INDERSCIENCE PUBLISHERS
Linking academia, business and industry through research

International Journal of Computational Economics and Econometrics

ISSN online: 1757-1189 - ISSN print: 1757-1170
https://www.inderscience.com/ijcee

Minimum wage as the determinant of productivity in EU countries

Jana Kopecká, Lenka Viskotová, David Hampel

DOI: 10.1504/IJCEE.2024.10062965

Article History:

Received:	25 May 2023
Last revised:	12 October 2023
Accepted:	20 January 2024
Published online:	17 March 2025

Minimum wage as the determinant of productivity in EU countries

Jana Kopecká, Lenka Viskotová and David Hampel*

Department of Statistics and Operation Analysis,
Mendel University in Brno,
Zemědělská 1, 61300 Brno, Czech Republic
Email: xkopeck2@mendelu.cz
Email: lenka.viskotova@mendelu.cz
Email: david.hampel.uso@mendelu.cz
*Corresponding author

Abstract: When introducing and setting minimum wages, primarily to reduce poverty and avoid undesirable phenomena in the labour market, it is necessary to monitor the impact on various aspects of the real economy. This paper focuses on demonstrating the positive impact of nominal minimum wage growth on productivity in EU countries. A cluster analysis is used to divide countries into two distinguished clusters. Using panel regression, the effect of a minimum wage is found to be significant and positive. To rule out spurious regressions and to demonstrate the robustness of the performed analyses, appropriate covariates are included in the models, different forms of productivity are modelled, and the models are also estimated independently for each cluster.

Keywords: cluster analysis; company production process; EU27; human capital; labour costs; low-wage employees; minimum wage; productivity of labour; panel regression model; training of employees.

JEL codes: C33, E24.

Reference to this paper should be made as follows: Kopecká, J., Viskotová, L. and Hampel, D. (2025) 'Minimum wage as the determinant of productivity in EU countries', *Int. J. Computational Economics and Econometrics*, Vol. 15, Nos. 1/2, pp.3–17.

Biographical notes: Jana Kopecká graduated in Economic Statistics, an academic study programme accredited by Eurostat within the European Master in Official Statistics network. She is mainly involved in technical data analysis.

Lenka Viskotová is an Assistant Professor at the Department of Statistics and Operation Analysis, Mendel University in Brno, Czech Republic. She is dealing with problems related to mathematical economics, including productivity issues.

David Hampel is an Associate Professor at the Department of Statistics and Operation Analysis, Mendel University in Brno, Czech Republic. He is focused on statistics and econometric modelling.

1 Introduction

The issue of minimum wages is increasingly discussed in the context of solving socio-economic problems and generally building a welfare state. The actual application of a minimum wage has various impacts on both individuals and firms. One of the less traditional lines of inquiry is the effect of setting a nominal minimum wage (NMW) on labour productivity. Labour productivity is determined by many variables, and it is reasonable to assume that NMW will generally have a small but statistically significant effect on it; nevertheless, for workers earning relatively low wages, the effect of NMW can be substantial. Historically, Webb (1912) mentions that NMW positively stimulates worker productivity and consistent selection of efficient workers. Stigler (1946) points out that the negative effect on unemployment outweighs the positive effect of stimulation in order to increase the productivity of the least productive workers. According to him, the aggregate output is reduced when a minimum wage is implemented. This happens despite the fact the minimum wage is efficient. On the other hand, he also mentions a so-called shock theory. Inefficient workers will either raise productivity or they will be discharged. Entrepreneurs are shocked into using new production techniques that were previously not profitable.

Generally, studies published in the twentieth century often focussed on certain sectors and there was a lack of empirical evidence for their assumptions. Current studies overcome historically insufficient empirical verification of the studied phenomena. Metcalf (2008) mentioned several reasons for the increase in productivity. One of the possibilities is that the capital becomes a substitute for labour. Another reason is that employers take measures to deepen human capital. Motivation may also be an important factor in this case as a higher wage may encourage some workers to work harder. Last but not least, a higher wage reduces employee turnover and as a result, work performance increases because there is no need to spend extra time looking for and training new employees, but rather to focus on the organisation to achieve higher output. Koch and McGrath (1996) observed ways to increase productivity by investing in human resource management. One way is to invest in hiring, which means to either seek out more applicants or to conduct research of potential candidates in order to find key employees. Another option is to invest in employee development as trained workers are likely to boost productivity and the probability of lowering employee turnover is higher if employees are company-specifically upskilled. Butschek (2022) deals with changes in job interviews in Germany after the introduction of NMW in 2015. Agell and Lommerud (1997) consider a situation whereby the marginal product of skilled labour is divided between workers and the employer with respect to workers' bargaining power and they showed that in this case the effect of the minimum wage on the allocation of human capital is positive.

Many other studies support these findings and sometimes add valuable observations, such as Forth and O'Mahony (2003) who found a positive relationship between NMW and productivity. They also described differences in various labour sectors. Draca et al. (2008) examined changes in company profitability after introducing NMW. They observed an overall wage increase, which negatively affected company profitability. In addition, they also investigated the NMW-productivity relationship, which turned out to be positive, but statistically irrelevant. Observation of the impact of NMW on employment is backed by a study by Croucher and Rizov (2012) which also provides an interesting comparison of how companies adapt to NMW. They found that while smaller

companies may have difficulty raising their product prices (and therefore productivity), larger ones with less competition can enforce higher prices on their customers and adapt easily. Ozdamar et al. (2022) worked with the gender saving-investment gap and demonstrated the differences between genders. The minimum wage generally acts to reduce similar gaps, and higher savings transformed into investment should act to increase productivity.

A study by Kim and Jang (2019) shows that while the immediate effects of introducing or raising NMW may positively influence productivity (as claimed by most studies), in practice this is only true for a two-year period, after which the employee performance motivation dissipates. Therefore, they recommend raising NMW every two years to create these positive shocks, but they also question how the long-term behaviour of workers evolves under such circumstances. They also mention an interesting observation whereby full-service restaurants are able to retain the shock effect for longer than two years in comparison to fast-food/limited-service establishments.

McLaughlin (2009) shows the performance changes of industries as a response to the introduction of NMW. He compares two very differently institutionalised countries, i.e., Denmark (long-term effective government funded worker training) and New Zealand (skilled worker shortage). The study introduces the issue of 'low-skill equilibrium' whereby companies prefer not investing in training their workers. A specific case is the employment of graduates or young people in general, where companies only hire people with certain experience, causing undesirable labour market phenomena leading to lower overall productivity, see Caglayan-Akay and Komuryakan (2022). The problem of not upskilling employees may become even more severe in countries that implement higher worker protection and may even lead to a situation where workers who generate less value than their salaries are not dismissed, as illustrated by Blanchard and Portugal (2001), thereby leading to a decline in productivity.

Coviello et al. (2022) conclude that if worker performance is largely not reflected in wages, the minimum wage reduces productivity, but if workers are rewarded based on performance, the productivity requirement increases with the minimum wage. The effects of the minimum wage are then stronger for those workers whose wages are close to the minimum wage level. In their study, the authors focused specifically on performance-related workers, using data from a large US retail chain. They came to the conclusion that since companies prefer more productive workers to those who do not reach even the lowest level of productivity, workers motivated by minimum wage increases do not face layoffs as often as a result of their productivity gains. Chava et al. (2023) show that increase in labour costs caused by a higher minimum wage leads to worse financial health of small businesses associated with employment reductions and a higher exit rate; the positive impact was an increase in productivity.

Rizov and Croucher (2011) worked with the aggregate productivity of the low-wage sector, which they determined by estimating productivity measures for individual companies based on their micro data. They showed a significant positive effect of NMW on this aggregate productivity over a ten-year period and highlighted the different magnitudes of the effect across sectors. The positive impact of NMW was found for all industries and was statistically significant for most industries except for hairdressing, leisure, and agriculture. Seok and You (2022) evaluated the effect of the minimum wage on employment with respect to productivity, and the results showed that NMW increases unemployment especially among low-productivity workers. As a consequence, company

capital investment increases as there will be an increase in the average worker productivity. Other studies demonstrating the positive impact of increased NMW on productivity include Wang et al. (2023), Clemens and Strain (2020), Nguyen (2019), Ibrahim and Said (2015) and Lee and Yuen (2015).

In addition to exploring the relationship between NMW and productivity, it is necessary to grasp the approaches of real productivity measurement. Cosmetatos and Eilon (1983) offer three definitions for labour productivity. The first option is 'output per man-hour', the second is 'output per head' (not evaluating how much time was spent working), and the third option is 'value added per head'. Value added can be calculated by subtracting the cost of raw materials from the total revenue. These values can be easily calculated but there is still room for discussion on how to define the output and whether to use physical or monetary units. These calculations are very general and more advanced calculations are used in practice, such as total factor productivity.

Riley and Bondibene (2017) used a different approach and measured productivity as turnover divided by employment or as a sum of remuneration and profits divided by employment. The second option was preferred and was used as a proxy for gross value added to factor costs divided by employment and applied the total factor productivity method. When focusing on companies, we can use a very practical measurement of productivity by calculating the company revenue and dividing it by its number of employees, as many modern studies do, e.g., Kim and Jang (2019).

In reality, the productivity of a given entity, whether it is a person, an establishment, a company, a country, or even the whole world, is very hard to determine exactly and robustly. A general tool for examining and describing productivity is the production function, which can be used for various investigations (see for example Roubalová and Viskotová, 2018). But it is common for seemingly identical entities, considering their area of involvement and inputs, to have widely different levels of productivity. Syverson (2011) evaluates the differences based on observing the top 10 percentile of entities (in this case manufacturing plants) and the bottom 10 percentile of entities. In the case of the USA, this difference shows that 'stronger' plants make 1.92 times more product compared to the lower percentile given the same measured inputs. Even when focusing on narrowly defined industries, significant differences occur. Furthermore, when looking at other countries, it is possible to find even wider differences. According to Hsieh and Klenow (2009), the top 10 percentile companies in China and India make more than five times more product compared to the bottom 10. There are other countries where the observed difference can be even more significant, which may be explained by a technological imbalance as well as corruption and other problems in less developed countries.

If we summarise the available work examining the impact of rising NMW on productivity, we can see that the topic is represented in the current literature, although often only as an adjunct to, for example, examining the impact of NMW on unemployment. The effects of NMW are often examined when it is introduced or significantly changed, which is certainly a good opportunity for research. Research focusing on the productivity impacts of NMW growth for multiple countries over a longer period of time is scarce, with the work of Trenovski et al. (2021) focusing on the Balkan countries being a case in point. As part of the harmonisation of economic policies across EU countries, a directive defining common minimum wage settings came into force in 2022. The aim of this paper is to detect the possible impact of setting NMW on the productivity of labour across the EU27 countries.

2 Material and methods

During the analyses, EU-27 countries were explored based on data from 2000 to 2019. The effect of setting NMW in particular countries was assessed. A total of 21 of the 27 EU countries have officially established NMW. Cyprus only has a minimum wage set by the government for some specific occupations and other countries have a minimum wage set by sectoral collective agreements, i.e., Denmark, Italy, Austria, Finland and Sweden. For these countries, the value of NMW is set at 0. The same setting is followed for Germany in the period before the introduction of an NMW.

The following variables served for grouping countries into clusters and for modelling productivity: unemployment rate (UN), tertiary education (Educ) defined as a percentage of people with a university degree compared to the population size in the particular country, nominal GDP per capita (GDPpc), and gross fixed capital formation (GFCF) expressed as a percentage of GDP (which consists of resident producers' acquisitions, less disposal of fixed assets during a given period, plus certain additions to the value of non-produced assets by the productive activity of producer or institutional units). The variable of net earnings (NE) per year in EUR is used to distinguish the effect of the minimum wage and the average wage level in the given country. Finally, three ways of productivity calculation were used. The main productivity indicator was GDP at current prices per hour worked (ProdGDP), for the purposes of checking robustness, other indicators will be assessed including value added at current prices per hour worked (ProdVA) and GDP at current prices per employed person (ProdPW). Data were sourced from the Eurostat database (https://ec.europa.eu/eurostat) and EU KLEMS database (https://euklems.eu/) hosted by the Vienna Institute for International Economic Studies. All the used data have an annual frequency with originally bi-annual data of NMW being averaged.

In our work we chose to model nominal quantities, not real quantities. Among other issues, we consider a nominal minimum wage and the productivity on the left side of the model equation is also derived from nominal quantities. If we were to adjust the variables for the effect of inflation, we would be making the same type of adjustment on both sides of the model equation. This aspect is different from other studies that use wages as the independent variable, but do not have a nominal variable on the left side of the equation. To verify that the inclusion of real variables instead of nominal variables would not change the results obtained, we estimated models with real variables and the effect of the minimum wage always remained significant (the difference was mainly in the insignificance of the accompanying trend variables).

As the first step, a cluster analysis (CA) was performed to assess whether productivity related conditions in particular EU countries are the same or vary. CA deals with data from a selected year, using the variables NMW, ProdGDP, NE, GDPpc, UN, Educ, and GFCF. Based on the multiple settings of CA, the standardised Euclidean distance between objects and Ward's distance between clusters were chosen as the final selection.

The next step involves a regression analysis. Panel data models were applied to the total data, which covered a period of 20 years (2000–2019) and also to subsets of countries according to the CA results. This is in line with the research of Trenovski et al. (2021) and Antonie et al. (2010). Generally, the model can be described as follows:

$$Y_{it} = \beta_0 + \beta_1 NMW_{it} + \beta_2 NE_{it} + \beta_3 UN_{it} + \beta_4 Educ_{it} + \beta_5 GFCF_{it} + \beta_6 D_{it} + trend + a_i + u_{it},$$

where Y is gradually substituted by *ProdGDP*, *ProdVA* and *ProdPW*, D is a dummy variable, D_{it} equals 1 when NMW is not established in country i in the year t, a_i mean the individual effect of countries, and u remains for random error. In order to eliminate spurious regression, the stationarity of residuals is tested by the Im-Pesaran-Shin unit root test, but due to missing values the test collapsed. Therefore, a different approach was used, the *trend* variable means inclusion of a linear time trend or set of time dummies into the model, and results without these additions are also calculated. Note that *GDPpc* was not included in the model, because it is contained in or strongly linked to a dependent variable and to *NE* and *GFCF* independent variables. The model was estimated in fixed effects (FE) and random effects (RE) forms, and the Hausman test was employed to decide between them. When the RE model was preferred, the Nerlove transformation was used to obtain estimates. All the analyses were performed in the computing system MATLAB R2022b and Gretl 2022c software. The significance level was set to 0.05.

The expected relations between explanatory variables and productivity will be briefly described below. For NMW, a positive relation is to be expected. Higher NMW motivates workers; hence, productivity grows. Unemployment has both effects. A positive effect may occur when workers are scared of being laid off when unemployment grows, and a negative effect occurs when there is tough competition on the labour market. Education positively contributes to productivity in terms of higher human capital. GFCF serves as a necessary complement to the workforce and has a positive impact on productivity.

3 Results

The variables used in the analysis are described in Table 1. In the case of NMW, there is a substantial growing trend and also considerable variability across EU countries. Similar patterns can be seen for net earnings, GDPpc, tertiary education share, and considered productivity variants. Unemployment declined towards the end of the period under review and takes on a smaller range of values than in 2000. GFCF remained relatively stable across the years.

The cluster analysis was computed for different years, obtaining similar results. As expected, countries are divided into clusters according to their overall development. Figure 1 shows a dendrogram for the cluster analysis of the 2019 data. It shows the division of countries into two distinct clusters, which can be geographically described as the north-western cluster and the south-eastern cluster of countries. It is worth mentioning that most of the countries with no official NMW are considered more developed. In Table 2, we can see the average characteristics of both clusters in the selected years. The cluster of north-western countries shows significantly higher productivity rates than the cluster of south-eastern countries. The average productivity in both clusters is increasing, but the distance remains virtually the same. The situation is similar for net earnings, GDPpc, and NMW. The share of tertiary education in both clusters is increasing, and we can see some convergence. Unemployment was considerably higher for the south-eastern cluster countries in 2000, also rose for the

north-western cluster countries in the crisis year of 2009, and fell to a relatively similar level for both clusters in 2019. The evolution of GFCF is rather stable, with only slight differences between clusters, although a higher value for the north-western cluster is visible in 2019.

Table 1 Characteristics of all countries in the selected years

Variable	*2000*		*2009*		*2019*	
	Mean	*Std*	*Mean*	*Std*	*Mean*	*Std*
NMW [EUR]	448	424	656	507	903	537
ProdVA [EUR/hour]	18.70	13.90	26.10	16.20	34.40	21.30
ProdGDP [EUR/hour]	21.00	15.60	29.30	18.10	38.60	23.30
ProdPW [EUR/emp.]	37,300	28,100	51,200	35,100	66,900	45,600
NE [EUR]	12,800	8,120	17,100	10,400	20,800	11,300
GDPpc [EUR]	17,100	12,600	23,100	15,200	31,600	20,900
UN [%]	9.30	5.01	9.00	3.52	6.05	3.32
Educ [%]	17.00	7.65	21.80	6.93	30.30	7.29
GFCF [%]	23.30	3.20	22.10	2.52	22.60	7.21

Note: NMW is characterised only on the basis of data from countries that have officially introduced it.

Figure 1 Dendrogram as a result of CA applied on data for 2019 (see online version for colours)

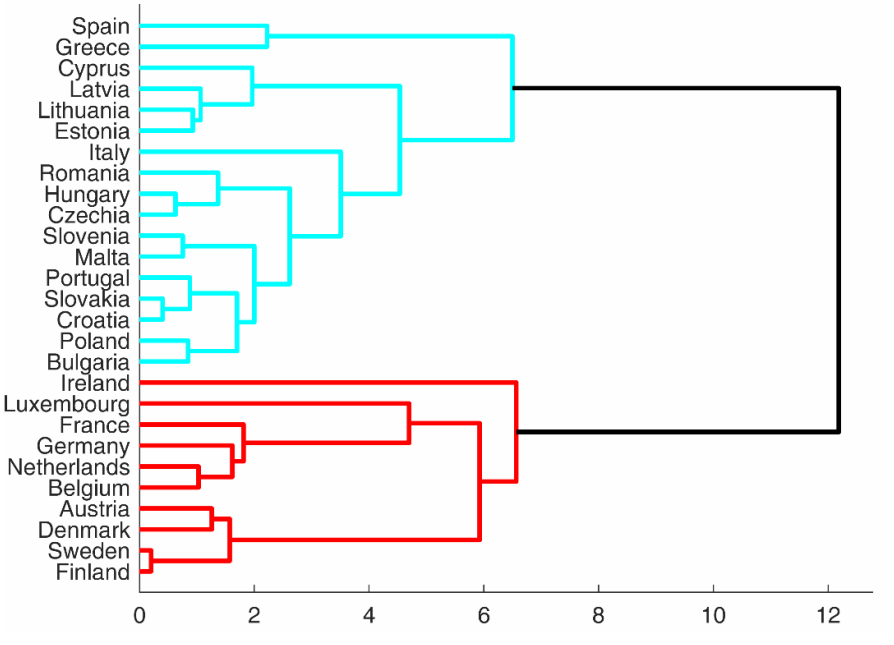

Table 3 shows the results of the panel regression with the dependent variable ProdGDP for the full dataset. For all variations of the time trend included in the model (no trend, linear trend, time dummy variables), the Hausmann test indicated the RE models. The

variables were always significant highly and the estimated coefficients for NMW, NE, and UN were stable. The coefficient values for Educ, GFCF, and D changed reasonably when different forms of the time trend were included. The dummy variable D indicating countries with no formally implemented NMW only helped improve the precision of the estimation, with omitting this variable from the model the other variables remained significant and with similar values of the estimated parameters. The substantive significance of the variables involved in the model can be derived using the estimated parameters (model with time dummies was selected for this purpose). If we increase gross fixed capital formation by one percentage point, productivity increases by 0.55 EUR/hour; for unemployment it is 0.238 and for the tertiary educated share it is an increase of 0.186 EUR/hour. It should be noted here that the increase in the independent variables in question is of a substantial nature and will mostly be undesirable in the case of unemployment. An increase in net earnings of one Euro will cause an increase in productivity of 0.001 EUR/hour and the same increase in NMW will cause an increase in productivity of 0.013 EUR/hour. Here it can be concluded that an increase in NMW will affect primarily the low-wage sectors of the economy and secondarily many other sectors. As the results were obtained using a panel model, the presented outputs should be considered as 'average', there may be differences within countries.

Table 2 Means for north-western (N-W) and south-eastern (S-E) clusters in selected years

Variable	*2000*		*2009*		*2019*	
	N-W	*S-E*	*N-W*	*S-E*	*N-W*	*S-E*
NMW [EUR]	1 080	183	1 450	347	1 670	524
ProdVA [EUR/hour]	34.5	9.4	44.3	15.3	58.7	20.1
ProdGDP [EUR/hour]	38.8	10.5	49.8	17.2	65.5	22.8
ProdPW [thou. EUR/emp.]	66.4	20.2	84.3	31.7	111.0	41.0
NE [thou. EUR]	20.5	6.42	28.0	9.75	34.0	13.1
GDPpc [thou. EUR]	30.3	8.80	38.6	13.9	52.9	19.2
UN [%]	5.3	11.4	7.5	9.9	5.4	6.4
Educ [%]	21.9	14.2	26.8	18.8	35.3	27.3
GFCF [%]	22.6	23.7	21.3	22.6	25.6	20.8

Note: NMW is characterised only on the basis of data from countries that have officially introduced it.

The model results for the dependent variable ProdGDP for each cluster are presented in Tables 4 and 5. In the case of the north-western cluster, the results differ from the model for the total data in the insignificance of the UN variable. If this variable is removed, the significances of the other variables remain. In the case of the south-eastern cluster, the differences from the results for the whole dataset are more pronounced. Unemployment is insignificant for no trend and the linear trend and significant with a negative coefficient when time dummies are included in the model. According to Weisskopf (2006), cooperative capital-labour relations and worker security are important characteristics of a country from a socio-economic perspective and determine the extent of the impact of unemployment on productivity. For GFCF, the significance varies. For the tertiary educated share, a significant effect is determined for the model with no time trend, borderline significant for the model with a linear trend, and insignificant for the model

with time dummies, which may indicate a spurious effect of the Educ variable on productivity. The successive elimination of the insignificant variables leads to models with statistically significant NMW and NE variables in each case.

Table 3 Estimates of models based on total data with the dependent variable ProdGDP and use of different trends

Trend	*None*		*Linear*		*Time dummies*	
Variable	*coeff.*	*p-value*	*coeff.*	*p-value*	*coeff.*	*p-value*
const	–19.087	<0.001	–18.259	<0.001	–18.517	<0.001
NMW	0.012	<0.001	0.013	<0.001	0.013	<0.001
NE	0.001	<0.001	0.001	<0.001	0.001	<0.001
UN	0.223	<0.001	0.255	<0.001	0.238	<0.001
Educ	0.324	<0.001	0.198	<0.001	0.186	0.002
GFCF	0.483	<0.001	0.535	<0.001	0.552	<0.001
D	14.781	<0.001	16.545	<0.001	17.331	<0.001
Trend significance	x		<0.001		yes	
Model type	RE		RE		RE	
Hausman p-value	0.161		0.146		0.133	

Note: The trend significance contains a p-value of a time trend parameter in the case of the linear trend; for the time dummies, 'yes' means the presence of significant time dummies.

To compare the estimated models for each country group, we use a model with time dummy variables, which should exclude spurious regression as much as possible. The first observation is that the variables Educ and GFCF are highly significant for the north-western countries but insignificant for the south-eastern countries. It can be inferred that capital formation takes place at a similar average level in both groups of countries, but the south-eastern countries have lower absolute levels of capital endowment and a given level of labour productivity is achieved other than through capital support associated with the implementation of innovation. The share of tertiary educated people grows at a similar rate in both clusters. The problem in the importance of tertiary education in shaping productivity in the south-eastern cluster may be both that lower levels of capital endowment do not require as many highly skilled graduates, and that the growth in tertiary educated people may be achieved at the cost of reducing difficult and advanced topics in the educational curriculum, which deprives the Educ variable of its explanatory value. In contrast, unemployment is statistically significant in the south-eastern cluster (it is not in the north-western cluster), but there is a discrepancy with the remaining models. The net earnings variable is borderline significant in the north-western cluster, the remaining models tend to indicate significance, which would be consistent with the results for the south-eastern cluster. For our object of interest, NMW, statistical significance holds in the models for both clusters, and the value of the estimated parameter is also similar.

Table 4 Estimates of models for the cluster of north-western countries with the dependent variable ProdGDP and use of different trends

Trend	*None*		*Linear*		*Time dummies*	
Variable	*coeff.*	*p-value*	*coeff.*	*p-value*	*coeff.*	*p-value*
const	–21.33	<0.001	–6.996	0.206	–6.155	0.311
NMW	0.010	<0.001	0.010	<0.001	0.010	<0.001
NE	0.001	<0.001	0.0005	0.008	0.0004	0.056
UN	0.232	0.165	0.287	0.075	0.223	0.215
Educ	0.543	<0.001	0.380	<0.001	0.420	<0.001
GFCF	0.652	<0.001	0.644	<0.001	0.673	<0.001
D	12.067	0.005	12.859	0.002	12.700	0.004
Trend significance	x		<0.001		yes	
Model type	RE		RE		RE	
Hausman p-value	0.388		0.409		0.298	

Note: The trend significance contains a p-value of the time trend parameter in the case of a linear trend; for the time dummies, 'yes' means the presence of significant time dummies.

Table 5 Estimates of models for the cluster of south-eastern countries with the dependent variable ProdGDP and using a different trend

Trend	*None*		*Linear*		*Time dummies*	
Variable	*coeff.*	*p-value*	*coeff.*	*p-value*	*coeff.*	*p-value*
const	–0.073	0.967	1.207	0.490	2.663	0.152
NMW	0.010	<0.001	0.009	<0.001	0.009	<0.001
NE	0.001	<0.001	0.001	<0.001	0.001	<0.001
UN	–0.035	0.181	–0.019	0.442	–0.065	0.010
Educ	0.105	0.001	–0.080	0.045	–0.061	0.138
GFCF	0.028	0.409	0.083	0.011	0.047	0.172
D	9.079	0.007	11.257	0.002	11.432	0.003
Trend significance	x		<0.001		yes	
Model type	RE		RE		RE	
Hausman p-value	0.066		0.086		0.054	

Note: The trend significance contains a p-value of the time trend parameter in the case of a linear trend; for the time dummies, 'yes' means the presence of significant time dummies.

To check the robustness of the obtained results, analogous models were estimated for the productivities ProdVA and ProdPW. In the case of total data, it is possible to observe a high significance of variables for both productivities, for ProdVA very similar parameter estimates are obtained. Due to different absolute values of ProdPW, the estimated parameters differ naturally from these estimated for ProdGDP and ProdVA, but they are stable for different trend settings. The significance of the two forms of time trend and the types of models remained the same.

For the cluster of north-western countries, analogous results were obtained for ProdVA and ProdPW as for ProdGDP. A slight difference appears for the linear trend included in the model with the dependent variable ProdVA. NE is not significant with p = 0.055 and UN is significant with p = 0.035. Neither the linear trend nor the time dummies are significant for ProdPW. The only difference for the south-eastern cluster compared to total dataset is the significance of UN with p = 0.049 in the model with no trend and insignificance of Educ with p = 0.495 in the model with a linear trend.

Finally, only slight changes within the model estimates are visible when modelling ProdVA or ProdPW instead of ProdGDP. In particular, no change in significance is present for NMW, which confirms the robustness of the achieved results in the sense of modelling another expression of productivity under the different trends included in the model.

4 Discussion

NMW appears to play an important role in economies. The trend of implementing NMW is spreading (Croatia in 2008, Germany in 2015) with the main aim of reducing poverty and increasing social equality and welfare. The link between NMW and productivity is seldom explored in the complex way as we do, but comparable studies supporting the results of our analysis can be found. An analysis of real data from different UK sectors was conducted by Forth and O'Mahony (2003), who observed a positive impact of NMW on productivity, specifically in various labour sectors. A panel regression is also used here, and the 1995-1998 estimate of a 0.016 pound/hour increase in productivity with a one-pound increase in NMW is close to our estimate. Kim and Jang (2019) proved that increasing federal NMW in the USA enhances restaurant productivity for up to two years. The authors use a panel model with transformed variables, focus on testing the lagged effect of NMW and report that a 1% growth in the minimum wage rate positively influences firm productivity by 0.179%. When approximated using the 2019 EU country data, this works out as a productivity increase of 0.008 EUR/hour with an NMW increase of one Euro, which again matches our results.

There are also studies that show the insignificant or negative impact of increasing NMW on productivity. Bossler et al. (2020) analysed the consequences of the introduction of the minimum wage of companies in Germany. The results of their study do not show an effect on either the productivity of individual companies or on capital investment, but personal costs increased significantly. Wimmer (2000) argues that an increase in the minimum wage will affect the production process of companies in terms of low-skilled labour depending on the industry or occupation concerned. Substantial reductions in labour productivity can be expected in the case of more capital-intensive services, as the eventual maintenance of the availability of these services is conditional on a decline in their quality. The negative effect of minimum wages on company productivity was also found by Álvarez and Fuentes (2018). The results of their analysis for the period between 1998 and 2000 are distinguished according to the skill requirements of workers in the sector. For low-skill sectors, they estimate a 5.8% reduction in total factor productivity as a result of a real increase in the minimum wage of about 22%. For high-skill-intensive sectors, the productivity reduction was estimated to be as high as 9.7%. Sabia (2015) concluded that the redistribution of the composition of

sectoral productivity due to minimum wage increases does not lead to net economic growth but is more likely to be harmful to some low-skilled employees. Del Carpio and Pabon (2017) looked at the issue of substantial minimum wage increases in the light of a subsequent increase in informal employment in response to layoffs. Companies are not as motivated to invest in employee training, which results in a reduction in the number of productive workers and thereby a reduction in overall labour productivity.

More broadly, our work examines the impact of the wage (influenced to some extent by NMW) on productivity. Traditional economic thinking is more concerned with the effect of labour productivity on wages. Meager and Speckesser (2011) deal with productivity, wages and employment in both theoretical and empirical way and offer more possible relations and implications. Standard neoclassical microeconomic theory, described for example in Besanko and Braeutigam (2014), suggests wage correspondence to the marginal productivity of labour. This is true especially in the case where the firm maximises profits, and for a short run. The concept of 'efficiency wages' introduced by Shapiro and Stiglitz (1984) implied a distortion of the suggested straightforward relationship between productivity and wages. Reverse causality is admitted here, where the employer sets a certain level of wages to achieve a specific level of productivity. In Kleinknecht (1998) we can read that Schumpeterian creative destruction process can be enhanced by higher wage growth, which will allow earlier onset of innovation and thus an increase in labour productivity. This explains the effect of wages on productivity in the medium or long run. In this respect, our work can be interpreted as empirical support for the effect of a certain type of wage growth on productivity growth in the short run.

When modelling productivity, inflation may appear to be an appropriate covariate, and the relationship between productivity and inflation has also been addressed in the literature, see for example Hondroyiannis and Papapetrou (1998), Christopoulos and Tsionas (2005) and Kim et al. (2013). In particular, VAR models and approaches using cointegration have been used to investigate the relationship between inflation and productivity, which is a markedly different approach from the one we use. Many studies, including aforementioned ones, found both productivity-inflation causality and inflation-productivity causality. In papers examining the effect of wages on productivity, inflation does not emerge as an independent variable, so we have not included it in the model either.

5 Conclusions

The performed analyses show that minimum wage growth within the EU27 has a positive effect on productivity. The results are sufficiently robust to the different expressions of productivity at a country level and to the accompanying variables included in the models, including different forms of time trends. Although the productivity-related variables naturally produce two distinct clusters of countries in which small differences can be observed when modelling productivity, the positive effect of the minimum wage on productivity remains.

This raises a question of the appropriate setting of NMW. It is also important to monitor other contexts of NMW growth and its impact on unemployment, total household income, and the financial indicators of companies, among others. The Directive on Adequate Minimum Wages in the European Union (European Parliament, 2022) has just been adopted. Member states are obliged to apply indicative reference

values such as 60% of the gross median wage and 50% of the gross average wage when considering the adequacy of statutory minimum wages. The directive is tricky in this respect, as it forces NMW to increase regardless of the specific state of the economy, which may have a negative impact on countries. These are reasons to continue to focus on the minimum wage and to monitor its consequences for the real economy.

Funding

This work was supported by Internal Grant Agency PEF MENDELU, No. PEF-TP-2021007.

References

Agell, J. and Lommerud, K.E. (1997) 'Minimum wages and the incentives for skill formation', *Journal of Public Economics*, Vol. 64, No. 1, pp.25–40, DOI: 10.1016/s0047-2727(96)01595-2.

Álvarez, R. and Fuentes, R. (2018) 'Minimum wage and productivity: evidence from Chilean manufacturing plants', *Economic Development and Cultural Change*, Vol. 67, No. 1, pp.193–224, DOI: 10.1086/697557.

Antonie, M.D., Cristescu, A. and Cataniciu, N. (2010) 'A panel data analysis of the connection between employee remuneration, productivity and minimum wage in Romania', *MCBE '10: Proceedings of the 11th WSEAS International Conference on Mathematics and Computers in Business and Economics*, Mathematics and Computers in Science Engineering, A Series of Reference Books and Textbooks, WSEAS Press, pp.134–139.

Besanko, D. and Braeutigam, R. (2014) *Microeconomics*, 5th ed., Wiley, Hoboken.

Blanchard, O. and Portugal, P. (2001) 'What hides behind an unemployment rate: comparing Portuguese and U.S. labor markets', *American Economic Review*, Vol. 91, No. 1, pp.187–207, DOI: 10.1257/aer.91.1.187.

Bossler, M., Gürtzgen, N., Lochner, B., Betzl, U. and Feist, L. (2020) 'The German minimum wage: effects on productivity, profitability, and investments', *Journal of Economics and Statistics* [*Jahrbücher für Nationalökonomie und Statistik*], Vol. 240, No. 2–3, pp.321–350, DOI: 10.1515/jbnst-2018-0074.

Butschek, S. (2022) 'Raising the bar: minimum wages and employers' hiring standards', *American Economic Journal: Economic Policy*, Vol. 14, No. 2, pp.91–124, DOI: 10.1257/pol.20190534.

Caglayan-Akay, E. and Komuryakan, F. (2022) 'The effects of education and experience on youth employee wages: the case of Turkey', *International Journal of Computational Economics and Econometrics*, Vol. 12, No. 1–2, pp.158–173, DOI: 10.1504/IJCEE.2022.120508.

Chava, S., Oettl, A. and Singh, M. (2023) 'Does a one-size-fits-all minimum wage cause financial stress for small businesses?', *Management Science*, DOI: 10.1287/mnsc.2022.4620.

Christopoulos, D. and Tsionas, E. (2005) 'Productivity growth and inflation in Europe: evidence from panel cointegration tests', *Empirical Economics*, Vol. 30, pp.137–150, DOI: 10.1007/s00181-004-0227-3.

Clemens, J. and Strain, M.R. (2020) 'Implications of schedule irregularity as a minimum wage response margin', *Applied Economics Letters*, Vol. 27, No. 20, pp.1691–1694, DOI: 10.1080/13504851.2020.1713978.

Cosmetatos, G. and Eilon, S. (1983) 'Effects of productivity definition and measurement on performance evaluation', *European Journal of Operational Research*, Vol. 14, No. 1, pp.31–35, DOI: 10.1016/0377-2217(83)90286-2.

Coviello, D., Deserranno, E. and Persico, N. (2022) 'Minimum wage and individual worker productivity: evidence from a large US retailer', *Journal of Political Economy*, Vol. 130, No. 9, pp.2315–2360, DOI: 10.1086/720397.

Croucher, R. and Rizov, M. (2012) 'The impact of the national minimum wage on labour productivity in Britain', *E-Journal of International and Comparative Labour Studies*, Vol. 1, Nos. 3–4, pp.263–289 [online] https://ejcls.adapt.it/index.php/ejcls_adapt (accessed 21 February 2024).

Del Carpio, X.V. and Pabon, L.M. (2017) *Implications of Minimum Wage Increases on Labor Market Dynamics: Lessons for Emerging Economies*, Policy Research Working Paper, No. 8030, DOI: 10.1596/1813-9450-8030.

Draca, M., Machin, S. and van Reenen, J. (2008) 'Minimum wages and firm profitability', *American Economic Journal: Applied Economics*, Vol. 3, No. 1, pp.129–151, DOI: 10.3386/w13996.

European Parliament (2022) *Directive 2022/2041 of the European Parliament and of the Council of 19 October 2022 on Adequate Minimum Wages in the European Union*, PE/28/2022/REV/1, OJ L 275, 25 October, pp.33–47.

Forth, J. and O'Mahony, M. (2003) *The Impact of the National Minimum Wage on Labour Productivity and Unit Labour Costs: A Report to the Low Pay Commission*, National Institute Of Economic And Social Research, London, UK [online] https://openaccess.city.ac.uk/id/eprint/20943/ (accessed 15 May 2023).

Hondroyiannis, G. and Papapetrou, E. (1998) 'Temporal causality and the inflation-productivity relationship: evidence from eight low inflation OECD countries', *International Review of Economics & Finance*, Vol. 7, No. 1, pp.117–135, DOI: 10.1016/S1059-0560(99)80020-3.

Hsieh, C-T. and Klenow, P J. (2009) 'Misallocation and manufacturing TFP in China and India', *The Quarterly Journal of Economics*, Vol. 124, No. 4, pp.140314–48, JSTOR [online] http://www.jstor.org/stable/40506263 (accessed 17 May 2023).

Ibrahim, N.A. and Said, R. (2015) 'The implementation of the national minimum wages in Malaysia', *Journal of Economics, Business and Management*, Vol. 3, No. 1, pp.125–131, DOI: 10.7763/JOEBM.2015.V3.167.

Kim, H.S. and Jang, S.S. (2019) 'Minimum wage increase and firm productivity: evidence from the restaurant industry', *Tourism Management*, Vol. 71, pp.378–388, DOI: 10.1016/j.tourman.2018.10.029.

Kim, S., Lim, H. and Park, D. (2013) 'Does productivity growth lower inflation in Korea?', *Applied Economics*, Vol. 45, No. 16, pp.2183–2190, DOI: 10.1080/00036846.2012.657352.

Kleinknecht, A. (1998) 'Is labour market flexibility harmful to innovation?', *Cambridge Journal of Economics*, Vol. 22, No. 3, pp.387–396.

Koch, M.J. and McGrath, R.G. (1996) 'Improving labor productivity: human resource management policies do matter', *Strategic Management Journal*, Vol. 17, No. 5, pp.335–354, DOI: 10.1002/(SICI)1097-0266(199605)17:5<335:AID-SMJ814>3.0.CO;2-R.

Lee, J.X. and Yuen, J.L.F. (2015) 'Will minimum wage translate into higher productivity? A case analysis of manufacturing firms in Malaysia', *International Journal of Education and Research*, Vol. 3, No. 4, pp.453–464 289 [online] https://www.ijern.com/journal/2015/April-2015/38.pdf (accessed 21 February 2024).

McLaughlin, C. (2009) 'The productivity-enhancing impacts of the minimum wage: lessons from Denmark and New Zealand', *British Journal of Industrial Relations*, Vol. 47, No. 2, pp.327–348, DOI: 10.1111/j.1467-8543.2009.00726.x.

Meager, N. and Speckesser, S. (2011) *Wages, Productivity and Employment: A Review of Theory and International Data*, Institute for Employment Studies [online] https://www.researchgate.net/publication/263414861_Wages_Productivity_and_Employment_A_review_of_theory_and_international_data (accessed 10 October 2023).

Metcalf, D. (2008) 'Why has the British national minimum wage had little or no impact on employment?', *Journal of Industrial Relations*, Vol. 50, No. 3, DOI: 10.1177/0022185608090003.

Nguyen, D.X. (2019) 'Minimum wages and firm productivity: evidence from Vietnamese manufacturing firms', *International Economic Journal*, Vol. 33, No. 3, pp.560–572, DOI: 10.1080/10168737.2019.1624806.

Ozdamar, O., Gunduz, S. and Giovanis, E. (2022) 'The effect of female employment on saving-investment gap and the role of their interaction in the economic growth', *International Journal of Computational Economics and Econometrics*, Vol. 12, No. 3, pp.241–262, DOI: 10.1504/IJCEE.2022.122830.

Riley, R. and Bondibene, C.R. (2017) 'Raising the standard: minimum wages and firm productivity', *Labour Economics*, Vol. 44, pp.27–50, DOI: 10.1016/j.labeco.2016.11.010.

Rizov, M. and Croucher, R. (2011) *The Impact of the UK National Minimum Wage on Productivity by Low-Paying Sectors and Firm-Size Groups: Report to the Low Pay Commission*, Project report, The Low Pay Commission, London [online] https://eprints.mdx.ac.uk/7531/ (accessed 15 May 2023).

Roubalová, L. and Viskotová, L. (2018) 'Productivity development in selected central european countries measured by the Sato production function', *Review of Economic Perspectives*, Vol. 18, No. 4, pp.353–370, DOI: 10.2478/revecp-2018-0018.

Sabia, J.J. (2015) 'Do minimum wages stimulate productivity and growth?', *IZA World of Labor*, No. 221, DOI: 10.15185/izawol.221.

Seok, B.H. and You, H.M. (2022) 'Macroeconomic impacts of increasing the minimum wage: the case of Korea', *Economic Modelling*, Vol. 113, p. 105880, DOI: 10.1016/j.econmod.2020.03.012.

Shapiro, C. and Stiglitz, J. (1984) 'Equilibrium unemployment as a worker discipline device', *American Economic Review*, Vol. 74, No. 3, pp.433–444.

Stigler, G.J. (1946) 'The economics of minimum wage legislation', *The American Economic Review*, Vol. 36, No. 3, pp.358–365.

Syverson, C. (2011) 'What determines productivity?', *Journal of Economic Literature*, Vol. 49, No. 2, pp.326–365, DOI: 10.1257/jel.49.2.326.

Trenovski, B, Kozheski, K, Tashevska, B. and Peovski, F. (2021) 'The minimum wage impact on labour productivity: the case of selected SEE countries', *Management Research and Practice*, Vol. 13, No. 3, pp.32–42, https://mrp.ase.ro/no133/f3.pdf (accessed 15 May 2023).

Wang, M., Lin, H., Huang, Y. and Lu, H. (2023) 'Poverty alleviation and firm productivity: evidence from China's minimum wage system', *International Review of Financial Analysis*, Vol. 87, p.102595, DOI: 10.1016/j.irfa.2023.102595.

Webb, S. (1912) 'The economic theory of a legal minimum wage', *Journal of Political Economy*, Vol. 20, No. 10, pp.973–998, DOI: 10.1086/252125.

Weisskopf, T.E. (2006) 'The effect of unemployment on labour productivity: an international comparative analysis', *International Review of Applied Economics*, Vol. 1, No. 2, pp.127–151, DOI: 10.1080/758528894.

Wimmer, B.S. (2000) 'The minimum wage and productivity differentials', *Journal of Labor Research*, Vol. 21, No. 4, pp.649–668, DOI: 10.1007/s12122-000-1038-8.