus de 2006 à 2009. *Emploi et salaires - Insee Références - Édition 2011*, 69-83.

Hendry, D F, Mizon, G E (2011), Econometric Modelling of Time Series with Outlying Observations. *Journal of Time series Econometrics*, 3(1), Art. 6.

Herr, H, Herzog-Stein, A, Kromphardt, J, Logeay, C, Nüß, P, Pusch, T, Schulten, T, Watt, A, Zwiener, R (2017), Makroökonomische Folgen des -Mindestlohns aus keynesianisch geprägter Perspektive. Abschlussbericht (Vergabe-n° 526652) für die Mindestlohnkommission 10.12.2017.

https://www.mindestlohn-kommission.de/DE/Forschung/Projekte/pdf/Bericht-Mindestlohn-keynesianische-Perspektive.pdf?__blob=publicationFile&v=3 [12.04.2019].

Herzog-Stein, A, Logeay, C, Nüß, P, Stein, U, Zwiener, R (2018), Positive gesamtwirtschaftliche Effekte des gesetzlichen Mindestlohns –eine ökonometrische Analyse. IMK-Report n°141.

Hirschauer, N, Mußhoff, O, Grüner, S, Frey, U, Theesfeld, I, Wagner, P (2016), Die Interpretation des p-Wertes – Grundsätzliche Missverständnisse. Jahrbücher für Nationalökonomie und Statistik, 236(5), 557–575.

Horn, G A, Joebges, H, Logeay, C, Sturn S (2008), Frankreich: Ein Vorbild für Deutschland? Ein Vergleich wirtschaftspolitischer Strategien mit und ohne Mindestlohn. IMK Report, n°31.

IAB- Arbeitsmarktspiegel (Forschungsberichte 1+12/2016, 2+9/2017):

vom Berge, P, Kaimer, S, Copestake, S, Eberle, J, Klosterhuber, W (2017), Arbeitsmarktspiegel: Entwicklungen nach Einführung des Mindestlohns (Ausgabe 4). IAB-Forschungsbericht n°09/2017, Nürnberg.

vom Berge, P, Kaimer, S, Copestake, S, Croxton, D, Eberle, J, Klosterhuber, W (2017), Arbeitsmarktspiegel: Entwicklungen nach Einführung des Mindestlohns (Ausgabe 3). IAB-Forschungsbericht n°02/2017, Nürnberg.

vom Berge, P, Kaimer, S, Copestake, S, Croxton, D, Eberle, J, Klosterhuber, W, Krüger, J (2016), Arbeitsmarktspiegel: Entwicklungen nach Einführung des Mindestlohns (Ausgabe 2). IAB-Forschungsbericht n°12/2016, Nürnberg.

vom Berge, P, Kaimer, S, Copestake, S, Eberle, J, Klosterhuber, W, Krüger, J, Trenkle, S, Zakrocki, V (2016), Arbeitsmarktspiegel: Entwicklungen nach Einführung des Mindestlohns (Ausgabe 1). IAB-Forschungsbericht n°01/2016, Nürnberg.

Johansen, S (1995), Likelihood-Based Inference in Cointegrated Vector Autoregressive Models. Oxford University Press, Oxford.

Juselius, K (1999), Models and Relations in Economics and Econometrics. Journal of Economic Methodology, 6(2), 259–290.

Lemos, S (2008), A Survey of The Effects of The Minimum Wage on Prices. Journal of Economic Surveys, 22(1), 187–212.

Logeay, C, Schreiber, S (2006), Testing the effectiveness of the French work-sharing reform: a forecasting approach. Applied Economics, 38(17), 2053-2068.

Lütkepohl, H (1993), Introduction to Multiple Times Series Analysis. 2nd edition. Springer-Verlag, Heidelberg.

Lütkepohl, H, Xu, F (2011), Forecasting Annual Inflation with Seasonal Monthly Data: Using Levels versus Logs of the Underlying Price Index. Journal of Time Series Econometrics, 3(1), Art. 7.

Minimum Wage Commission (2016), Erster Bericht zu den Auswirkungen des gesetzlichen -Mindestlohns. Bonifatius GmbH Druck-Buch-Verlag, Paderborn, 28.06.2016

Minimum Wage Commission (2018), Zweiter Bericht zu den Auswirkungen des gesetzlichen -Mindestlohns. Bonifatius GmbH Druck-Buch-Verlag, Paderborn, 26.06.2018

Müller, K-U (2009), Wie groß sind die Beschäftigungsverluste aufgrund eines allgemeinen Mindestlohns?. DIW Wochenbericht n°26, 430-433.

Nelson, C R, Plosser, C I (1982), Data from Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications. Journal of Monetary Economics, 10(2), 139-62.

Neumark, D, Wascher, W (2008), Minimum Wages. MIT Press, Cambridge (Massachusetts).

OECD (2015), OECD Employment Outlook 2015. OECD Publishing, Paris.

Pagan, A (2003), Report on modelling and forecasting at the Bank of England. Bank of England Quarterly Bulletin, Spring 2003, 60-88.

Pesaran, M H, Smith, L V, Smith, R P (2007), What if the UK or Sweden had joined the Euro in 1999? An empirical Evaluation using a global VAR. International Journal of Finance & Economics, 12(1), 15-87.

Stewart, M B (2012), Wage Inequality, Minimum Wage Effects, and Spillovers. Oxford Economic Papers, 64(4), 616–634.

vom Berge, P, Weber, E (2017), Beschäftigungsanpassung nach Mindestlohneinführung: Minijobs wurden teilweise umgewandelt, aber auch zulasten anderer Stellen. IAB-Kurzbericht n°11.

Wanger, S, Weber, E (2016), Effekte des gesetzlichen Mindestlohns auf die Arbeitszeit von Minijobbern. IAB Aktuelle Berichte n°23.

ANNEX

A1: Wage effect from official statistics

Based on the data from VSE 2014 and VE 2015 it is possible to quantify the spillover effect due to the introduction of the national minimum wage in Germany. The VSE 2014 and VE 2015 provide data on the distribution of jobs by hourly wage levels (rounded to wage intervals of 10 cents, i.e. the wage interval of 8.50 Euros includes, for example, all jobs with gross earnings between 8.45 and 8.54 Euros per hour). Following the information provided by the two data sets (Frentzen and Günther 2017) and the inspection of Fig. F1 the spillover effect is calculated up to a wage of 10.00 Euro per hour.

To quantify the spillover effect of the introduction of the minimum wage we construct a hypothetical distribution of jobs by hourly wage levels for the year 2015 based on the information of the VSE 2014 such that the difference between the hypothetical distribution for 2015 and the distribution of employment by hourly wage levels in 2015 based on the VE 2015 corresponds to the spillover effects of the minimum wage. Or in other words, based on the information of the VSE 2014 we construct a hypothetical distribution of jobs by hourly wage levels for the year 2015 without minimum introduction. Several assumptions and adjustments are necessary to obtain this hypothetical distribution of jobs for 2015:

First, we have to take into account that employment increased markedly between 2014 and 2015. There are 921,061 additional jobs in the VE 2015 compared to the VSE 2014. To take this rise in employment into account and to make the VSE 2014 and the VE 2015 comparable it is assumed that the total increase in employment took place in the wage intervals from 8.50 Euro onwards. Mathematically, the number of jobs in each wage category from 8.50 Euro per hour onwards in the VSE 2014 is uniformly increased by 2.9%. Hence, the number of jobs earning 8.50 Euro per hour and more in the VSE 2014 is increased by a total of 921,064. In this way the increase in employment between 2014 and 2015 is eliminated and has no impact of the quantification of the spillover effect. Furthermore, we make some adjustment for the fact that there was a possible negative net

employment effect with respect to minijobs of around -74,000 jobs (see Herr et al. 2017, Annex A2). All these assumptions together lead to the hypothetical distribution of jobs by hourly wage levels for the year 2015 necessary to calculate the spillover effect due to the introduction of a minimum wage. (See line 2 in the Tab. A1). The following calculations are based on these modified statistics for 2014.

Second, some workers who earned a wage below 8.50 Euro per hour in 2014 received a wage which was strictly larger than 8.50 Euro per hour in 2015. This phenomenon is not part of the spillover effect as discussed in the economic literature. In 2015 there are around 2.77 million less jobs with a wage below 8.50 Euro per hour than in 2014 (See bracket 4a of Tab. A1). In contrast there are 1.91 million jobs earning the minimum wage of 8.50 Euro per hour in 2015 (Bracket 3b of Tab. A1). Hence, after the introduction of the minimum wage a large number of jobs that had an hourly wage of less than 8.50 Euro per hour in 2014 earned more than the minimum wage in 2015. Therefore, we need an additional assumption on how these 2.77 million jobs are distributed over the wage distribution in 2015.

We assume that all these 2.77 million jobs under 8.50 Euro per hour (Bracket 4a of Tab. A1) are distributed over the minimum wage interval of €8.50 and the wage intervals immediately following it according to the number of jobs in these intervals on the basis of the information from the VE 2015: 1.91 million jobs are counted in the minimum wage interval of 8.50 euros (Bracket 5b of Tab. A1). The remaining $2.77 \text{ million} - 1.91 \text{ million} = 859,000$ jobs with an hourly wage of less than 8.50 Euro in 2014 and for which an hourly wage of more than 8.50 Euro per hour was paid in 2015, are distributed completely over the wage intervals from 8.60 to 8.80 Euro per hour (Bracket 5c of Tab. A1). Hence, for the estimation of the spillover effect only information from the wage intervals between 8.90 and 10.00 Euro is used.

Table A1: Decomposition of the spillover effect (in 1000s)

	Below MW (a)	At MW (b)	Above MW (c)	Total (d)
VSE 2014 (1)	3.855	0.400	31.002	35.257
Hypothetical Distribution 2015 (2)	3.780	0.412	31.912	36.104
VE 2015 (3)	1.014	1.907	33.257	36.177
Difference (3-2)	2,766			0
Distribution of this Difference (4)		1.907	0.859	

Source: Own calculations based on VSE 2014, VE 2015.

Third, according to the national accounts from 2014 to 2015 gross wages and salaries per hour worked increased by 2.6% on average in Germany. This wage increase is not part of the spillover effect of the minimum wage and not properly accounting for it would inflate our estimates of the spillover effect. Therefore, total gross wages and salaries per hour worked for the wage intervals between 8.90 and 10.00 Euro obtained from the hypothetical distribution 2015 are also increased by 2.6%. This is intended to eliminate the effect of the overall wage increase in 2015.

Finally, from VSE 2014 and VE 2015 we only have information on the distribution of employment by hourly wage levels. We do not have a wage distribution based on the annual number of hours worked of each worker. Therefore, a further assumption on the average number of hours worked per worker earning less than 10.00 Euro per hour is necessary. According to VE 2015 (Frentzen and Günther 2017, Tab. 10), the average weekly working hours in the jobs in the wage interval of 8.50 Euro per hour (gross 8.45 to 8.54 €/h) was 17.1 hours a week in 2015. Extrapolated over the working year, this corresponds to an annual working time of just under 892 hours. Since no information is available on the number of hours worked in jobs earning between 8.90 and 10.00 Euro per hour it is assumed that the working time in these jobs between 8.90 and 10.00 Euros was also just under 892 hours per year. This figure is considerably lower than the average annual number of hours worked per employee in Germany, which was 1301.5 hours in 2015 as shown in the national accounts. Nevertheless, the lower figure is deliberately chosen on the basis of the VE 2015. This ensures that

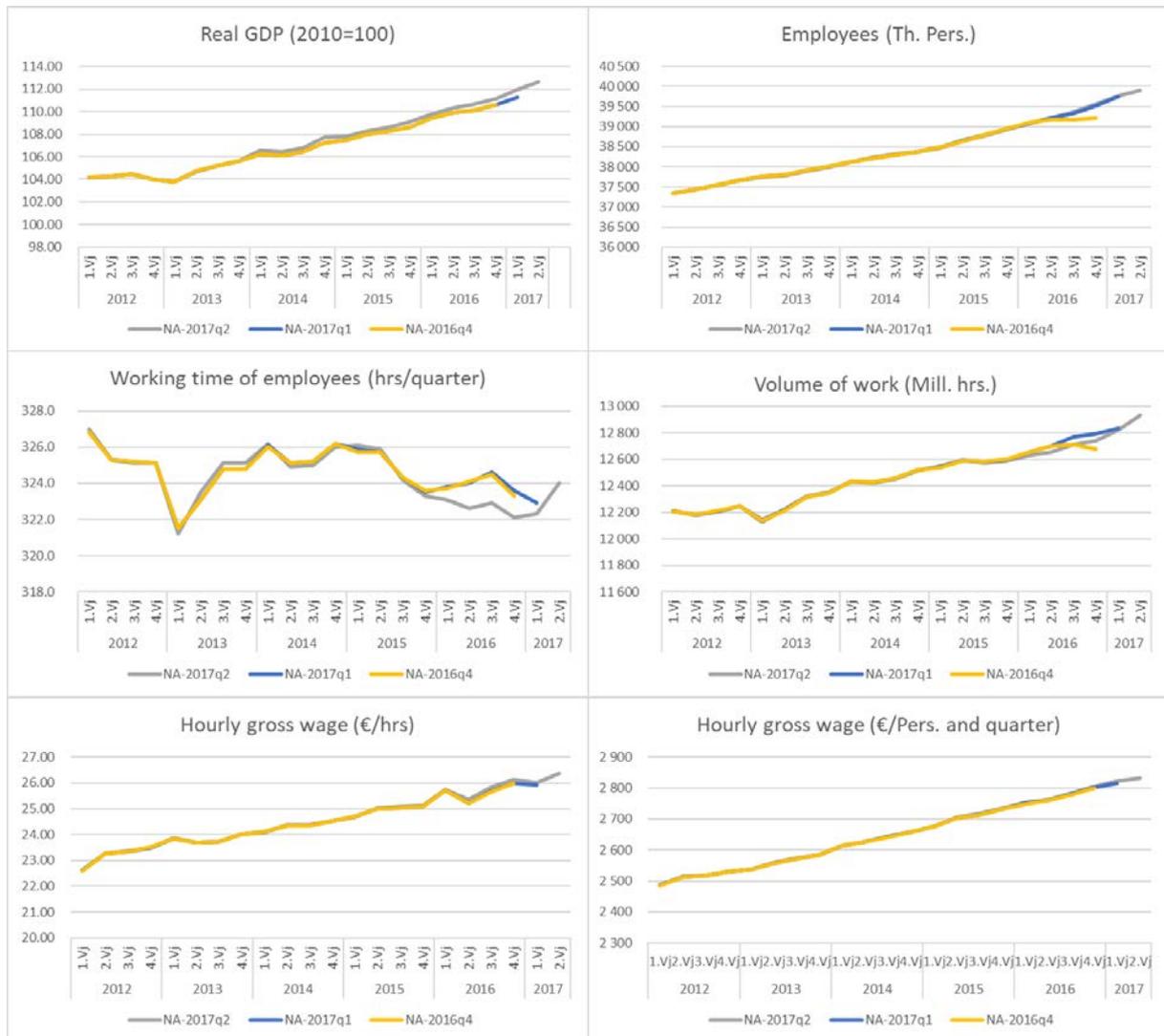
the chosen assumption for the number of hours leads to a rather conservative estimate of the spillover effect.

Given all these assumptions we are able to calculate total gross wages and salaries for the wage intervals between 8.90 and 10.00 Euro in 2015 on the basis of the information provided by the VSE 2015 as well as based on the information from the hypothetical distribution in 2015. Total gross wages and salaries for the wage intervals between 8.90 and 10.00 Euro in 2015 is equal to 36.6 billion Euros. Similarly, total gross wages and salaries for the wage intervals between 8.90 and 10.00 Euro in 2014 – based on the information from the hypothetical distribution 2015 – is equal to 31.2 billion Euro.

The difference between total gross wages and salaries for the wage intervals between 8.90 and 10.00 Euro in 2015 and total gross wages and salaries derived from the hypothetical distribution 2015 is the spillover effect of the introduction of the minimum wage in Germany. This spillover effect is equal to 5.4 billion Euros or 0.44% of total wages and salaries in 2014 as a result of the minimum wage introduction in 2015.

A2: Data issues

Figure A1: VGR-Data revisions of chosen variables (NA-2016q4 vs. NA-2017q1 vs. NA-2017q2)



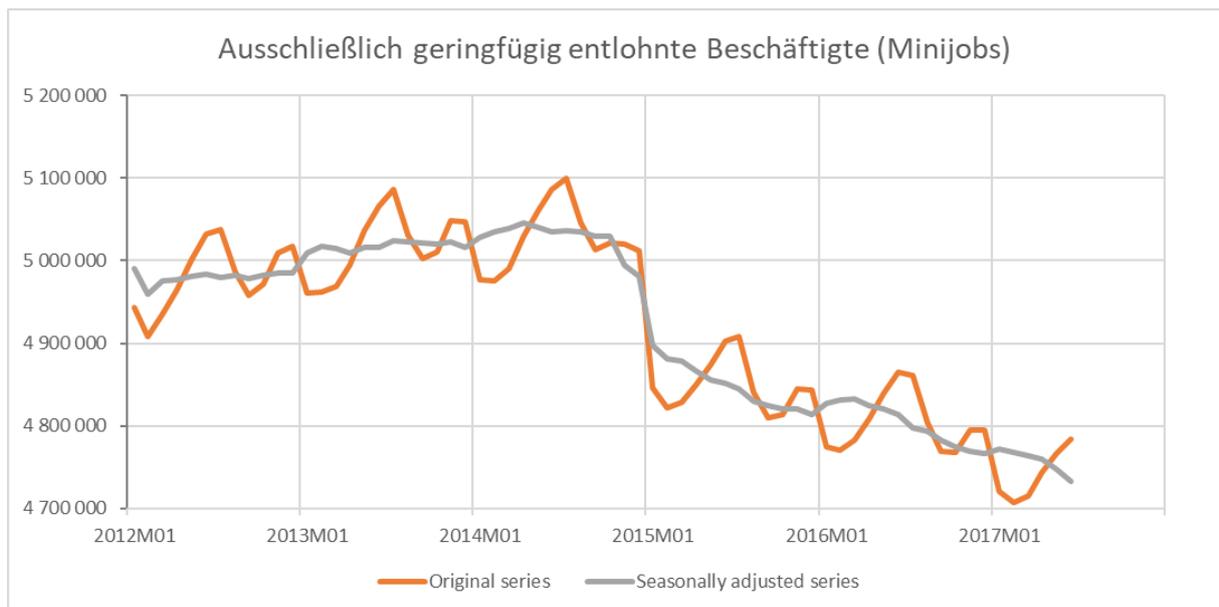
Source: NA-statistics (FS18R1.3), own representation.

Table A2: Difference between the NA-statistics vintages (FS18-R1.3)

	Real GDP		Employees		Volume of work	
	2017q2 vs. 2017q1	2017q1 vs. 2016q4	2017q2 vs. 2017q1	2017q1 vs. 2016q4	2017q2 vs. 2017q1	2017q1 vs. 2016q4
2014	0.3%	0.0%	0	0	0.0%	0.0%
2015	0.4%	0.0%	-12	0	0.0%	0.0%
2016	0.4%	0.0%	15	123	-0.4%	0.3%
	Working time		Gross wage (per cap.)		Gross wage (per hour)	
	2017q2 vs. 2017q1	2017q1 vs. 2016q4	2017q2 vs. 2017q1	2017q1 vs. 2016q4	2017q2 vs. 2017q1	2017q1 vs. 2016q4
2014	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2015	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%
2016	-0.4%	0.0%	0.1%	0.1%	0.5%	0.0%

Remark: All figures are expressed in % except for the employees who are expressed in Th. Persons Source: NA-statistics (FS18R1.3, own calculations).

Figure A2: Path of the minijobs around the time of the minimum wage introduction



Source: Federal Labour Office (BA, non-seasonally adjusted data) and own calculations (seasonally adjusted data with X12-ARIMA).

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Publisher: Hans-Böckler-Stiftung, Hans-Böckler-Str. 39, 40476 Düsseldorf, Germany
Phone: +49-211-7778-331, IMK@boeckler.de, <http://www.imk-boeckler.de>

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