FIRM-LEVEL EFFECTS OF MINIMUM WAGES*

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Abstract
We investigate how increases in minimum wage affect various firm-level characteristics. We study firm-level data from Poland, where the minimum wage experienced a large and persistent increase in 2008 and 2009. We show that firms which were more exposed to the minimum wage increase faced higher increases in total labour costs and larger reductions in profitability. Intuitively, higher total labour costs driven by higher minimum wages directly reduce firm profits in the absence of price adjustments. We also show that the sharp increases in the minimum wage increased capital and decreased overall labour productivity and employment. The impact of policy is statistically significant only on capital.

Keywords: Minimum wage, firm profitability, Kaitz index, difference in differences
JEL Classification: C21, J23, L25

1. Introduction

The economic impact of minimum wages continues to be debated among policy makers and researchers. Although the rich literature has rigorously documented a positive impact of minimum wages on the earnings of low-wage workers, existing studies provide ambiguous predictions about potential implications for performance, including changes in firm profitability, capital, labour productivity and sales. The evidence on how firm profits are affected by increases in the minimum wage has attracted little attention[1].

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1 An extensive survey by Lemos (2008) documents over 300 papers on employment effects and none on profit effects in the earlier literature. Draca *et al.* (2011) and Harasztosi and Lindner (2019) are a few examples of recent studies focusing on firm profitability.

In this context, our analysis seeks to contribute to the scarce literature by studying the impact of rising minimum wages on firm profitability and its implications for a range of other characteristics of firms. Unlike most existing papers, which focus on developed countries, this paper aims to understand the minimum wage effect in a transition economy context. This study is the first, to our knowledge, to provide a comprehensive assessment of firm-level adjustments in response to increased minimum wages in Poland.

We focus particularly on the very large and persistent increases in minimum wages in Poland during 2008 and 2009. Figure 1 illustrates this case by showing the historical dynamics of the minimum wage in Poland, while Figure 2 presents the ratio of the minimum to average wages from 1999 to 2017. Prior to 2008, the minimum wage was increased gradually to adjust for inflation growth, whereas the ratio of the minimum wage to the average wage in the economy declined slightly. Figure 2 further shows notable increases in the ratio of the minimum wage to the average wage from around 35% in 2007 to 38% in 2008 and subsequently to 41% in 2009, where it remained during 2010 and 2011. This dramatic and lasting increase in the wage floor coupled with stable growth in the following years provides a quasi-experimental setting which we aim to exploit. We apply a difference-in-differences strategy to examine the economic impact of the minimum wage increases on various firm characteristics, following the methodology of Draca *et al.* (2011).

We perform the analysis using firm-level repeated cross-sectional data from Poland spanning the period between 2005 and 2010. To identify the effect of minimum wage increases, we divide all firms into control and treatment groups based on the Kaitz index, that is, the ratio of the national minimum wage to the average wage for a particular firm. One of the advantages of this approach is the ability of the Kaitz index to capture time-varying changes in minimum wages. To fully understand firms' responses to changing minimum wage levels, we analyse several firm-level outcomes, including total labour costs, firm profitability, employment, capital, labour productivity and sales. To account for potential heterogeneity in wage-setting behaviour among firms and in their responses to the minimum wage policy, we control for firm characteristics, NACE industry codes and NUTS2 regional codes, and we include yearly fixed effects.

We document a positive relationship between exposure to minimum wage rises and firms' total labour costs, and a negative relationship between the exposure and firms' profit margins. Furthermore, we document that labour productivity of firms exposed to minimum wage jumps decreased, while their physical capital levels increased. This suggests the presence of non-negligible capital-labour substitution among the affected firms. Due to a lack of data, we are not able to estimate the effect of the minimum wage rises on output prices. To overcome this issue, we evaluate the effect on firm sales, which is a product of quantity and prices.

Our estimates suggest that firm sales were not affected by the minimum wage increases. Finally, we find no statistically significant effect of minimum wages on employment rates.

Our paper is related to several strands of literature. Firstly, we contribute to the existing studies on earning and employment effects of minimum wages. Standard economic theory suggests that minimum wages increase the earnings of low-wage workers and depress employment rates (Borjas, 2010; Brown, 1999). The empirical literature generally finds positive impacts on the structure of wages, but reaches mixed conclusions on employment effects. On the one hand, Neumark and Wascher (1992) and Baker *et al.* (1999) document a significant negative impact of the minimum wage on employment of teenagers. Another strand of literature suggests that minimum wage increases raise wages of less-skilled younger workers and decreases employment of younger and less educated individuals (Dube *et al.*, 2010; Neumark and Wascher, 2007; Sabia *et al.*, 2012). A number of studies suggest that minimum wage rises have no effect or even have small positive impacts on employment in the fast food industry (Card and Krueger, 2000; Giuliano, 2013; Hamermesh, 1995; Hirsch *et al.*, 2015; Stewart, 2004; Welch, 1995).

Secondly, our study contributes to the literature studying the minimum wage effect in the context of Central and Eastern European countries. For instance, Melnyk (1996), Eriksson and Pytlikova (2004), Fialová and Mysíková (2009) indicate moderate job losses in response to the minimum wage introduction in Poland, Czechia and Slovakia. Further, Jacukowicz (2007), Majchrowska and Zolkiewski (2012) find no impact of the minimum wage on employment, with an adverse impact only on the youngest workers.

Thirdly, our paper contributes to the literature on the effect of minimum wage changes on firm profitability. Draca *et al.* (2011) confirm that introduction of a minimum wage has a negative impact on firm profitability, based on the introduction of a minimum wage in the UK in 1999. Bell and Machin (2018) study fluctuations in firm value in response to an increase in the wage floor. Their results indicate a significant drop in the stock market value for low-wage firms. This decrease in firm value is associated with a decline in profitability. Following Draca *et al.* (2011), Mayneris *et al.* (2018) document lower probability of survival for firms exposed to a minimum wage reform in China in 2004. Harasztosi and Lindner (2019) study the impact of minimum wages in Hungary. They present a comprehensive estimate of the impact of minimum wage increases on employment and different margins of minimum wage adjustment. The link between minimum wages and different firm-level outcomes remains only briefly addressed by existing studies for Eastern European Countries. We aim to extend this strand of research.

Finally, our paper is related to studies that evaluate effects of minimum wage increases. Since firms incur higher wage costs, their profits are at a risk of being reduced. In order to avoid losses, firms can adjust to new conditions by increasing their output prices.

Most studies report very limited effects of the minimum wage on prices (Lemos, 2008; Wadsworth, 2010). However, there are several exceptions, including studies of fast food sectoral prices (Aaronson, 2001) and restaurant prices (Aaronson and French, 2007; Aaronson *et al.*, 2007).

Overall, this study contributes to scant literature investigating the margins of adjustment to minimum wage increases in Poland. The results suggest that, in Poland, the costs of imposing a higher minimum wage are followed by reductions in firm profitability and, in contrast to Harasztosi and Lindner (2019), those costs are not transferred to the consumers.

The paper proceeds as follows. Section 2 provides a description of the minimum wage policy in Poland. Section 3 describes the study model design and empirical specifications of the model together with robustness checks. Section 4 presents the data and the definition of treatment. Section 5 estimates impacts of minimum wage increases on different firm-level outcomes. Section 6 concludes.

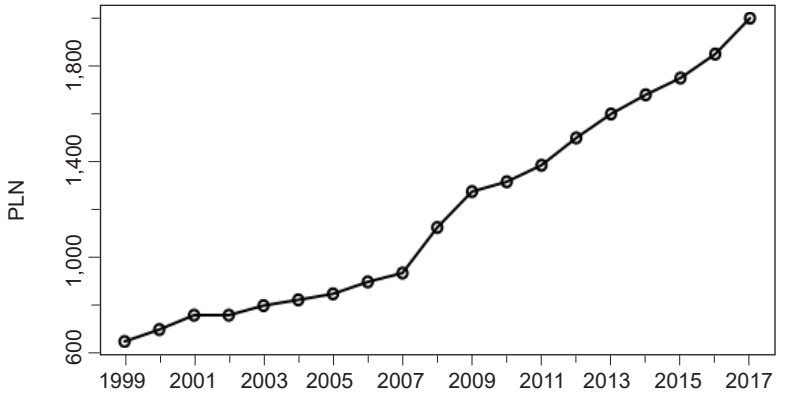
2. Minimum Wage in Poland

The nationally binding minimum wage was introduced in Poland in 1999. Since the Act of 10 October 2002, the level of the minimum wage has been updated annually by the Tripartite Commission for Social and Economic Affairs and is announced by 15 September of the preceding year. The minimum wage is generally updated once per year; however, it is adjusted a second time if the price index is too high (105% or higher).

Figure 1 illustrates the historical minimum wage dynamics in Poland between 1999 and 2017. The size of the wage upratings fluctuated considerably from 0% between 2001 and 2002, when the minimum wage stayed flat at 760 PLN, to 20.3% in 2008, when the wage floor was increased from 936 PLN in the previous year to 1,126 PLN in the following year. The first noticeable rise of around 8% happened between 2000 and 2001. In the subsequent period from 2002 to 2007, the minimum wage growth was slower and relatively stable, leading to an increase from 760 PLN to only 936 PLN over the entire five-year period. After 2007, there were two consecutive episodes when the national wage floor was raised significantly: by 20.3% in 2008 and by 13.3% in 2009. This rapid growth was followed by less than 5% upratings in 2010–2011 and it accelerated slightly in the period 2012–2018, though it never reached the growth rates observed in 2008 and 2009. Overall, there was more than a threefold increase in the minimum wage from 650 PLN in 1999 to 2,000 PLN in 2017[2].

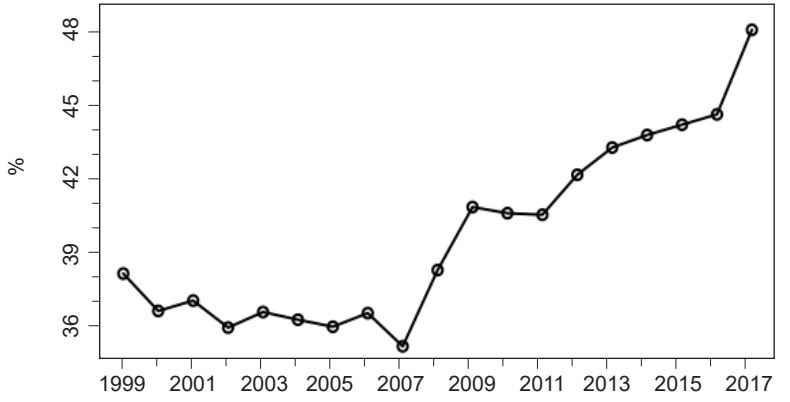
2 The level of minimum wage in Poland increased from 158.9 EUR in 1999 to 453.5 EUR in 2017.

Figure 1: Minimum wage



Source: www.stat.gov.pl

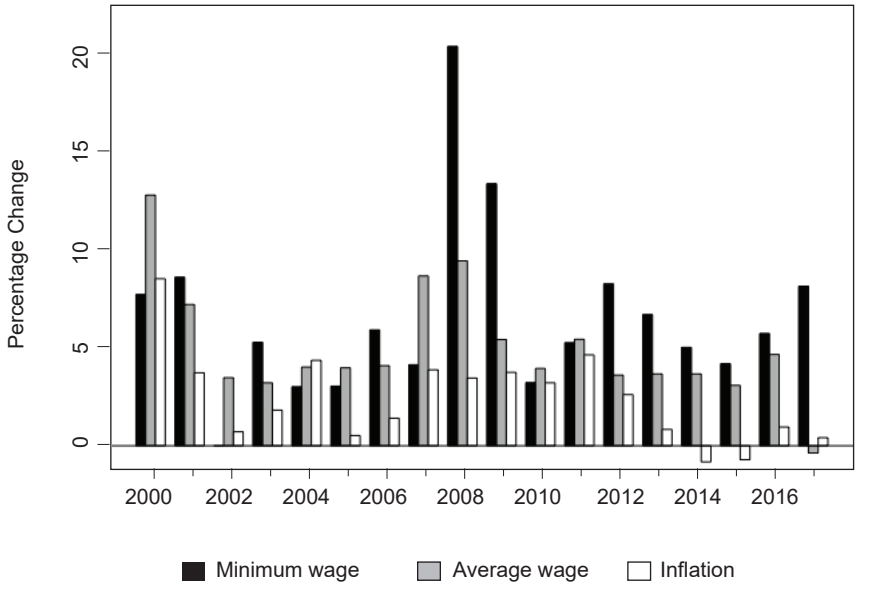
Figure 2: Minimum-to-average wage ratio



Source: www.stat.gov.pl

Figure 2 augments the description of the minimum wage in Poland by comparing its growth dynamics with the average wage and inflation for the time interval considered. It can be observed that the average wage grew in tandem with the minimum wage except the periods of 2008–2009 and 2012–2013, when the growth in the former was twice slower than in the latter. In relative terms, the ratio of the minimum wage to the average wage increased from around 0.35 in 2007 to almost 0.49 in 2017.

Figure 3: Minimum wage growth, average wage growth and inflation in Poland



Source: www.stat.gov.pl

Figure 3 further shows that inflation responds well to increases in the minimum wage in the period before 2008; however, minimum wage growth begins to surpass inflation consistently starting from 2008 with especially pronounced domination in 2008–2009 and 2012–2017. This suggests that the minimum wage remained relatively stable in real terms before 2007 and between 2010 and 2011, while it grew strongly in 2008–2009 and after 2012. In the Polish setting, firms and workers know that the minimum wage will change each year, but they never know by how much. While firms try to guess what the coming year's minimum wage level will be and set their current wages accordingly, they are not able to guess it perfectly. Therefore, there are some firms that overestimate it slightly, whereas others underestimate it. This creates some randomness in firms' pre-change wage levels, at least around the next year's minimum wage. This unexpectedness of the size of minimum wage increases creates the quasi-experimental setup where firms paying wages just below the minimum wage level can be compared to firms paying just above the minimum wage level. Therefore, the difference-in-differences technique is a suitable methodology for evaluating the economic impact of this policy. In particular, we focus on the abnormal, and thus difficult to predict, minimum wage increase in 2008–2009 and study its implications for firms' outcomes. The incidence of persistent increase

of the minimum wage in Poland in 2008–2009 with the highest growth rate of minimum wage in 2008 motivates the identification strategy of this study. This research question has not been addressed by the existing studies; thus, we aim to fill this gap in the literature.

One potential criticism of our choice of the studied period is that the unprecedented increase in the national minimum wage happened at the onset of the financial crisis. As a result, the actual impact of the event under our consideration could be muted by the adverse global shock on Poland's economy. Although this argument could generally be a source of major concern, we would like to point out the fact that Poland was the only European Union country that did not experience a recession. According to Drozdowicz-Biec (2011), this could be explained by several main factors. Firstly, a significant amount of direct investments into Poland's economy strengthened the productivity growth during the crisis period. Secondly, the presence of a relatively large domestic market and little dependence on exports to other countries made the worldwide slump less noticeable for Poland. Thirdly, a flexible exchange rate and currency depreciation supported the international exports and prevented the country from increasing its own costs of production during the recession. The last, but not least, factor is the economic boost caused by EU transfers after the country entered EU in May 2004. The volume of the inflows was not distributed uniformly over the period 2004–2010 and was the largest in 2007–2008. All those conditions helped Poland to survive the financial recession extremely well.

3. Theoretical Framework

In order to gain a better understanding of the scope for minimum wages to influence firm profitability, we follow Ashenfelter and Smith (1979) and present a simple theoretical framework. This model illustrates how the introduction of a minimum wage affects the outcome of a profit-maximizing firm. Consider a competitive firm which hires a fixed amount of workers L at the fixed wage rate W. Additionally, the firm uses another factor of production, capital K at the price r. The final output Q is sold at the price p. Consequently, the firm solves a simple profit maximization problem:

$$\Pi(W, r, p) = pQ - rK - WL \text{ , where } Q = Q(K, L)$$

The first-order conditions imply that the values of all marginal products are equalized to the corresponding prices of inputs:

$$\frac{\partial \Pi}{\partial K} = p\frac{\partial Q}{\partial K} - r = 0, \quad \frac{\partial \Pi}{\partial L} = p\frac{\partial Q}{\partial L} - W = 0$$

Using FOCs, we can find the optimal allocation of labour L and capital K. Substituting the optimal labour L and capital K into the objective function, we obtain the firm's profit $\Pi = \Pi(W, r, p)$ as a function of the prices W, r, and p. Taking first- and second-order derivatives of the profit function with respect to W produces:

$$\frac{\partial \Pi}{\partial W} = p\left(\frac{\partial Q}{\partial L}\frac{\partial L}{\partial W} + \frac{\partial Q}{\partial K}\frac{\partial K}{\partial W}\right) - \left(L + W\frac{\partial L}{\partial W}\right) - r\frac{\partial K}{\partial W} = \tag{3.1}$$

$$\frac{\partial \Pi}{\partial W} = p\left(\frac{\partial Q}{\partial L}\frac{\partial L}{\partial W} + \frac{\partial Q}{\partial K}\frac{\partial K}{\partial W}\right) - \left(L + W\frac{\partial L}{\partial W}\right) - r\frac{\partial K}{\partial W} = \tag{3.2}$$

$$\frac{\partial^2 \Pi}{\partial W^2} = -\frac{\partial L}{\partial W} \tag{3.3}$$

Assume that the minimum wage W^* is introduced. The situation when the existing wage W is above the required threshold W^* is trivial since the minimum wage will have no impact on the firm's inputs and profit. Therefore, we are interested in a non-trivial case where the firm initially offers the wage level W below a required wage rate W^*. What will happen with the firm's profitability in this situation? It will be reduced by $\Pi(W, r, p) - \Pi(W,^* r, p)$ Substituting the first- and second-order derivatives defined by (3.1)–(3.3) into a second-order Taylor series for the profit function, we can approximate a reduction in the firm's profitability as follows:

$$\Pi\left(W, r, p\right) - \Pi\left(W^*, r, p\right) = -L\left(W^* - W\right) - \frac{1}{2}\frac{\partial L}{\partial W}\left(W^* - W\right)^2$$

or equivalently

$$\Delta\Pi = -WL\left(\frac{\Delta W}{W} + \frac{\eta}{2}\left(\frac{\Delta W}{W}\right)^2\right) \tag{3.4}$$

where $\Delta W = W^* - W > 0$ and $\eta = \frac{W}{L}\frac{\partial L}{\partial W} < 0$ is the elasticity of labour demand. Equation (3.4) has two components on the right-hand side. The first term, $-WL \times \frac{\Delta W}{W}$, captures the labour demand effect, namely, a reduction in the firm's profitability due to higher costs of labour input. The second term, $-WL \times \frac{\eta}{2}\left(\frac{\Delta W}{W}\right)^2$, reflects the change in the firm's profitability due to labour adjustment in response to higher labour costs. The size of this adjustment depends on the elasticity of labour demand. There are two important cases that are worth mentioning.

Firstly, assuming no change in labour demand ($\eta = 0$), Equation (3.4) simplifies to

$$\Delta\Pi = -WL\left(\frac{\Delta W}{W}\right) \tag{3.5}$$

Thus, one would observe a decline in the firm's profitability equal to the wage bill multiplied by the proportionate change in the wage. Moreover, this decline is expected to be larger for those firms with lower wages since they will be more affected by the wage policy.

Secondly, a general case with a non-zero elasticity of labour demand ($\eta \neq 0$), produces an ambiguous result. In this situation, the sign of the impact depends on η through the second-order effect. Equation (3.4) shows that the second term may outweigh the proportionate change in the wage, leading to increased profitability of the firm. Intuitively, the firm can substitute more costly labour of low-wage workers with capital and avoid paying higher wages.

The results of the theoretical model further motivate the empirical study of minimum wage effects in Poland. Mechanically, an increase in the level of a binding minimum wage affects the firm's accounting profit in different ways. The lower the initial level of firm wages, the higher the reduction in firm profitability. However, firms can offset the losses associated with a higher minimum wage through various labour-demand adjustments. The difference-in-differences model proposed in this study evaluates the impact of a binding wage increase on different firm-level outcomes and assesses possible channels of firm adjustments.

4. Model Design

The empirical analysis proposed in this study is based on the difference-in-differences approach in the spirit of Draca *et al.* (2011). We initially specify *a treatment group* consisting of those firms that are most likely to be affected by the new minimum wage level. The definition of "most likely to be affected" means that the minimum wage increase will likely lead to an increase in the existing wages of the firms under our consideration. Further, we identify *a control group* consisting of those firms where wages are not affected or are affected to a much lesser extent after the new minimum wage is imposed.

The following research design allows us to examine different responses of profitability and other firm-level outcomes of control and treatment firms before and after the minimum wage increase in 2008. To control for the yearly changes in the minimum wage level, we define the Kaitz index[3] as a ratio of the minimum wage in each year to the average wage in the firm i in a particular year:

3 See Neumark and Wascher (1992), Neumark and Wascher (1994), Lee (1999), Autor *et al.* (2016), among others.

$$Kaitz_{it} = \frac{MW_t}{AW_{it}}$$

This ratio takes into account time-varying likelihood of the firms to be treated. The closer the Kaitz index to unity, the higher the bite of the minimum wage legislation for a particular firm in a specific year.

4.1 Empirical specification

We estimate the impact of the minimum wage increase on employment and firm-level outcomes (costs of labour, profits, capital and sales). Similarly to Harasztosi and Lindner (2019), we compare more affected and less affected firms over six financial years (three years before and three years after the minimum wage increase). We estimate the responses of interest by running various two-stage difference-in-differences regressions:

$$y_{it} = \gamma_1 Time + \gamma_2 Kaitz_{it} + \gamma_3 Kaitz_{it} Time + IND_{st} + \beta X_{it} + \varepsilon_{it} \quad (4.1)$$

$$Kaitz_{it} = \alpha_0 P_{S2008} + \alpha_1 IND_{st} + u_{it} \quad (4.2)$$

The dependent variable in the first-stage Equation (4.2) is the Kaitz index of the firm i in the year t. The right-hand side variable P_{S2008} controls for the industry-level exposure to the minimum wage increase in 2008. Specifically, this is a proportion of workers in each NACE 3-digit industry for which the minimum wage is binding in 2008. IND_{st} are industry-level controls. The response variable y_{it} of the second-stage regression (4.1) represents the logarithm of employment or one of the firm-level outcomes: total costs of labour, profit margin, capital, sales and labour productivity. We define the firm-level profit margin as a fraction of firm-level operating profit over sales, firm-level capital as tangible fixed assets over sales and labour productivity as fraction of sales over employment. The full set of second-stage control variables contains the following variables: *Time* is a dummy variable equal to 1 for the time periods after the minimum wage increase (2008–2010) and 0 for the time periods before the minimum wage increase (2005–2007), X_{it} are firm characteristics (depreciation share, lag of employment share and age of the company), IND_{st} is a set of 2-digit NACE industry dummies. For the main analysis, we exclude firms where the number of workers is less than 9 or the average wage in the firm is less than 80 percent of the minimum wage.

The two-stage formulation of the treatment variable, the Kaitz index, allows us to deal with the endogeneity issue in Equation (4.1). The Kaitz index is defined as a ratio of the minimum wage to the average for the particular firm. The average wage in the firm is likely to be endogenous in Equation (4.1) as it can be affected by factors other than

the level of minimum wage in the particular year. The same factors may affect the firm-level outcomes. The endogeneity problem in Equation (4.1) leads to a bias in the estimate of the Kaitz index. The direction of the bias is affected by the correlation between the unobservables and the Kaitz index (average wage). For instance, the unobservables can be related to the firm's productivity, and these might be some firm characteristics that make the firm more productive in general: pay higher wages and at the same time report higher productivity. Therefore, we would like to instrument the Kaitz index by some factors that are external to the firm but affect the wage distribution captured by the Kaitz index. The industry-level proportions of workers directly affected by the minimum wage in the year 2008 in Equation (4.2) should control for the variation in the Kaitz index that results from inflation or another aggregate factor at the industry-level (Neumark and Wascher, 2007) rather than the minimum wage policy itself. The variable will be a valid instrument if its relevant, explains the variation in the Kaitz index and is really exogenous, not correlated with the firm's outcome. While we cannot explicitly test the second condition (there are as many instruments as we have endogenous variables), we will test the relevance of the instrument in Section 6.1. The two-stage identification procedure with the proportions of minimum wage workers at each industry defines the average causal effect of treatment for those whose treatment status is affected by the instrument (Angrist and Imbens, 1995).

4.2 Robustness checks

The empirical strategy described in the previous sections establishes that, under the setting of minimum wage increases in Poland, the difference-in-differences methodology provides a strongly founded framework for evaluating the impact of the minimum wage increase on different firm-level outcomes. However, it is still possible to further fine-tune the results by formally verifying the validity of our assumptions and performing robustness checks of the estimates. In this study, we test the possibility of pre-policy trends in the outcome variables between treatment and control groups by performing a "placebo test" using the pre-policy data. A potential caveat of the quasi-experimental data is that our conclusions might be driven by the initial low-wage status and are not a result of the policy. We check this possibility in detail by carrying an extensive examination of firm outcomes for treatment and control groups in response to placebo tests in the pre-policy periods.

5. Data and Descriptive Statistics

This paper uses two main sources of data: Bureau van Dijk Amadeus dataset and Structure of Wages and Salaries by Occupations in Poland. Amadeus is a comprehensive firm-level database of companies registered in the National Court Registry: joint-stock companies, limited liability companies, cooperatives, state enterprises, joint-stock companies, banks, insurance companies and investment funds, as well as others. Companies should provide their annual and semi-annual reports to the National Court at the end of their financial year. The informal sector is excluded from the database. The key advantage of this dataset is that it is a full database of companies listed in the National Court Registry and on top of providing detailed financial and accounting information, it also allows us to extract firm-level employment counts and average wages. Therefore, a significant number of diverse firms are present in the database, which makes our analyses possible to conduct. Amadeus contains detailed financial and accounting information on firms, including balance sheets and profit and loss statements, together with other relevant characteristics such as the year of incorporation, official address, legal form, auditors, number of employees, and industry codes. Unfortunately, Amadeus does not report individual earnings of workers and their personal characteristics. However, Amadeus reports the total labour costs and the numbers of employees, which allows us to calculate the average earnings per worker within the firm. Amadeus covers approximately 200,000 Polish companies. In our analysis, we focus on firms where the number of workers is more than 9 and the average wage in the firm is less than 2,600.00 PLN[4]. Therefore, we construct a repeated cross-sectional sample of 6,008 firms over six financial years from 1 January 2005 to 31 December 2010. The detailed description of all firm-level variables used in our analysis is presented in Table 5 together with the descriptive statistics of the key variables in Table 1.

The Structure of Wages and Salaries (SWS) by Occupations in Poland[5] is a large enterprise sample survey that covers entities where the number of employees exceeds 9 persons and is carried out with biennial frequency. The structure of the survey allows analysis of earnings and their structure. The data on earnings are registered only for individuals who allow linking their demographic and socio-occupational characteristics with monthly earnings.

4 According to calculations provided by the Central Statistical Office of Poland, the median wage in Poland in 2008 was 2,600.00 PLN. The choice of this particular threshold aims to select firms with a similar distribution of earnings.

5 The Structure of Wages and Salaries (SWS) by Occupations in Poland is provided by the CSO of Poland and is a part of the original Structure of Earnings Survey collected for the Eurostat.

Table 1: Descriptive statistics – Bureau van Dijk Amadeus

	Year 2005		Year 2006		Year 2007	
	Mean	St.D.	Mean	St.D.	Mean	St.D.
Labour costs	0.224	0.295	0.209	0.183	0.257	2.680
Profitability (= EBIT/SALES)	−0.012	0.525	0.026	0.213	−0.215	10.413
Capital	0.678	1.737	0.790	2.700	2.491	95.004
Material costs	0.478	0.262	0.468	0.278	0.492	0.304
Firm size	192.714	367.576	120.184	257.312	124.733	348.332
Sales	20,788,941	42,212,264	16,991,373	39,343,218	19,454,848	43,321,790
Labour productivity	258,013.60	467,959.70	235,134.20	390,230.40	269,849.30	395,841.50
	Year 2008		**Year 2009**		**Year 2010**	
	Mean	St.D.	Mean	St.D.	Mean	St.D.
Labour costs	0.220	0.610	0.254	1.865	0.194	1.006
Profitability (= EBIT/SALES)	−0.027	1.734	−0.186	8.702	−0.014	1.175
Capital	0.528	1.739	0.805	7.320	0.546	4.952
Average material costs	0.482	0.348	0.479	0.457	0.558	0.262
Firm size	102.879	326.611	77.183	261.810	147.002	319.992
Sales	16,485,015	43,272,155	12,683,757	37,969,734	25,976,005	47,421,485
Labour productivity	252,378.90	372,138.10	247,701.20	457,799.50	334,846.50	722,536.00

Note: This table presents descriptive statistics (mean and standard deviation) of firm-level Bureau van Dijk Amadeus for the period 2005–2010. It shows the summary statistics of main variables used for the firm-level analysis. Labour costs, capital expenses (tangible assets) and material costs are calculated as a fraction of total revenue (sales). Average firm size (number of employees) is expressed in actual units. Labour productivity is calculated as a fraction of total revenue per employee.

Source: Bureau van Dijk Amadeus and own calculations

Average monthly wages and salaries are compiled by the categories of earnings obligatory in a given period, *i.e.*, as gross ones (including deductions towards income tax from natural persons and obligatory social insurance – retirement and disability and sick pension paid by the insured employee). Additionally, the survey collects information on individual characteristics such as gender, age, level of education, work seniority and occupation

performed as well as the Polish Classification of Activities for the place of work, which is comparable to NACE. For the further analysis, we matched the firm-level Amadeus dataset with the Structure of Wages and Salaries based on industry-level characteristics. Unfortunately, we cannot find a direct association between the two databases as workers from the Structure of Wages and Salaries do not report their places of work, but they do report the industry information about their places of work. Therefore, we calculate the proportions of workers directly affected by the minimum wage legislation at each NACE three-digit industry level in the year 2008 and assign this value to each firm in the same three-digit industry.

Table 6 in the Appendix provides a comparison between proportions of minimum wage firms in each NACE 1-digit industry from the Bureau van Dijk Amadeus and Structure of Wages and Salaries datasets. The definition of minimum-wage firm requires that the average wage in the firm in the previous year was less than the minimum wage in the particular year $AW_{t-1} < MW_t$.

According to the numbers presented in Table 6, the distribution of minimum-wage workers is similar in both datasets. Manufacturing, transportation and real estate are industries with the highest concentration of minimum-wage workers, while mining and quarrying is an industry completely without minimum-wage workers in both datasets. This similarity in the distribution of minimum-wage workers supports further matching of both datasets. We tested the existence of a relationship between the distributions of minimum-wage workers in Amadeus and SWS formally using a two-sample t-test. The *p*-value of the test is greater than 0.05. Therefore, the mean difference between the proportions of minimum-wage workers in both databases is not statistically different from zero.

We calculate the proportions of workers for which the minimum wage is binding in each NACE three-digit industry from the Structure of Wages and Salaries and use them to control for the industry-level exposure of minimum wage in 2008 by means of Equation (4.2).

6. Main Results

6.1 Firm-level estimates of the impact of minimum wage increase

Table 2 reports the results obtained by estimating separate difference-in-differences regressions of total labour costs, profit margin, employment, labour productivity and sales using classical OLS and two-stage procedure described by Equations (4.1) and (4.2). The numbers presented in Table 2 suggest that IV estimates and OLS estimates differ, but the IV estimates tend to be of the same sign and magnitude as the OLS estimates.

All the OLS estimates except sales and employment are highly statistically significant, while the IV estimates are not.

Before going into details of the main results, we would like to stress that the first-stage F-statistic is very high, the excluded instruments are statistically significant and therefore relevant. Our estimates imply that firms more exposed to the minimum wage increase face higher increases in total labour costs. For example, our estimates suggest that an average firm in the manufacturing industry (with the Kaitz index in 2008 equal to 0.650, see Table 7) faced an increase in labour costs of about 23.5 percentage points. This result is supported by Figure 4 in the Appendix. This figure presents the evolution of log earning distribution over time, where we can observe that the left tail of the distribution plot has a tendency to be squeezed to the centre. This result suggests the positive impact of minimum wage policy on the earnings of low-wage workers.

Further, our results show that an increase in the minimum wage contributes negatively to firm profitability. Using the example of an average firm in the manufacturing sector, we observe that in response to the 2008 minimum wage increase, its profits dropped by about 14 percentage points. The estimates of total labour costs and firms profitability are not statistically significant but consistent with the prediction of the theoretical model outlined in Section 3. Furthermore, we find that the minimum wage has no significant impact on employment and sales for both IV and OLS models. The insignificant impact of the policy on sales might indicate that firms do not adjust their output prices and pass all the costs associated with higher minimum wages directly into profit margins. Unfortunately, Amadeus does not record information on firm output prices. Therefore, we cannot estimate directly the impact of the policy on prices. The estimate of the impact of the minimum wage policy on labour productivity shows that labour productivity decreased substantially in response to the minimum wage increase. We report a non significant drop in labour productivity, about 27 percentage points for the average firm in the manufacturing sector. In contrast, capital increases as a result of the policy. The increase in the capital is statistically significant for both the two-stage and OLS models. According to our results, the average firm in the manufacturing sector experienced a huge 93 percentage-point increase in its capital. This might indicate the presence of capital-labour substitution in production. In addition, the considerably high values of the estimate of capital could have been influenced by a significant increase in foreign capital in Poland before the EU accession and elimination of barriers to free flow of investment capital after the EU accession. The direct access to foreign capital was supported by a sizeable increase in gross fixed capital formation, from –0.1% in 2003 and 6.4% in 2004 to 17.6% in 2007 (Kaluzynska *et al.*, 2009).

Table 2: Firm-level estimates of impact of minimum wage increase in 2008

	Labour costs	Profit margin	Employ-ment	Capital	Labour productivity	Sales
	(1)	(2)	(3)	(4)	(5)	(6)
DID IV	0.361 (0.311)	−0.215 (0.478)	−0.232 (1.344)	1.432* (0.788)	−0.422 (0.708)	−0.654 (1.077)
DID OLS	0.636*** (0.228)	−0.798** (0.324)	1.441 (1.203)	1.523*** (0.529)	−1.197** (0.536)	0.244 (0.937)
Observations	6,008	6,000	6,008	5,956	6,008	6,008

Notes: Each column shows the results of a separate difference-in-differences regression of the treatment for different firm-level outcomes over the period 2005–2010. The "before" minimum wage increase period corresponds to 2005–2007 and the "after" minimum wage increase period to 2008–2010. The standard errors are clustered at the NACE three-digit industry level. The regression controls are: firm age, two-digit NACE industry dummies, NUTS2 regional industry dummies, lag of depreciation share and lag of employment. *** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 1 percent level.

Source: own calculations

Table 3: Lags and leads for difference-in-differences estimator

	Labour costs	Profit margin	Employ-ment	Capital	Labour productivity	Sales
	(1)	(2)	(3)	(4)	(5)	(6)
Policy in 2005	−0.0176 (0.0823)	0.309 (0.211)	−0.0338 (0.280)	0.214 (0.207)	−0.362** (0.155)	−0.396* (0.220)
Policy in 2006	0.0112 (0.0254)	−0.00802 (0.0461)	−0.288*** (0.0935)	−0.00248 (0.129)	−0.118 (0.0735)	−0.406*** (0.0817)
Policy in 2008	0.495* (0.274)	−0.291 (0.424)	0.143 (1.261)	1.191 (1.675)	−1.005 (0.633)	−0.862 (1.001)
Policy in 2009	0.224 (0.242)	−0.107 (0.399)	−0.646 (1.071)	1.163 (1.583)	−0.228 (0.596)	−0.874 (0.904)
Policy in 2010	0.254 (0.257)	−0.168 (0.414)	−0.0846 (1.124)	1.132 (1.587)	−0.0944 (0.604)	−0.179 (0.915)
Observations	6,008	6,000	6,008	5,956	6,008	6,008

Notes: Each column shows the results of a separate difference-in-differences regression which tests for existence of a pre-sample common trend. The "before" minimum wage increase period corresponds to 2005–2007 and the "after" minimum wage increase period to 2008–2010. The standard errors are clustered at the NACE three-digit industry level. The regression controls are: firm age, two-digit NACE industry dummies, lag of depreciation share and lag of employment. The regression models enable leads and lags of the treatment.

*** Significant at the 1 percent level, **Significant at the 5 percent level, * Significant at the 1 percent level.

Source: own calculations

6.2 Testing for the existence of pre-treatment common trend

The empirical strategy described in the previous sections establishes that, under the setting of minimum wage increases in Poland, the difference-in-differences methodology provides a strongly founded framework for evaluating the impact of the minimum wage increase on economic variables. The main identifying assumption for the difference-in-differences technique is parallel trends for treatment and control firms under no extreme minimum wage shifts. The formal method for testing this assumption is to add leads of the treatment instead to a main specification (Autor, 2003). Specifically, verifying the common trend assumption in the difference-in-differences approach requires testing the hypothesis that the coefficients on all leads of the treatment are zero.

The results presented in Table 3 suggest that total labour costs, profit margin and capital in highly exposed and non-exposed firms follow the same parallel trend before the minimum wage increase in 2008. The statistical significance of the leads for sales, labour productivity and employment suggests that policy has effect on those variables, but we have to interpret it with caution, because of diverging pre-policy trends for less and more affected firms.

6.3 Testing for attrition bias

The following section presents the test to examine sensitivity of our main estimates to possible selective attrition. Unfortunately, the structure of the dataset in the study does not allow us to observe the same firms over time. Some reporting information on balance sheets or profit/loss accounts may not be filled in by the companies for all years. The reasons behind this may be different. The Law on Accountancy obliges firms to fill in and publish information about their accounts but not all of the companies comply with those rules. Systematic differences between firms that drop out from the sample and those that stay can introduce bias into results – attrition bias. However, the results may not necessarily be biased, despite different drop-out rates.

We introduce a regression similar to (4.1) with one extra control (Wooldridge, 2010), a dummy variable (drop-out indicator) indicating whether information about average earnings (as we construct our control and treatment groups based on availability of the earnings variable) is also available for the next year. The insignificant coefficient of this dummy variable means that the presence of earning data in the next year is not systematically related to our response variable and there is no evidence of systematic attrition. We estimate five separate difference-in-differences equations where dependent variables are total labour costs, profit margin and capital. The results from Table 4 suggest

that dummy variables are insignificant in the specifications with labour costs, profit margin and capital. Therefore, there is no systematic difference between firms which drop out from the sample and those that remain. The interpretation of the results for employment, labour productivity and sales has difficulties for both tests: common trend and systematic attrition. The reason behind this result might be endogeneity of those variables with respect to minimum wage. The results presented in Table 3 suggest that, before 2008, firms with higher Kaitz index had lower employment levels (sales). Those firms were dropping out from the sample over the time.

Table 4: Testing for attrition bias

	Labour costs	Profit margin	Employ-ment	Capital	Labour productivity	Sales
	(1)	(2)	(3)	(4)	(5)	(6)
Drop–out Indicator	−0.004 (0.014)	−0.011 (0.021)	0.190*** (0.018)	0.003 (0.033)	0.027* (0.016)	0.217*** (0.025)
Observations	6,008	6,000	6,008	5,956	6,008	6,008

Notes: Each column shows the results of a separate difference-in-differences regression of the treatment on different firm-level outcomes over the period 2005–2010. The "before" minimum wage increase period corresponds to 2005–2007 and the "after" minimum wage increase period to 2008–2010. The standard errors are heteroskedasticity-robust corrected for autocorrelation (HAC). The regression controls are firm age, two-digit NACE industry dummies, lag of depreciationshare and lag of employment. *** Significant at the 1 percent level, ** Significant at the 5 percent level. * Significant at the 1 percent level.

Source: own calculations

7. Conclusions

Exploiting the repeated firm-level cross-sectional data from Bureau Van Dijk "Amadeus" database, this study presents compelling empirical evidence that firms more affected by the minimum wage increase in Poland in 2008 experienced higher increases in total labour costs. As a result, firm profitability was reduced. The increase in overall labour costs as well as the reduction in profitability were highly statistically significant for the model with classical OLS estimates and not statistically significant for the model with instrumental variables. Furthermore, we find that employment and sales were not affected by the policy. Our results suggest that labour productivity decreases substantially in response to a higher minimum wage. Our estimates of capital suggest that the share of capital increases in response to a minimum wage rise. This may indicate the presence of some capital-labour substitution in production. The results are consistent with

predictions of a theoretical model for a profit-maximizing firm and are robust to alternative assumptions in the identification strategy.

There are, of course, a number of shortcomings in the study that future research could explore. Firstly, it would have been useful to test our assumption, which is based on the evidence of similar studies in other countries, that the firms do not pass higher costs resulting from minimum wage rises on to consumers. Testing this hypothesis would require obtaining and comparing the difference-in-differences estimates based on firm-level data according to the competitiveness of the industry. Secondly, having the data on prices would enable us to directly check whether prices responded to an increase in the minimum wage. Thirdly, it will be useful to explore the potential dynamics of the minimum wage increase over a longer time span as the increase in the minimum wage persists for further years (Callaway and Sant'Anna, 2018).

Finally, the current analysis focuses on short-term responses of firms but it would be equally interesting to explore changes in our results if there is a possibility that firms could leave or enter the labour market in response to rises in the minimum wage.

Appendix: Firm-level data

The Bureau van Dijk Amadeus dataset contains information about private and publicly owned non-financial firms in Poland.

Table 5: Description of main variables

Profit	Operating profit (EBIT)	All operating revenues - a ll operating expenses (gross profit - other operating expenses)
Revenue	Operating revenue (turnover)	Total operating revenues (net sales + other operating revenues + stock variations)
Employment	Number of employees	Total number of employees included in the company's payroll
Labour costs	Costs of employees	Detail of all the employee costs of the company (including pension costs)
Sales		Net sales
Capital	Tangible fixed assets	All tangible assets such as buildings, machinery, etc.
Material expenses	Material costs	Details on purchases of goods (raw materials + finished goods). No services.
Depreciation	Depreciation and amortization	Total amount of depreciation and amortization of assets

Source: Bureau van Dijk Amadeus

Table 6: Industry-level proportions

	Amadeus	SWS
Agriculture, hunting and forestry	5.41	0.00
Mining and quarrying	0.00	0.00
Manufacturing	9.01	26.80
Electricity, gas and water supply	3.60	3.18
Construction	0.00	3.07
Wholesale and retail trade	6.31	4.51
Hotels and restaurants	1.35	1.20
Transport, storage and communication	37.84	16.10
Financial intermediation	3.60	4.81
Real estate, renting and business activities	28.83	29.40
Education	1.35	8.48
Other activities	2.70	2.45

Notes: This table summarizes information about proportions of minimum-wage workers in each NACE one-digit industry in the year 2008 in the Structure of Wages and Salaries (SWS) by Occupations in Poland and proportions of minimum wage firms in the Bureau van Dijk Amadeus database. Zero numbers in the table mean that there are no firms with an average wage below the minimum wage (Amadeus) or workers with a salary below the minimum (SWS).

Source: Bureau van Dijk Amadeus, Structure of Wages and Salaries (SWS) by Occupations in Poland and own calculations

Table 7: Mean values of Kaitz index over 2005–2010

	2005	2006	2007	2008	2009	2010
Agriculture, hunting and forestry	0.536	0.527	0.565	0.652	0.768	0.724
Mining and quarrying	0.515	0.536	0.589	0.712	0.796	0.751
Manufacturing	0.545	0.558	0.555	0.650	0.747	0.717
Electricity, gas and water supply	0.571	0.533	0.566	0.670	0.786	0.696
Construction	–	–	–	0.640	0.735	0.644
Wholesale and retail trade	0.480	0.559	0.565	0.666	0.797	0.749
Hotels and restaurants	0.377	0.554	0.623	0.672	0.816	–
Transport, storage and communication	0.535	0.568	0.585	0.673	0.782	0.721
Financial intermediation	0.752	0.571	0.593	0.717	0.873	1.040
Real estate, renting and business activities	0.423	0.487	0.542	0.678	0.783	0.662
Education	0.464	0.481	0.469	0.570	0.720	0.602
Other activities	0.529	0.488	0.574	0.674	0.746	0.805

Notes: This table provides information about mean values of the Kaitz index for the period 2005–2010. The dashed line for Construction and Hotels and restaurants represents missing observations for these industries.

Source: Bureau van Dijk Amadeus and own calculations

Figure 4: Evolution of log earnings distributions over time

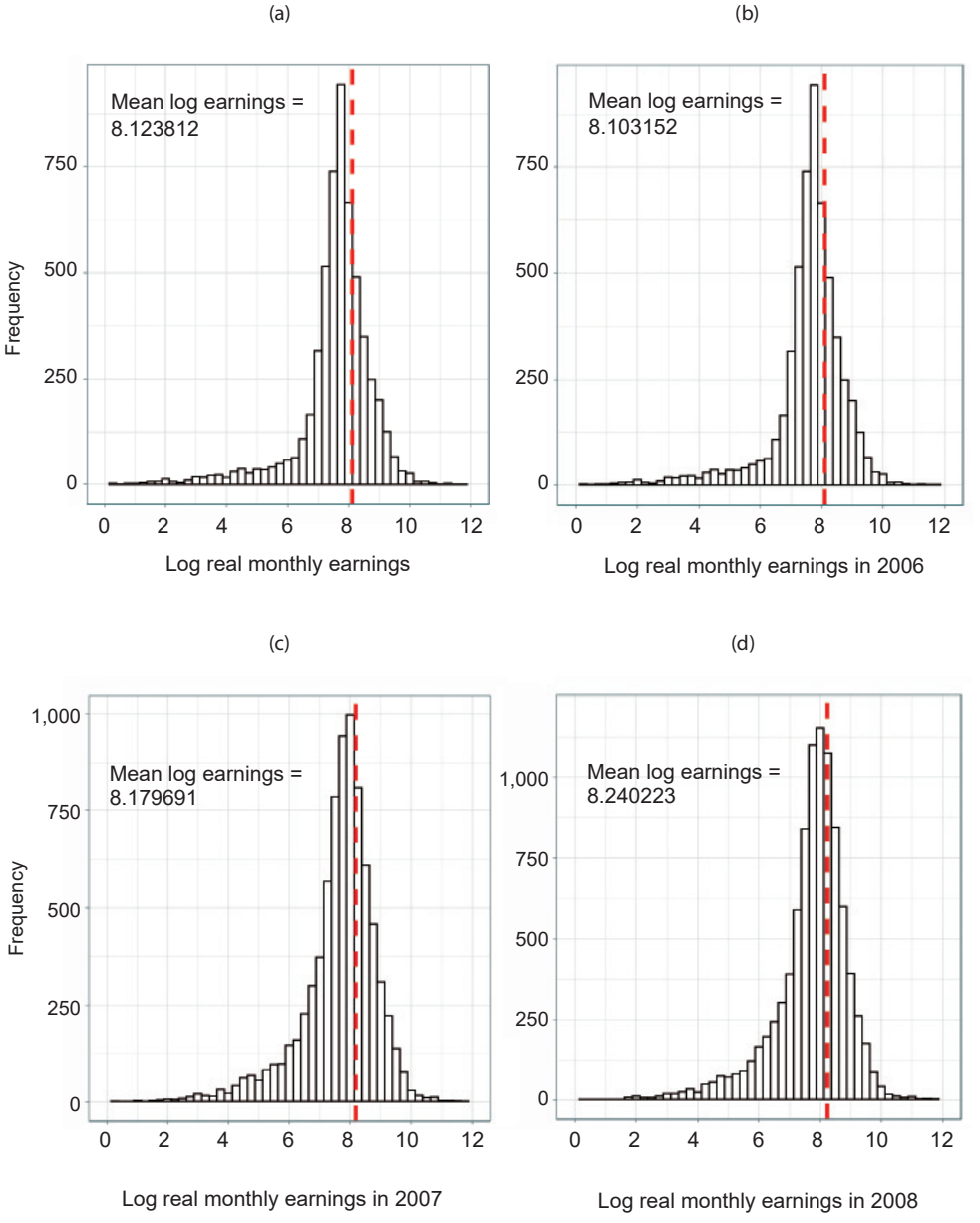
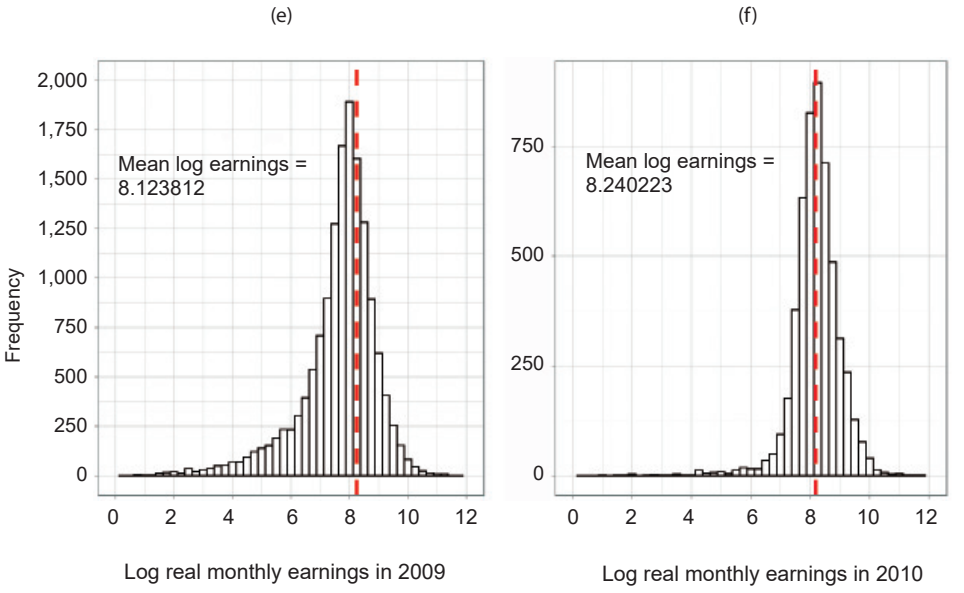


Figure 4: Continuation



Source: Bureau van Dijk Amadeus and own calculations

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