Short-Term macroeconomic evaluation of the German Minimum age with a VAR/VECM

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Abstract *(158 word): The German minimum wage was introduced in January 2015 (8.59€/h). This paper documents a research done for the Minimum Wage Commission to gauge the macroeconomic impacts of the minimum wage. To do so the authors follow a twin strategy: first empirical evidence on price, wage and employment evidence are gathered from official statistics and put in regard to results from international literature. Then a small macroeconomic VAR analysis is performed. The 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 departures are interpreted as minimum wage effects. Robustness checks within the VAR analysis as well as a comparison with the descriptive empirical results is done to assess the validity of the interpretations. On the whole, small positive price effects, significant positive wage effects and positive employment effects although not robust in their magnitude are found for 2015.*

JEL: E65, E17, E01

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1. Introduction

The German national minimum wage was introduced in January 2015 (8.50€/h) and increased in January 2017 (8.84€/h). It should increase further in 2019 (9.15€/h). Accompanying its introduction, the German Minimum Wage Commission was created and should among other thing monitor the effects of the minimum wage on the economy and the workers (§ 9 Abs. 4 MiLoG). It issues for this purpose regularly calls for research. At the beginning of 2017 one call offered to analyse the effects of the introduction of the minimum wage from a macroeconomic and Keynesian perspective. A consortium of several authors under the umbrella of the Macroeconomic Institute (IMK) wins this call and handed its final report at the end of 2017 (Herr et al. 2017, Herzog-Stein 2018). This paper presents the extended third part of this final report, the VAR-short-term analysis, and compare its results with the second part, the descriptive statistics from official statistics.

The aim of this contribution is to estimate the macroeconomic impact of the minimum wage on key variables. Despite the name of the report they are issued from, the VAR and the descriptive statistical parts were done *without* imposing a theoretical frame. The intention 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.

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. The VAR models, the one extreme, stands at the opposite to the structural models à la DSGE, the other extreme. VAR models are commonly used for forecasting 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 forecasts-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. With this respect we are able to gauge the minimum wage effect from two sides, both not theoretically driven.

As a final word it must be pointed out that the time for the preparation of this short study was short: Due to announced strong data revisions, the publication of the national accounts data from the end of August 2017 had to be waited. However, the results had to be documented by the end of September 2017. This meant that only a limited number of variants could be carried out. Macroeconomically, at the time of writing (Sept. 2017), this contribution takes place ten quarters after the introduction of the minimum wage, the first six of which can be considered to be less susceptible to revision (cf. Kholodilin/Siliverstovs 2009, see also Annex).

The structure of the paper is as follow: in the next section the evidence from descriptive statistics on price, employment and wage is presented. The section 3 presents then the used Dataset for the VAR. Section 4 justify the estimation of the VAR/VECM with usual diagnostic tests. Section 5 show the comparison results and put them in perspective of the evidence presented in Section 2. Section 6 concludes.

2. Descriptive statistics: expected effects and observed effects

Price

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 last results from the IAB Establishment Panel 2015 show for Germany, that 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 USA and the United Kingdom. Lemos (2008, p.196) comes to the conclusion in a literature review that macroeconomic price effects are difficult to find, and that across all studies the magnitude of the price effect if the minimum wage increases by 10% is around 0.2 %. Arpaia et al. (2017, p.26-27) examine recently the minimum wage effect on consumer prices in 20 EU countries. They come to the conclusion that an increase in the minimum wage in the consumer prices increased by a total of 0.4 to 0.6 % in the range of 10 % with the effect of the minimum wage varying greatly depending on the product category (Arpaia et al. 2017, p. 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 leads to the following calculations: The Minimum Wage Commission (2016) shows in its first report in Table 12 (p. 119) the price development of 17 goods and services (merged into 15), and services from sectors highly affected by the statutory minimum wage. If the weight of these goods and services is taken into account, which together is about 11 %, and multiplied the price increases shown by the corresponding good or service, this adds up to a contribution of **0.22 percentage points for 2015** out of the total price increase of 0.3% (Table PRI). Therefore, thanks to the minimum wage price increases Germany did not experience a deflationary year. This range of order was confirmed by the second report of the Minimum Wage Commission (2018, p. 137).

Table PRI: 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); Statistisches Bundesamt (Fachserie 17 Reihe 7) and Statistisches Bundesamt (2013); Own calculations after Herr et al. (2017).

Wage

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, it may be attenuated if the minimum wage introduction or increase also means that wages above the minimum wage level will also be increased. 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, p. 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. WAGE) 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.

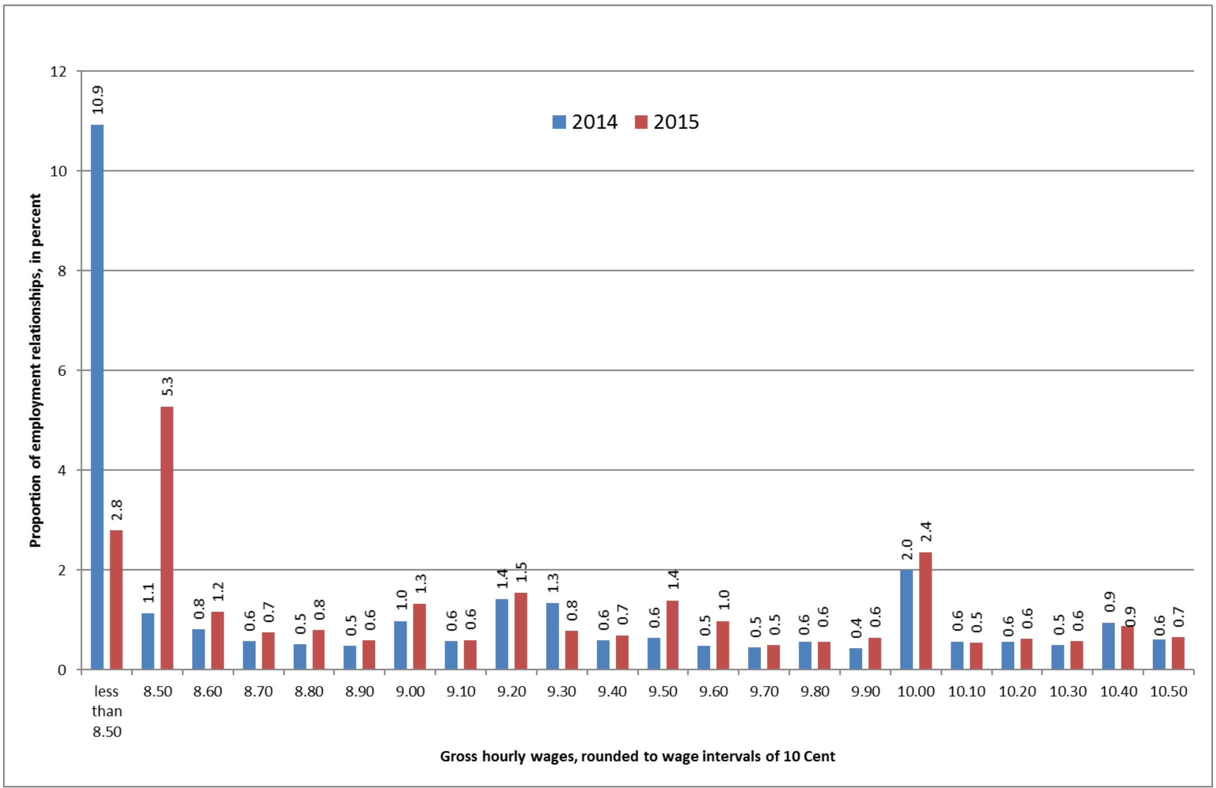
Table WAGE: Selected research studies to spillover effects in USA, UK and France

Study	Country	Results
Belman und Wolfson (2014), meta-study	USA/UK	USA: Clear Spillover effects. Depending of the studies, it reaches from just over the MW to the 3rd wage decile. UK: various results from none (by the introduction of the MW) to significant spillover effects (later increases).
Neumark und Wascher (2008)	USA	Increases of the MW influence wage that lie till 20% over the MW. This influence is the strongest near the MW-level.
Card und Krueger (1995)	USA	MW increases of 1990-1991: Clear spillover effect at the 5th and 10th wage percentiles.
Autor et al. (2016)	USA	MW increases between 1979-2012: Decreasing spillover effects till the 25th wage percentile.
Dickens und 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 25th wage percentile.
CSERC (1999), meta-study	France	Clear spillover till wages by 1,5xMW. The spillover effects did significantly decrease in the 90’s. They affect differently workers depending on their sex, age and professional position.
Goarant und Muller (2011)	France	MW increases 2006-2009 (after the working time reduction): Decreasing spillover effects till a wage level of 3xMWs.
Aeberhardt et al. (2016)	France	MW increases between 2003-2005 (during the adjutment phase to the working time reduction): Spillover effects till the 7th wage deciel for men and 5th wage decile for women. Here too the fecctes are decreasing with the wage level.
Arpaia und van Herck (2017)	France	MW increases between 2007-2012: Spillover effects till the 8th wage decile, with decreasing effects with the wage level.

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

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 VSE 2014 and the VE 2015 (Fig. DIS; 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 show significant growth, which speaks for noticeable spillover effects. From an hourly wage of 10.00 euros onward, 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 DIS: 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 A3 p. 83ff of Herr et al. 2017) - the overall spillover effect have a magnitude of around 5.4 billion euros or slightly more as 0.4 % of the Gross wages of 2014. This is the same order as the direct (compression) effect calculated by the Minimum wage Commission (2016, p. 116, footnote 50). The order of magnitude of this indirect effect roughly corresponds to the direct minimum wage effect on the gross wage bill. Overall the effect of the minimum wage 2015 would have increased the wage bill by 0.4% directly (wages of the minimum wage earners still working) and by further 0,4% indirectly (increase of the wages of workers earning above the minimum wage), making a total of **0.8% of the gross wage bill**.

It should be noted that a parallel project to our funded equally by the Minimum Wage Commission (Barauel et al. 2018) using other data comes to the conclusion that the direct wage effect and the spillover effect are of much less magnitude and found 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 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 to 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 the same conclusions: hardly any significant employment effects from minimum wages can be identified (OECD 2015, Table 1.3, p. 47). Specific to Germany, the previously available research results on the sectoral minimum wages confirmed this international findings too (see the brief overview in Minimum Wage Commission 2016, p. 24).

For Germany, so far at the point of the project (2017) but this is confirmed also for 2018, the evidence gathered by the Minimum Wage Commission (2016, p. 75ff. and p. 105ff) shows that the development of employment was robust. It could be observed however that a shift from minijobs to employment subject to social contribution occurred (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 working time (our interpretation from Destatis 2017, p. 56 and Table 10, a conclusion achieved also by a parallel project to our funded by the minimum wage commission too: Bonin et al. 2018). 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 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 p. 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 submitted to social security 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 should be modest at around 0.2 pp contribution to inflation rate steeming from products and services where the minimum wage has a high incidence.

The effects on employment should be very modest to positive on the overall values, in line with the international literature. Especially the decrease of the minijobs seems to have been overcompensated by the employment subject to social security. It will be therefore important to control for business cycle effect 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. So the conclusion are to be taken cautiously. Eventual negative effects on the working time can be inferred from the shift from minijobs to employment subject to social security. Overall the effect on the volume of work should have been modest too.

The wage effect is so far evaluated by 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, series 18, series

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, method 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). 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 change. 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 security 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 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 estimate, 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 of the problem of minimum wages, which 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, p. 195, 199-200 or Bowles/Carlin/Stevens (2017, Unit 9).

Wage measures: The wage can be defined along three dimensions: which tax/constributions is excluded, which underlying employment measure is considered and whether price correction are done. Since the minimum wage is defined as the (gross) hourly wage, and because of the working time problem discussed above, it seems more sensible to consider an hourly gross wage in the VAR. The wage wedge (tax and contribution share in % of gross wages) increased sharply in the 1990s, so that the choice between wage costs, gross wages or net wages could well lead to different results. For the relevant period of the 2015-2017 years considered and a decade before, however, there is hardly any movement to be seen (see Fig. XLK).

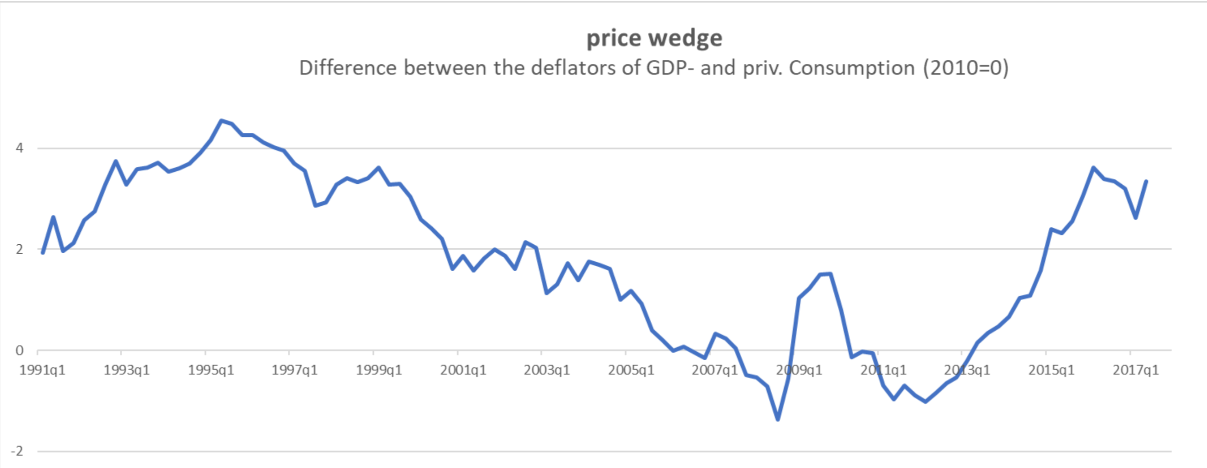
From the employer's point of view, price adjustment is best done with the GDP deflator, from the employee's point of view with the consumption deflator. The price wedge (difference between the deflators of GDP and private consumption) is also subject to more fluctuations at the end of the period (see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

Fig. XLK: 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) was included as an exogenous variable in the model.

Fig. XPK: 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. XVAR and Fig. XVAR):

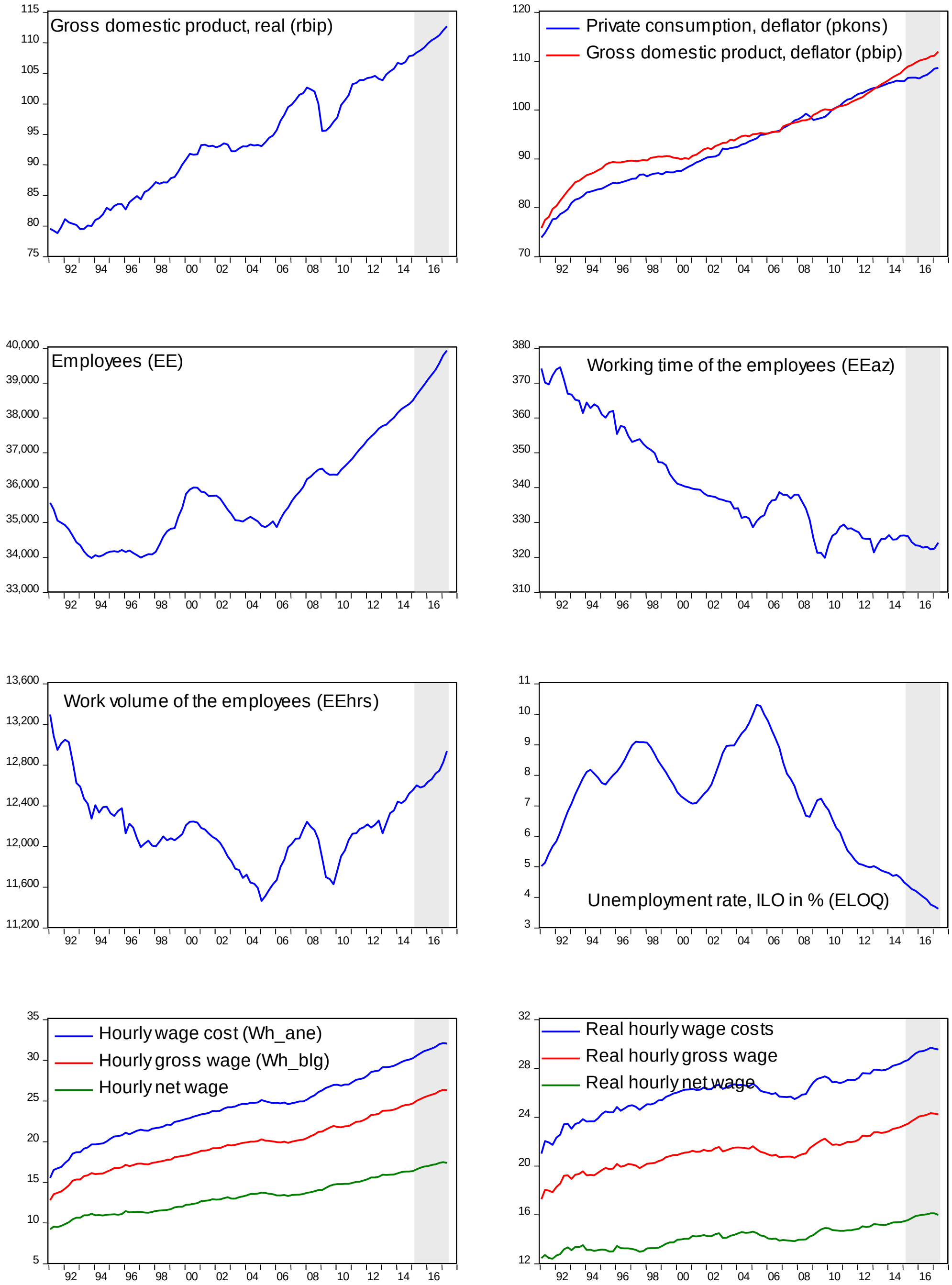
Tab. XVAR: Variables list (Germany, 1991q1-2017q2)

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	Durchschnittliche Arbeitszeit der abh. Beschäftigten	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 macroeconometric analysis. This data transformation mostly solves problems of heteroscedastic residuals (i.e. whose variance is not equal over time, leading to inefficient estimators) and makes the interpretation of differentiated variables as approximated growth rates easier.

Fig. XVAR: 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. XVAR (this also applies to the oil price which is not shown), all ADF tests must include a linear trend (Model III) into account, except for the unemployment rate (Model II). Regarding to working hours and employees, both ADF test variants are considered since the trend feature is not so clear.

The results are presented in Table XADF. All variables are considered as I(1), as expected because macroeconomic variables are often found and considered as I(1) (Nelson/Plosser 1982; Juselius 1999, pp. 264-266). Another choice for lag length, based on short-term t-statistics, was a clear I(1) conclusion for logarithmic deflators and average hourly wages

Tab. XADF: Results of the ADF-Tests (p-values, H0: unit root)

			Level, ADF-p-value		Difference, ADF-p-value		
Name	*Variable*	*Trans-formation*	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 cncept)	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 on p. 11 to equation 4.1 p. 45):

Vector**a**uto**r**egressive Model, VAR-Form: $X_t = \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \cdots + \Pi_p X_{t-p} + \Psi D_t + \varepsilon_t$

Vector **e**rror **c**orrection **m**odel, 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 deterministics 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 relations) was chosen because it corresponds best to 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. XVAR (quadratic trends for the 5th variant or no trend in variants 1 and 2).

4. VAR/VECM-Estimation

The estimation period is now set to 1993q1-2014q4 (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 with (l_rBIP, l_pKONS, l_Wh_blg, l_EE, l_EEhrs, ELOQ)^T (k=6), all variables except the unemployment rate are in logs (the prefix l_ stands for this). A trend and a constant belong to the model, as does the logged oil price (**D**-matrix).

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

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

Diagnostic tests (Autocorrelation, Normality und Homoskedasticity)

Diagnostic tests (Tab. XRES) on the two estimated VARs are performed: a visual check of the autocorrelation functions and the Lagrange multiplier autocorrelation tests (up to the 8^{th} 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.

The normality of the residuals is first rejected by Jarque-Bera tests (JB) for the GDP and employment equations for both lag lengths 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 outliers (cf. Hendry/Mizon 2011, on consequences and solutions of outliers in co-integrated VAR): 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 outliers are caught with three impulse dummies (2009q1, 2006q1, 2003q1).

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

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

Table XJOH shows the test results and points to 2 cointegration relations (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 analysis purposes to do forecasts and nothing else, it is not relevant here neither 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 no further restrictions are imposed above the trend restrictions discussed earlier (variant 3 or H1(r)).

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

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

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

Stability tests

Since many coefficients are 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 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 estimates and are therefore often presented with 68% instead of the usual 90 to 99% (see e.g. an ECB paper Bobeica/ Jarociński 2017). The 68% and 95% confidence intervals are both pictured. The **VECM forecasts for 2015/2016** (Fig. XProg1, Tab. XProg11) are now commented on with the actual development. This comparison is interpreted as the minimum wage effect, because the VECM forecasts transfer the previous development without shock, taking into account the mutual variable dependencies, into the future.

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. This can be seen as positive: 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 estimation uncertainties. 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.

Tab. XProg11: 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 with 0.2% in 2015. In 2016 the VECM is clearly worse, with 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 figures can no longer identify with a minimum wage effect alone. We restrict ourselves therefore to the year 2015 for this reason together with the aforementioned revision issue.

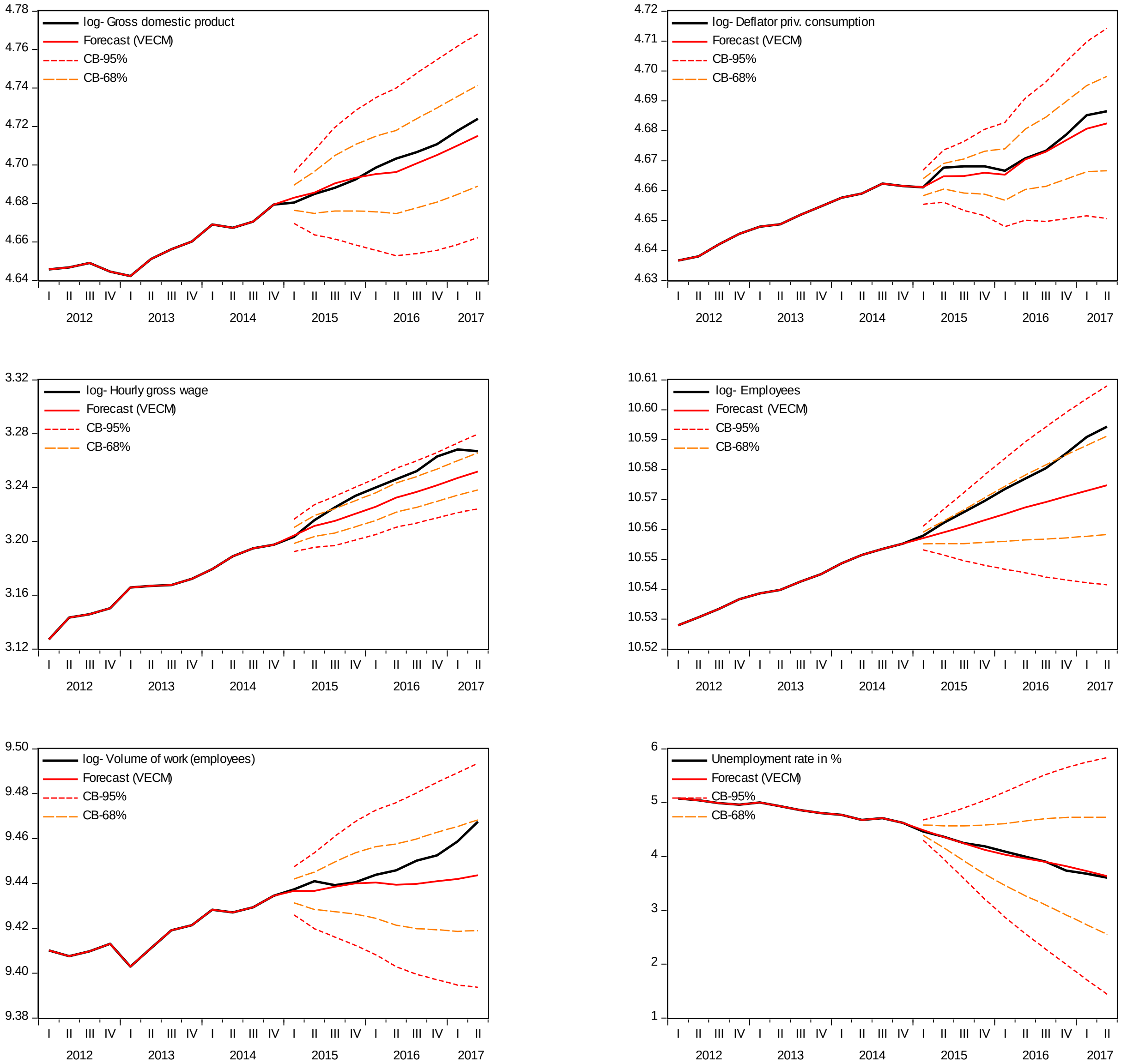
The consumption price is underestimated by the VECM by 0.2% in 2015 (by 0.1% in 2016), despite an optimistic GDP forecast. This fits very well interpretatively with the positive minimum wage effect found in Section 2 on prices, which is noticeable in the heavily affected sectors but is modest at the 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 (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 quite slightly). This would mean that the spillover effect of the minimum wage would be about as high as the direct effect, what was also found in the 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 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 to 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 the 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 explanation (cf. Anderton et al. 2014 for an investigation of the influence of the composition of the use of GDP in the Okun context), the interpretation is rather cautious: the very negative forecasts 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.

Fig. XProg1: 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 with the 6 variables discussed (trend explicitly in the cointegration relations, different number of cointegration relations and p=6) provided much worse forecast results and are therefore not commented on any further, as forecast errors[3] certainly dominate the picture here.

An alternative estimate 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 (Table XProg12). The real GDP is very well forecasted for 2015, the price effect is modest at the aggregated level (0.2%), the wage effect is pronounced (0.6%, statistically significant), the 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. XProg1: no

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

significant effects on real GDP, very small price effects, larger wage effects, positive employment effects.

Tab. XProg12: 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 can be no confusion between forecast errors (related to the economy) and anticipated effects.

The following conclusions can be drawn from Fig. XProg2 and Table Xprog22: real GDP is estimated relatively accurately for 2014 and 2015, so that no misinterpretation of economic developments can 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.

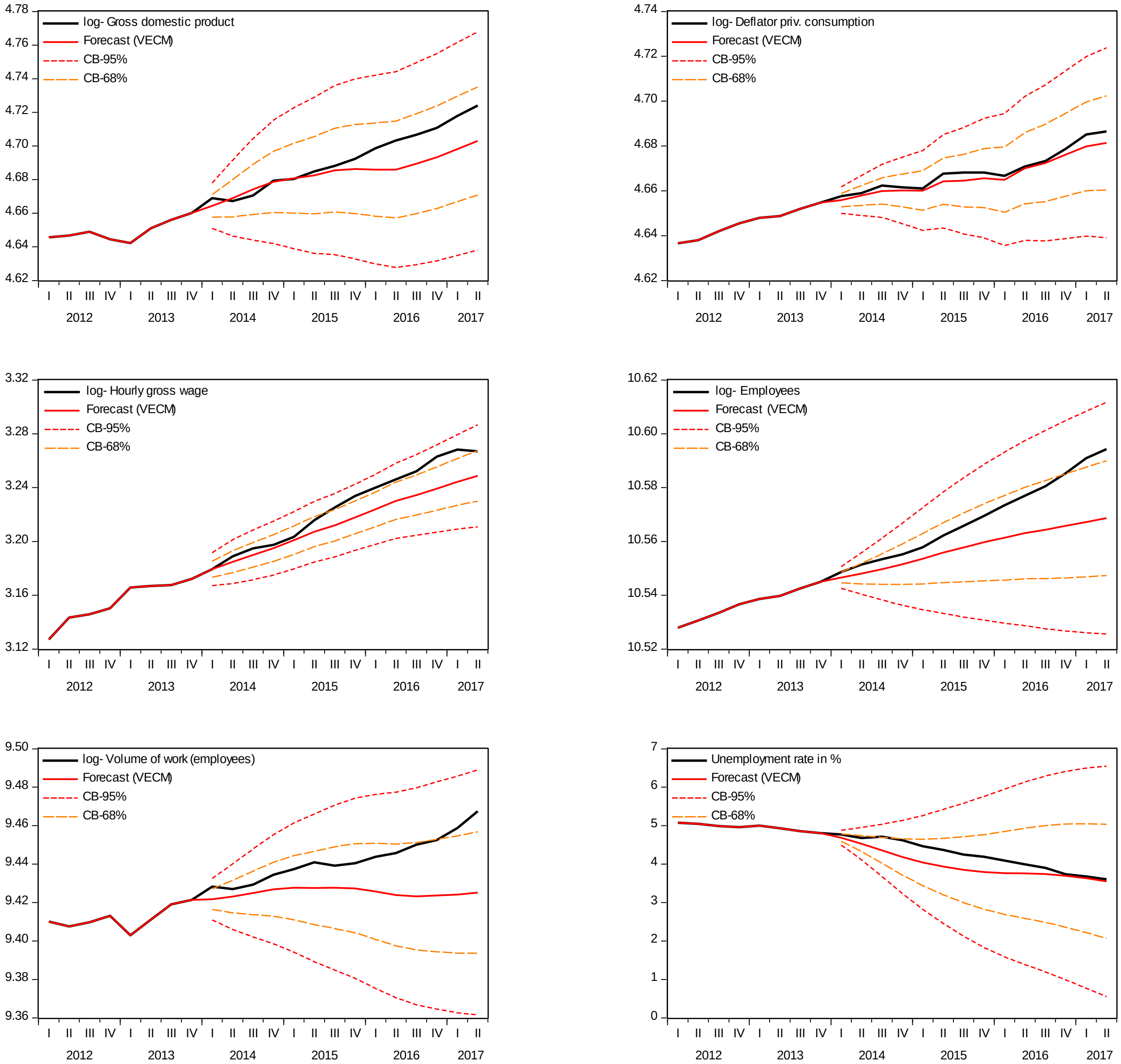
The two problematic variables are now the volume of work, which is already clearly underestimated at 0.6% in 2014, an error that doubles to 1.2% in 2015 and the dependent employment, which is also clearly underestimated first by 0.3% and then by 0.7%. At least from these comparisons it is confirmed that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

Tab. XProg22: 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.

Fig. XProg2: VECM-Forecasts 2014q1-2017q2 (p=2, r=2)



6. Conclusions

This study estimated a small multivariate VECM model for 1991q1-2014q4, 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 2015q1-2017q2 after the introduction of the minimum wage 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 variables was then carried out and interpreted as a possible minimum wage effect. Robustness checks and statistical significance tests qualified the resilience of the results.

The results are additionally put in comparison to figures obtained from official statistics on price, wage and employment. The VECM-estimated departure between forecasts and actual trends, interpreted as minimum wage effects, are quite in line with the measured effects 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 minimum wage introduction year, 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 aggregated 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 only the (robustly estimated) positive signs of the sizes clearly contradict the negative ex-ante predictions of many studies.

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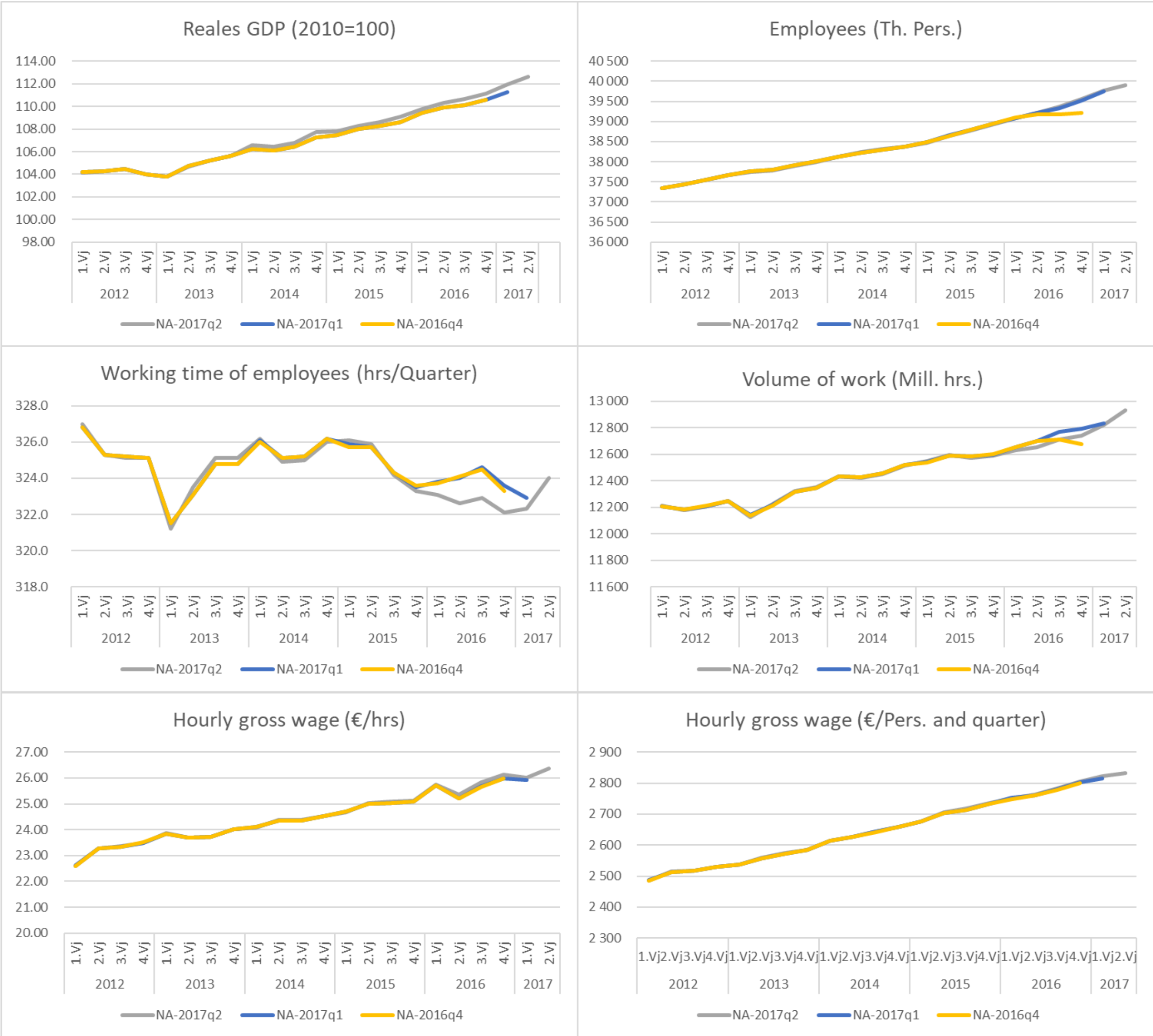
8. ANNEX

Data issues

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



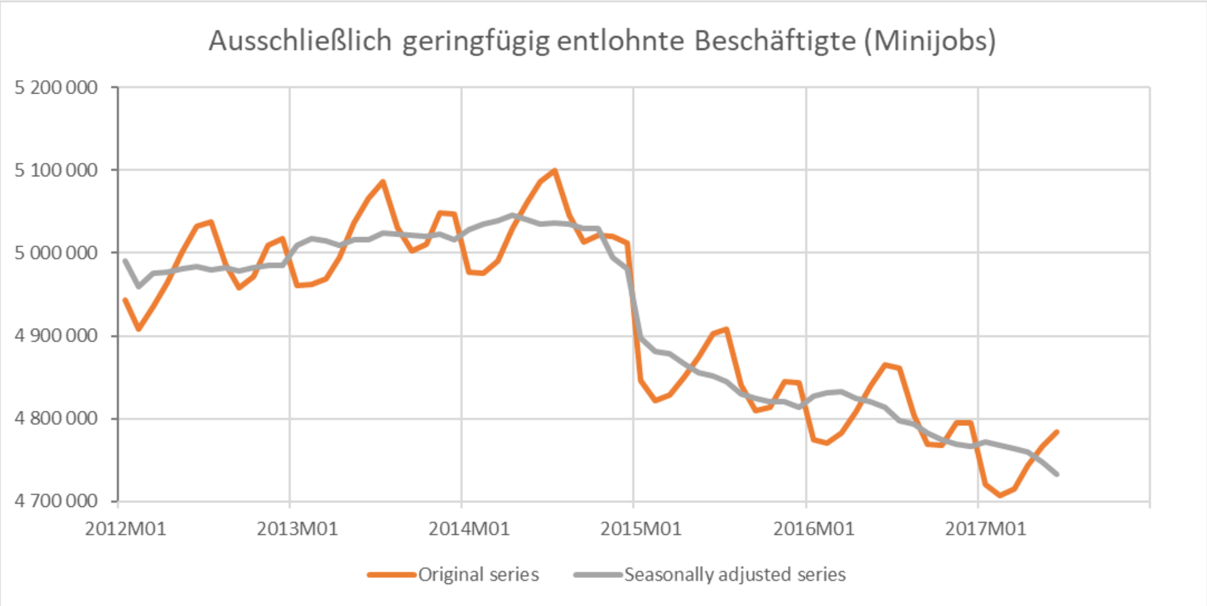
Source: NA-statistics (FS18R1.3), own representation.

Tab. 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).

Fig. A3: 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).