Wage and Employment Impact of Minimum Wage: Evidence from Lithuania*

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Abstract

This paper evaluates the worker-level effects of a historically large and permanent increase in the minimum wage in Lithuania. Our identification strategy leverages variation in workers' exposure to the new minimum wage, and exploits the fact that there has been no increase in the minimum wage in previous years, to account for heterogeneous labor market prospects of low-wage workers relative to high-wage workers. Using detailed administrative records to track workers before and after the policy change, we show that the minimum wage hike significantly increased the earnings of low-wage workers. This direct effect was amplified by wage spillovers reaching the median of the pre-policy income distribution. Overall, we find no negative effects on the employment prospects of low-wage workers. However, we provide suggestive evidence that young workers, highly exposed municipalities, and tradable sectors may be more negatively affected. In contrast, labor market concentration or the presence of envelope wages appear to be associated with lower job losses. Taken together, our findings imply an employment elasticity with respect to the minimum wage of -0.021, and an own-wage elasticity of -0.033, suggesting that wage gains dominated employment losses.

JEL classification: J23, J38, J48

Keywords: Minimum Wage, Employment, Wages

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1 Introduction

Minimum wage is the flagship policy to increase wages at the bottom of the income distribution. In the U.S., a total of 74 cities, counties, and states raised their minimum wages in 2021 (Lathrop, 2020). In the European Union, minimum wage legislation is also gaining momentum with several member states raising national minimum wages (Aumayr-Pintar et al., 2020), and the Council recently agreeing on a mandate to implement a European framework for adequate minimum wages (Council of the European Union, 2021). Despite being widely used, however, minimum wage policy is not without controversy, as the evidence on the overall effect of minimum wages on low-wage workers remains mixed (Neumark and Shirley, 2022; Manning, 2021).

In this paper, we analyze the labor market prospects of low-wage workers following a significant increase in the minimum wage in Lithuania. On the 19th of December of 2012, the government announced an increase in the minimum wage from 317 to 373 euros, effective on the 1st of January of 2013. This 17.7% hike represents the largest relative increase in Lithuania's history and has several features that make it an interesting case for investigating the effect of the minimum wage on the labor market. First, the hike is among the largest single-step minimum wage increases analyzed in the literature. Second, it was a permanent increase that profoundly altered the earnings distribution, as around 25% of wage earners had monthly incomes of less than 373 euros at the end of 2012. Third, it was enacted only 5 months after an earlier, relatively smaller raise, that followed 4 years of no change. Fourth, this historically large increase was adopted in a context of favorable conditions, namely sustained economic and price growth, as well as being the result of an agreement between the social partners.

To evaluate the impact of such increase, we use detailed monthly Social Security records covering a quarter of the Lithuanian population to track the labor market outcomes of workers, i.e., income and employment, before and after the legislative change. Our identification strategy relies on two unique features of our setting. We exploit the high-frequency nature of our data and leverage variation in workers' exposure to the new minimum wage just prior to its increase. Therefore, we precisely locate workers along the income distribution, from the most to the least exposed to the policy change, thereby being able to identify both the direct and indirect effects of the minimum wage.

As emphasized by Ashenfelter and Card (1982), labor market outcomes of low-wage workers differ from those of workers higher up in the income distribution both in terms of

employment retention probabilities and potential income growth, regardless of any change in the minimum wage. To account for these differences, we adopt a strategy similar to that of Dustmann et al. (2022). We take advantage of the period in which we observe no change in the level of the minimum wage to contrast labor market outcomes over such period to those after the minimum wage increase, and use the upper tail of the income distribution to account for economy-wide effects. In this framework, we identify the causal effect of the minimum wage increase on worker-level outcomes under the assumption that macroeconomic changes and heterogeneous labor market prospects of workers located at different points in the income distribution are properly accounted for. Thus, in the absence of the minimum wage increase, labor market outcomes would have evolved in the same way for workers exposed differently to the minimum wage.

Our results indicate that workers directly affected by the new minimum wage, i.e., those whose income was below 373 euros in December 2012, experienced an average increase in income equal to 11.5% after a year, compared to individuals located in the upper tail of the income distribution. We also document that the impact of the minimum wage extends beyond directly affected workers. Spillover effects are substantial for workers near the new minimum wage and diminish, but are still present, up to about the median of the pre-policy income distribution. Both direct and indirect effects are strongest just after the minimum wage increase, and weaken somewhat a year later. We perform a detailed heterogeneity analysis and find that the positive wage effects are particularly salient among groups who exhibit lower average income, i.e., women, young workers, and non-tradable industries. Interestingly, wage effects are almost equal to the size of the actual minimum wage hike among firms that pay envelope wages, suggesting that tax-evading firms may be reacting to the minimum wage by legalizing undeclared wages (Tonin, 2011; Bíró et al., 2022).

As for employment effects, we find that the minimum wage increase had no discernible effect on the employment prospects of Lithuanian workers, with the sole exception of workers in the lowest income category, which includes mostly part-time workers, who were negatively affected. Notably, this negative effect is not immediate, and only appears one year after the increase in the minimum wage. In our heterogeneity analysis, we provide suggestive evidence about the existence of possible disemployment effects among young workers, in highly exposed municipalities, and the tradable sector. We also find suggestive evidence that raising the minimum wage may produce fewer employment losses

in more concentrated industries, consistent with monopsony theory (Manning, 2013), as well as among companies engaging in payroll tax evasion, in line with the declaration of underreported wages as an absorption mechanism (Gavoille and Zasova, 2021).

To support the causal interpretation of our findings, we show that the impact of the minimum wage only occurs after the increase was enacted. In addition, we compare our minimum wage increase of interest to a milder, earlier hike and show that the larger the increase, the larger the effect identified. Finally, we perform a falsification test on the upper tail of the income distribution and show that the labor market outcomes of high-wage workers did not react to the minimum wage increase. Therefore, the impact of the minimum wage only appears among workers at the bottom of the income distribution, the individuals affected by the policy.

Lastly, we compute the employment elasticities implied by our point estimates. Our calculations yield an employment elasticity with respect to the minimum wage of -0.021 (s.e. 0.034) and an own-wage employment elasticity equal to -0.033 (s.e. 0.053). Both implied elasticities are consistent with the minimum wage hike increasing the earnings of low-wage workers without harming their employment prospects (e.g., Dube, 2019). Consequently, the minimum wage policy contributed to reducing wage inequality.

Our work complements different strands of the minimum wage literature. First, an extensive empirical literature investigating how minimum wage policy affects wages and employment (Card and Krueger, 1995; Neumark and Wascher, 2010; Manning, 2021) has focused on changes in employment levels among teens (e.g., Neumark et al., 2014; Allegretto et al., 2017) or in specific sectors (e.g., Dube et al., 2010), and more recently on overall employment (Meer and West, 2016; Cengiz et al., 2019; Giupponi et al., 2022). Instead, we examine the worker-level effects of a large and persistent minimum wage increase, which is key for understanding the ability of minimum wage policy to improve the situation of low-wage workers. Our individual approach is closely related to that of Currie and Fallick (1996); Clemens and Wither (2019); Dustmann et al. (2022); Gopalan et al. (2021), or Choi et al. (2021) who investigate the effect of the minimum wage on workers' income and employment trajectories. We contribute to this line of work by looking at a country not previously analyzed in the literature, Lithuania, and a nationwide minimum wage hike that is among the largest, one-time, increases investigated in the literature and was enacted under very favorable conditions. Importantly, we account for the peculiarities of the labor market prospects of low-wage workers using a pre-policy

period, but we investigate an increase in the minimum wage, not the first time such legislation has been introduce as in Dustmann et al. (2022), and we also provide evidence on short and medium-term effects.

Second, we add to the literature on spillover and distributional effects of minimum wage legislation (recent research on this topic includes Autor et al., 2016; Rinz and Voorheis, 2018; Ferraro et al., 2018b; Cengiz et al., 2019; Gopalan et al., 2021; Engbom and Moser, 2021; Choi et al., 2021; Dustmann et al., 2022; Gregory and Zierahn, 2022; Giupponi et al., 2022). The central point in this literature is the existence (and magnitude) of spillover effects after a minimum wage increase. While much of this research identifies the spillover effects from changes in the income distribution following an increase in the minimum wage, we quantify their magnitude by tracking the wages of workers located at different points in the income distribution over different time horizons and compare them to the evolution of wages in a pre-policy period. Our findings are consistent with existing evidence of sizable spillover effects that decline steadily up to, at most, the median of the pre-policy income distribution (e.g., Cengiz et al., 2019). However, by looking at different time horizons, our analysis suggests that the time dimension somehow matters for the magnitude of spillovers. Our empirical strategy also allows us to examine the existence of possible spillover effects for workers at the upper tail of the income distribution. Recently, Gregory and Zierahn (2022) has examined the introduction of a minimum wage with an extraordinary bite during an economic downturn. The authors find positive spillover effects (on both wages and employment) for workers slightly above the new minimum wage, but, surprisingly, negative effects for workers further up in the income distribution. In contrast, our results point to no effects for the latter group of workers, highlighting that economic conditions interact in a non-negligible way with the labor market effects of minimum wage changes (Clemens and Wither, 2019).

Third, several papers have been published in the last two decades, using very different methods and data sources, investigating the labor market effects of minimum wages in Central and Eastern European countries such as Czech Republic (Grossmann, 2021), Estonia (Ferraro et al., 2018a), Hungary (Harasztosi and Lindner, 2019), Latvia (Gavoille and Zasova, 2021), North Macedonia (Jovanovic et al., 2021), Poland (Albinowski and Lewandowski, 2022), Slovakia (Eriksson and Pytlikova, 2004), and Slovenia (Vodopivec, 2015). Evidence from this set of studies is still mixed. We contribute to this literature not only because of Lithuania's inclusion in the list of countries, but also for other rea-

sons. First, the 17.7% minimum wage hike that we investigate is in the upper-tail of the distribution of hikes previously analyzed, which has a median minimum wage change of 10.3%. Second, our identification strategy directly accounts for differences in workers' labor market prospects that are unrelated to changes in the minimum wage, something that has been overlooked in all papers analyzing the worker-level effects of minimum wage changes in the region (Ferraro et al., 2018b; Eriksson and Pytlikova, 2004; Vodopivec, 2015), with the sole exception of Grossmann (2021). Finally, our comprehensive administrative data allows us to analyze the impact on different groups of workers, firms, or market structures and, hence, to better understand the labor market effects of changes in the minimum wage. Therefore, the sharp and persistent increase in the minimum wage, combined with the quality of our high-frequency administrative data and the existence of a long pre-policy period, allows us to causally identify the labor market effects of a minimum wages and explore its heterogeneous effects.

Our results are in line with the studies that find no or limited negative effects on employment, but some groups are more affected than others (e.g., youth). Moreover, our exhaustive heterogeneity analysis highlights the importance of zooming in on specific labor markets, as the effect of the minimum wage may vary depending on firms' ability to pass on labor costs in prices or on their market power. Similarly, suggestive evidence on envelope wages as a potential mechanism partially behind muted employment effects following a minimum wage increase, in line with recent evidence from Latvia (Gavoille and Zasova, 2021), emphasizes the value of taking into account interactions between payroll tax evasion and minimum wage legislation (Tonin, 2011; Bíró et al., 2022).

Finally, our analysis also contributes to the policy debate on whether minimum wage policy can be an effective tool to address the high levels of income inequality that characterize many of Central and Eastern European economies (Heyns, 2005; Bandelj and Mahutga, 2010; Brien et al., 2019), compared to other European countries (Bubbico and Freytag, 2018). In this regard, our paper offers a possible explanation for the decline in wage inequality observed in these countries between 2002 and 2014, which was driven by a faster increase in wages at the bottom of the income distribution (Magda et al., 2021).

The rest of the paper is organized as follows. Section 2 explains the minimum wage legislation and economic context. Section 3 describes the data, whereas Section 4 introduces the econometric model. Section 5 discusses the wage and employment effects of the minimum wage. Section 6 concludes.

2 Institutional Background

2.1 Minimum Wage Policy

Minimum wage legislation constitutes the main policy regulating the minimum monthly remuneration to which workers in Lithuania are legally entitled, as collective bargaining agreements setting higher minimum wages in some regions or sectors are not common.[1] The policy is uniformly applied to all salaried workers, in both the private and public sectors, and its compliance is monitored by the State Labor Inspectorate.[2] The monthly minimum wage is set by the government following the recommendation of the Tripartite Council (a national institution for social dialogue comprised by labor unions, employer associations, and the government) and further regulated by the Labor Code.[3] If no agreement is reached during the Tripartite Council negotiations, the decision on raising the minimum wage is ultimately taken by the government.[4]

Table 1: National Monthly Minimum Wage, 2008-2020

Negotiations					Minimum Wage	
Start	End	Agreement	Announcement	Enforcement	Euros	Growth (%)
13-Nov-2007	13-Nov-2007	Yes	7-Dec-2007	1-Jan-2008	299	14.6
17-Jun-2008	19-Jun-2012	No	20-Jun-2012	1-Aug-2012	317	6.0
18-Dec-2012	18-Dec-2012	Yes	19-Dec-2012	1-Jan-2013	373	17.7
25-Mar-2014	9-Sep-2014	No	24-Sep-2014	1-Oct-2014	386	3.5
27-Jan-2015	21-Apr-2015	Yes	27-Jun-2015	1-Jul-2015	419	8.5
27-Oct-2015	27-Oct-2015	Yes	2-Dec-2015	1-Jan-2016	451	7.6
3-May-2016	17-May-2016	No	22-Jun-2016	1-Jul-2016	490	8.6
23-May-2017	21-Sep-2017	Yes	11-Oct-2017	1-Jan-2018	516	5.3
18-May-2018	18-Sep-2018	No	16-Oct-2018	1-Jan-2019	555	7.6
23-Apr-2019	28-May-2019	No	3-Jul-2019	1-Jan-2020	607	9.4
23-Sep-2020	30-Sep-2020	No	14-Oct-2020	1-Jan-2021	642	5.8

Source: Statistics Lithuania and Tripartite Council meeting minutes. Notes: The start and end of negotiations are defined as the first and last dates of the Tripartite Council meetings with the question of the minimum wage in the agenda since the last increase. As of January 1, 2019, the Social Security contribution rates paid by the employer and the employee were modified, which affects the way all salaries are declared. The minimum wage is re-scaled by such rate change (1.289) prior to 2019. Growth refers to the nominal growth rate in the national minimum wage (NMW) relative to its previous level.

[1] According to the OECD database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention, and Social Pacts (ICTWSS), in 2019 union density was just 7.4%, while the coverage of collective agreements was 7.9%.

[2] With the introduction of the *New Labor Code* in July 2017, the minimum wage can only be paid for unskilled work, i.e. work that does not require any special skills or professional experience.

[3] The hourly minimum wage, relevant especially for part-time workers, is the ratio of the monthly minimum wage to *usual* monthly working hours. Hence, unless there is a regulatory change in working hours, the minimum hourly wage is implicitly determined by the monthly minimum wage.

[4] In October 2017, the Tripartite Council reached an agreement to establish a formula for determining the level of the minimum wage each year and depoliticize its decision. Specifically, the national monthly minimum wage (i) must be between 45 and 50 percent of the average monthly labor income, excluding bonuses, allowances and additional payments that are not paid each period, and (ii) cannot be lower than the average ratio of the EU countries in the top quartile of this measure over the last three years.

Table 1 provides a detailed description of the Tripartite Council negotiations between 2007 and 2021 along with the national monthly minimum wage that came into effect after each discussion. During this period, negotiations lasted an average of 180 days and in less than half of the cases the Tripartite Council reached an agreement. The new wage floor usually came into effect two months after the announcement made by the government and was increased by an average of 8%, but with significant dispersion across years. For example, the minimum wage enacted in January 2013 represents the largest increase (17.7%) in Lithuania's history and is the focus of our analysis.[5] Noteworthy, this increase is in the upper tail of the distribution of minimum wage increases analyzed in Central and Eastern Europe or in any of the most recent minimum wage studies (see Table A.1 in Appendix A).

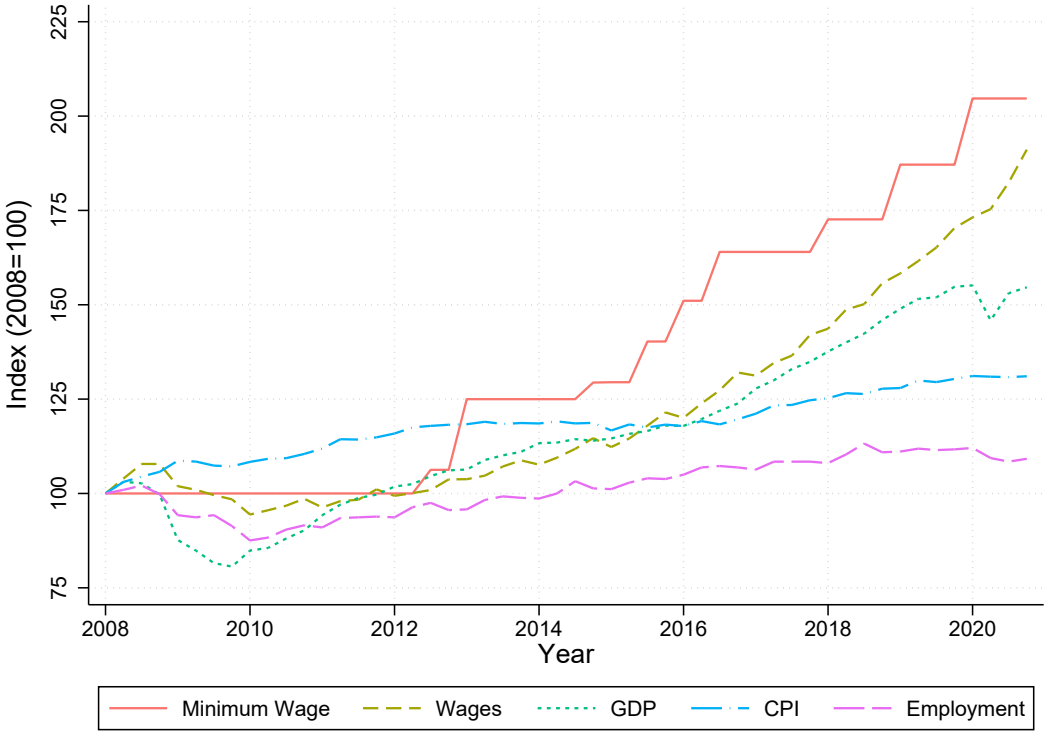
2.2 Macroeconomic Environment and the Minimum Wage Hike

In Figure 1, we document the evolution of key macroeconomic indicators between 2008 and 2020. The Lithuanian economy was severely affected by the Great Recession of 2008, which led to GDP shrinking by almost 20% in nominal terms at the height of the crisis in 2009, a slump three times larger than that of the Eurozone or the United States. However, compared to other developed economies, the negative shock was short-lived (Reinhart and Rogoff, 2014), and by 2010 the Lithuanian economy was already growing and reaching its pre-Great Recession level of nominal GDP in 2012. The evolution of nominal wages and employment portrayed similar patterns, although not as sharp and sudden, and again by 2012 the observed losses had almost completely recovered. From 2012 onwards, spurred by economic growth, aggregate labor market conditions continued to improve. Importantly for our analysis, throughout the period of economic distress, prices continued to rise, while the nominal monthly minimum wage remained unchanged, resulting in a devaluation of almost 15% in real terms between 2008 and 2012.

In June 2012, after 4 years of unsuccessful meetings of the Tripartite Council to increase the minimum wage, the government decided to unilaterally enact a modest increase in the minimum wage as of August 1, 2012, from 299 to 317 euros, equivalent to a 6% increase. However, on December 18, 2012, within one day of negotiations, the Tripartite Council agreed on a new minimum wage that came into effect on January 1, 2013, which

[5]See Garcia-Louzao and Tarasonis (2021) for a description of all minimum wage increases in the history of modern Lithuania.

Figure 1: Macroeconomic Environment



Source: Statistics Lithuania and authors' calculations. Notes: Monetary variables (minimum wage, wages, GDP) are in nominal terms. Wages refer to the average monthly income in a given year. GDP and CPI stand for gross domestic product and consumer price index, respectively.

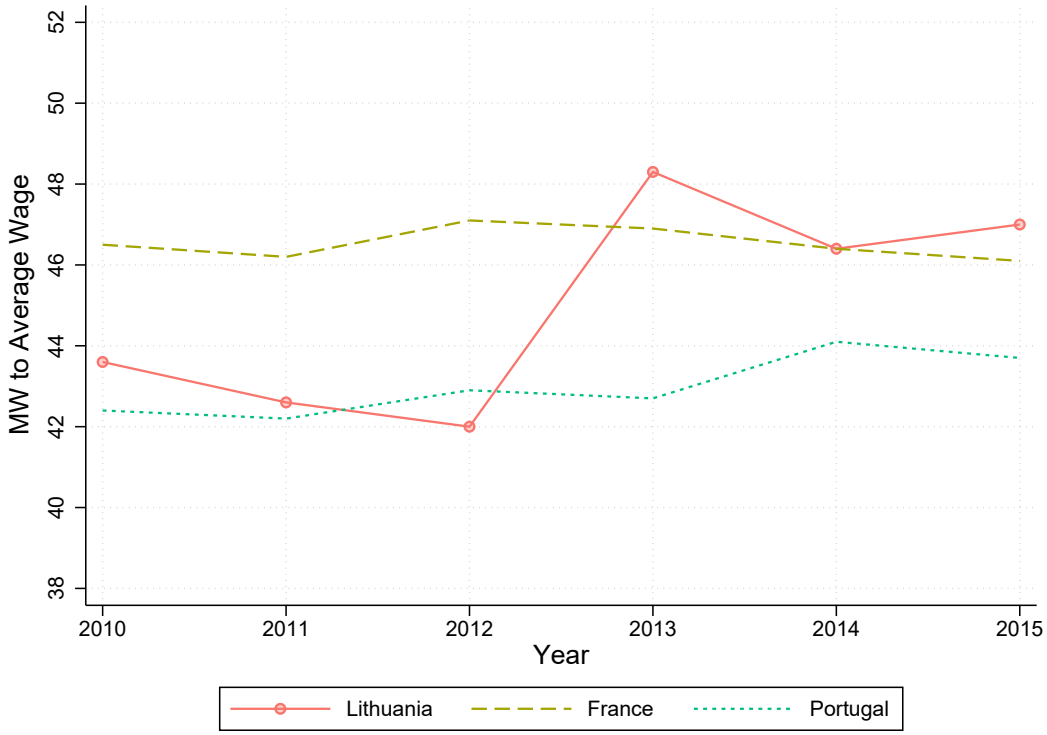
would raise the minimum wage from 317 to 373 euros. With a nominal increase of 17.7% and an implementation period of less than two weeks after the announcement, this is the largest (and fastest) relative increase in the minimum wage in Lithuanian history. Figure 2 shows the magnitude and persistence of this increase. The minimum wage bite, measured as the ratio of minimum wage to average monthly income, stood at around 42%, a level comparable to that of Portugal. After the 2013 minimum wage hike, the bite jumped to a new level similar to France that equals 48% of the average monthly income.[6]

This large and permanent increase in the minimum wage after a long period with no change in its level thus offers a unique scenario for evaluating the effect of minimum wage increases on the labor market prospects of workers. The increase, however, took place in the midst of a favorable economic situation characterized by significant economic growth, which fostered a positive evolution of the labor market, together with a sustained increase in prices that started before the Great Recession. Therefore, while the conditions

[6]We select France and Portugal to place the policy change into context for two main reasons. First, nowadays they are among the countries with the highest minimum wage bite in Europe. Second, they show a relatively stable evolution of the minimum wage bite during the period of interest that allows providing bounds on the bite in Lithuania in a natural way.

surrounding this particular minimum wage increase provide an interesting scenario for assessing the impact of minimum wage policy, the peculiarities in the economic context should also be borne in mind when interpreting the results.

Figure 2: Minimum Wage Bite



Source: Eurostat and authors' calculations. Notes: The minimum wage bite refers to the ratio (in percent) between the monthly minimum wage and the average monthly earnings for each year.

3 Data

3.1 Social Security Data

Our main data source comes from administrative records provided by the State Social Insurance Fund Board (SoDra).[7] The data is a sample of individuals born in an odd-numbered month of each even-numbered year enrolled in the Social Security system at any time between 2000 and 2020.[8] These individuals are tracked on a monthly basis as of 2010, whereas before that year the frequency was quarterly, as employers were required

[7]The dataset is confidential and provided under an exclusivity agreement by SoDra to the Bank of Lithuania.

[8]Individuals registered with the Social Security administration include those making Social Security contributions (e.g., employees, self-employed) as well as people receiving any type of social benefits (e.g., unemployment insurance, child benefits, pension). Due to legal reasons, individuals do not appear in our sample until they are 18, even if they were present in the Social Security system at younger ages.

by law to report information on their employees only on a quarterly basis.

For each member of the sample, we have information on income and welfare benefits received per period, gender, age, place of residence, employment status, occupation, start and end of the employment relationship, reason for termination of employment, location of the workplace and sector of activity, firm size and total wage bill measured at the end of the year, as well as unique firm identifiers that allow us to track matches between the worker and the company over time.

There are two important limitations that are worth discussing. On the one hand, the dataset does not report information on hours worked. This implies that we cannot classify workers by the minimum hourly wage, so it is likely that some individuals whose monthly labor income is below the minimum monthly wage are part-time employees who may not be minimum wage workers in terms of hourly wage. However, it should be noted that part-time employment is not very common in Lithuania, accounting for only about 6 percent of total salaried employment on average over the period 2010-2020.[9]

On the other hand, the labor income variable refers to *all* work-related income that is subject to Social Security contributions, including the base salary, but also non-regular payments, such as bonuses, allowances, overtime pay, commissions or severance payments. Unfortunately, the dataset does not contain information to compute gross monthly earnings net of additional remuneration not received each month. This is a significant drawback as minimum wage legislation regulates only regular worker's remuneration. Therefore, minimum wage workers may be classified above the monthly minimum wage threshold because our measure of labor income is a broader metric. Although non-regular payments can be received by any worker, they are more frequent among high-wage workers, thus mainly affecting the upper tail of the income distribution.[10]

3.2 Analysis Sample

Sample Restrictions. To select our analysis sample, we impose the following restrictions to the raw data. We focus on all individuals between 18 and 60 years old who have a wage-employment relationship with a company with at least two employees in the reference period. Among these individuals, we exclude those on parental leave or receiving

[9]The evolution of hours worked followed a similar pattern (see Figures A.1 and A.2 in Appendix A).

[10]These non-regular payments are also more likely to be paid at the end of the year and equal to around 7.5% of usual labor income, with notable heterogeneity across industries (see Figures A.3 and A.4 in Appendix A).

partial unemployment benefits or retirement pension. We also eliminate workers in the transportation sector due to differences in the wage determination setting. In addition, we only consider individuals working the full month and earning at least half of the minimum wage prevailing in December 2012, i.e., 317 euros. The rationale for this restriction is twofold: (i) to mitigate the influence of non-compliance with hours and (ii) to bring the income measure closer to regular remuneration. Under a full compliance assumption, full-time employees who work the entire month must legally earn at least the minimum wage. Therefore, the majority of people earning 317 euros or more should be full-time workers. Moreover, by considering only workers employed for the full month, we avoid including severance payments in the measure of income, since workers are not laid off in the reference period. Finally, if a worker has more than one job, we keep the job reporting the highest income, and remove individuals whose income increases by three times or more between two periods. The constraints yield a baseline sample consisting of 192,798 workers in December 2012.

Minimum Wage Workers. Table 2 reports basic summary statistics for selected income groups in the month prior to the minimum wage increase to characterize who the minimum wage workers are (i.e., workers earning less than 373 euros in December 2012). Compared to individuals above the median of the income distribution (i.e., workers whose income in December 2012 is 569 euros or higher), minimum wage workers are more likely to be female, younger, noneemployed in the previous year, and located in small cities. Minimum wage workers are less likely to work in public administration or state-owned enterprises, and they are over-represented in micro, small, and medium enterprises. They are also more likely to work in the construction sector, retail trade, accommodation and food services.[11]

Preliminary Evidence of the Minimum Wage Effect. In Figure 3, we examine the evolution of the frequency distribution of monthly income after the increase in the minimum wage in January 2013. We compare the income distribution in the last month before the minimum wage hike (December 2012) with the one in the 12 months after (December 2013). The figure reveals three key facts. First, there is substantial bunching

[11]In Appendix B Table B.1 we investigate who are the minimum wage workers in a regression framework. We estimate a linear probability model for the likelihood a worker earns less than 373 euros on the same set of variables as displayed in Table 2. The results are in line with our basic descriptive statistics and, importantly, they are stable across years before the January 2013 minimum wage increase.

Table 2: Descriptive Statistics

	Income Bin in December 2012			
	[159,373)	[373,569)	[569,1017)	[1017,∞)
Female	0.559	0.553	0.580	0.514
Lithuanian	0.985	0.987	0.992	0.992
Employed in December 2011	0.624	0.780	0.859	0.915
Age Group				
Age ∈ [18-24]	0.129	0.117	0.087	0.032
Age ∈ [25-44]	0.467	0.466	0.496	0.559
Age ∈ [45-60]	0.405	0.416	0.416	0.409
Location				
Vilnius; Kaunas; Klaipeda	0.402	0.444	0.495	0.608
Firm Type				
Public Admin/State-Owned	0.169	0.225	0.356	0.409
Young	0.179	0.109	0.072	0.082
Micro, Small, and Medium	0.634	0.386	0.253	0.225
Industry				
Agriculture; Mining	0.040	0.035	0.030	0.021
Manufacturing	0.196	0.209	0.206	0.166
Electricity; Waste Management	0.010	0.017	0.032	0.032
Construction	0.096	0.088	0.069	0.047
Wholesale Trade	0.115	0.100	0.081	0.098
Retail Trade; Accommodation and Food Services	0.221	0.198	0.115	0.058
Information and Communication Tech	0.013	0.012	0.020	0.055
Finance; Insurance; Real Estate Activities	0.035	0.029	0.035	0.059
Professional Services; Administrative and Support Services	0.084	0.079	0.074	0.101
Public Administration; Education; Human Health	0.149	0.201	0.309	0.346
Arts, Entertainment; Other Services	0.041	0.032	0.030	0.019
Observations	45,205	44,183	57,184	46,226

Notes: Income refers to monthly insured labor income in nominal terms. Vilnius, Kaunas, and Klaipeda are the three biggest municipalities (out of 60). Young stands for firms with less than 5 years of activity. Micro, Small, and Medium refers to firms with less than 50 employees as of the last day of December 2012.

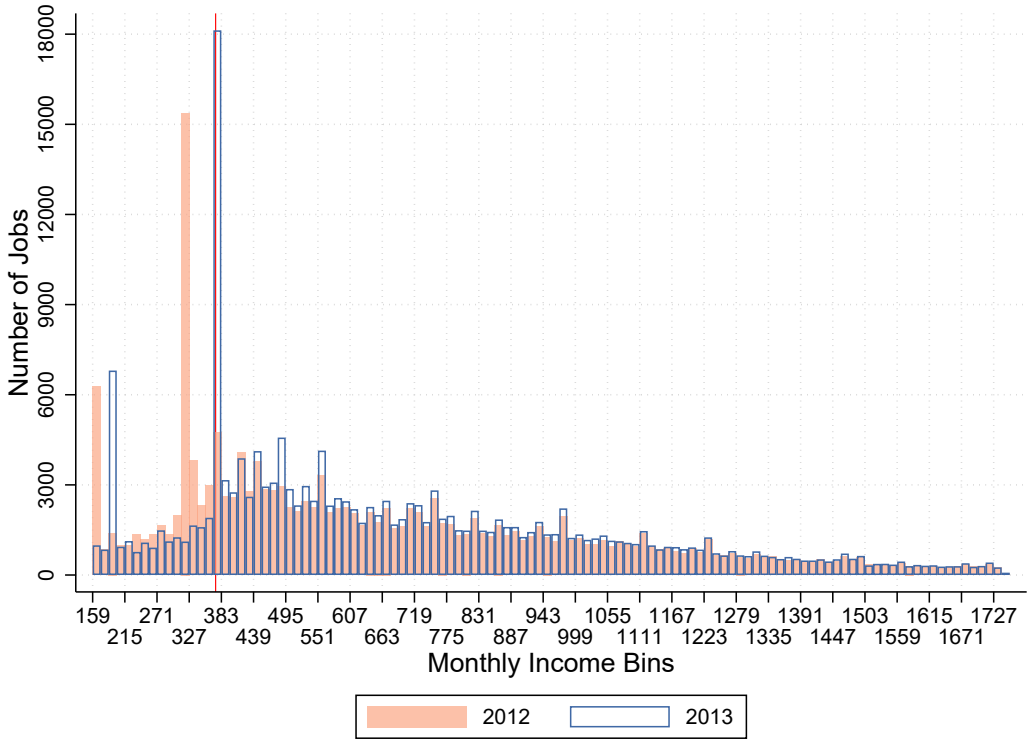
in the pre-policy income distribution at the prevailing minimum wage (317 euros), but also at half that value, likely reflecting part-time employees working half the usual hours. Second, given the relatively low incidence of part-time employment, the prevalence of jobs below the existing minimum wage suggests that not all firms are in full compliance with the legislation.[12] Third, the January 2013 minimum wage increase clearly altered the income distribution. A significant number of jobs below the new minimum wage disappeared, a response that was accompanied by an increase in the number of jobs at or (slightly) above the level of the new minimum wage.[13] Importantly, this shift did not occur in the absence of a minimum wage increase, and was milder in the presence of a much smaller minimum wage increase (see Figure B.1 in Appendix B). The observed changes in the income distribution provide an indication that jobs below the new minimum wage

[12] Goraus-Tanska and Lewandowski (2019) document that, between 2003 and 2012, approximately 7% of Lithuanian minimum wage workers were paid below the legal minimum.

[13] There is also an increase in the number of jobs well above the new minimum wage. However, these increases should be interpreted in the context of positive economic growth discussed in Section 2.

did not disappear, but rather were retained, gained a pay raise, and caused bunching at and slightly above the minimum wage. In other words, the increase in the minimum wage appears to have contributed to boosting wages at the bottom of the distribution without a strong negative effect on the employment prospects of low-wage workers. The remainder of the paper is devoted to formally evaluating this claim.

Figure 3: Income Distribution in 2012 and 2013



Notes: Frequency distribution of monthly income in December 2012 (pre-policy period) and December 2013 (post-policy). Income refers to monthly insured labor income in nominal terms. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

4 Econometric Approach

To investigate the worker-level effects of the minimum wage, we compare the labor market outcomes after the minimum wage increase of individuals located at different points in the income distribution prior to the hike, in the spirit of Dustmann et al. (2022). We break the pre-treatment monthly income distribution by increments equal to one-half of the scheduled increase in the minimum wage (e.g., 28 euros), with the exception of the tails of the distribution, for a total of 27 income groups. Therefore, the set of income bins is $K = \{[159, 317), [317, 345), [345, 373), [373, 401), ..., [989, 1017), [1017, \infty)\}$. We

then estimate regression models of the following form

$$\Delta_h y_i = \sum_{k=1}^{K-1} \alpha_k \mathbb{1}\{w_i \in k\} + X_i\Omega + \gamma_r + \gamma_s + \epsilon_i \tag{1}$$

Δ_h represents changes in individual outcomes y_i, i.e., monthly income or employment status, from t to $t+h$.[14] $\mathbb{1}\{w_i \in k\}$ are indicator variables that identify individuals whose monthly income in December 2012 belongs to income group k. X_i represent worker characteristics such as age and gender, while γ_s and γ_r stand for sector and location fixed effects, respectively. In the estimation, we use the highest income bin, $k = [1017, \infty)$, as the reference category, since this income category is unlikely to be affected by the minimum wage increase, as suggested by Figure 3. Provided that the increase in the minimum wage does not bite so high in the income distribution, this reference category allows us to capture changes in the macroeconomic environment that followed the Great Recession and that we discussed in Section 2. This implies that α_k measures the average change in y for worker i who belong to income category k *over and above* economy-wide changes, assuming that these effects affect the entire income distribution equally.

However, in this framework the parameters of interest α_k are potentially biased due to mean reversion: low-wage workers tend to be less likely to retain employment and to experience higher wage growth compared to high-wage workers, regardless of minimum wage policy (Ashenfelter and Card, 1982). Under the assumption that, in the absence of the minimum wage hike, employment and income changes would evolve in the same way for individuals located in the same income category after controlling for changes in the macroeconomic environment, we can exploit the pre-policy period to estimate income-bin specific effects to account for non-minimum wage related changes (Dustmann et al., 2022). More precisely, we re-parametrize Equation 1 as follows

$$\Delta_h \tilde{y}_i = \sum_{k=1}^{K-1} \beta_k \mathbb{1}\{w_i \in k\} + X_i\Omega + \gamma_r + \gamma_s + \epsilon_i \tag{2}$$

where $\Delta_h \tilde{y}_i = \Delta_h y_{i(k)} - \hat{\alpha}_k^{Dec2010}$, and $\hat{\alpha}_k^{Dec2010}$ are estimates of income-bin specific components recovered from the estimation of Equation 1 between December 2010 and De-

[14] We focus on a 12 month horizon change, i.e., from December 2012 to December 2013, to mitigate the influence of seasonal effects. However, we provide additional results by looking at 1, 6, and 18 month horizon changes.

cember 2011, when there was no change in the minimum wage.[15] Therefore, $\beta_k = \alpha_k^{Dec2012} - \hat{\alpha}_k^{Dec2010}$ measures, for each income-bin k, the impact of the minimum wage hike on outcome y for worker i over and above economy-wide changes *and* income-bin specific components. In other words, the parameters β_k identify the causal effect of the minimum wage on worker-level outcomes under the assumption that our empirical strategy adequately accounts for macroeconomic changes and mean reversion effects.

5 The Impact of the Minimum Wage Hike

5.1 Worker-Level Effects

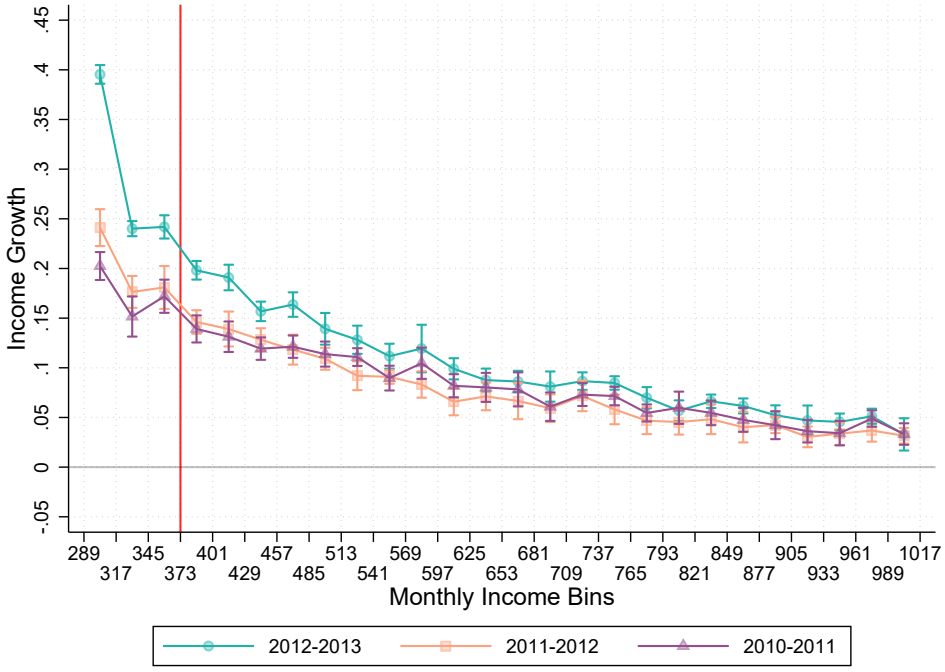
Income Growth. In Figure 4 Panel A, we report our first set of estimates of the impact of the minimum wage increase on income growth, obtained from Equation 1. The figure plots one-year income growth for individuals employed in December $t-1$ against their initial income bin, separately for the 2010-2011, 2011-2012 and 2012-2013 periods. The evidence indicates that for individuals in the bottom tail of the income the distribution experienced higher income growth relative to individuals further up in the distribution, even before the increase in the minimum wage was enacted. Importantly, Panel A of Figure 4 indicates that the 17.7% increase in the minimum wage in January 2013 had a significant impact on affected workers: for workers whose baseline income was below the new minimum wage (373 euros), income growth between 2012 and 2013 was substantially higher relative to 2010-2011, when the minimum wage was not introduced, but also considerably higher relative to 2011-2012, when there was a milder increase in the minimum wage (6%). This impact is not observed in the upper tail of the distribution.

We quantify these effects using regression Equation 2, where income-bin specific components are accounted for using estimates from the pre-policy period (2010-2011). In Panel B of Figure 4, we report *excess* income growth separately for 2011-2012 and 2012-2013 periods relative to 2010-2011. Consistent with Panel A, our findings indicate that income growth between 2012-2013 substantially exceeded that of 2010-2011 for workers located below the minimum wage of 373 euros introduced in January 2013. The excess growth amounts to about 10 percent for workers with a minimum wage or slightly above, i.e., 317 euros, and about 20 percent for workers with the lowest incomes, who are likely

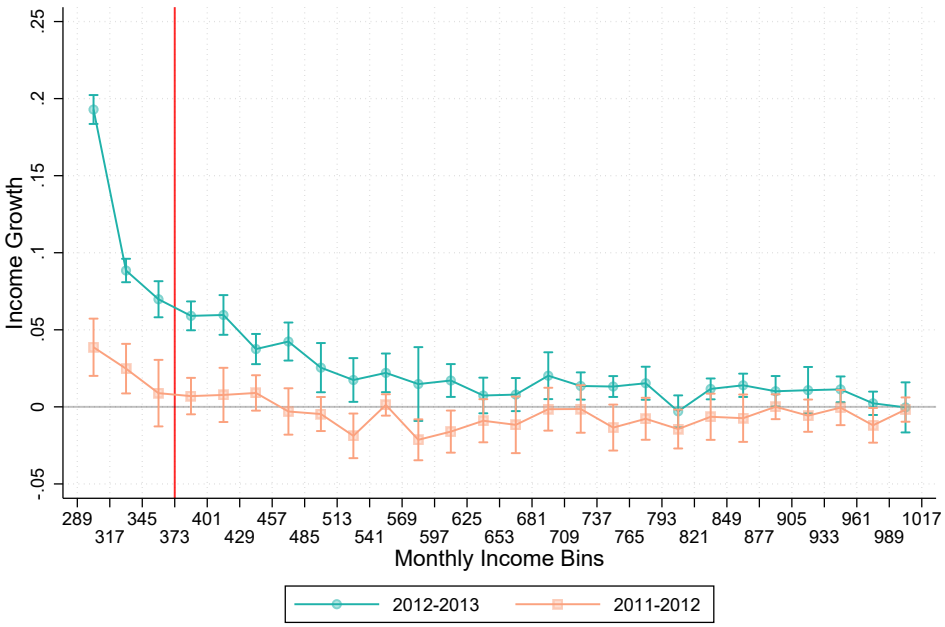
[15] Note that any differences in the macroeconomic environment between years are accounted for in our regression framework under the assumption that the reference category exclusively captures economy-wide changes.

Figure 4: Minimum Wage Hike and Income Growth

A. Baseline Changes



B. Changes Relative to 2010-2011



Notes: Panel A plots income growth for individuals employed in December in $t-1$ and t against the initial income group separately for the periods 2010-2011, 2011-2012, and 2012-2013. Estimates correspond to α_k parameters from Equation 1. Panel B reports *excess* income growth by starting income category for periods 2011-2012 and 2012-2013 relative to income growth between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

to be mostly part-time workers. Of primary interest for our causal interpretation, we find that between 2011-2012, when the minimum wage was raised from 299 to 317 euros, income growth exceeded that of 2010-2011 for workers in the lowest income group, i.e., those directly affected by this milder increase. These results therefore validate our empirical approach and the data, as they support that the minimum wage in question was binding with a real economic impact on the affected workers.

We also document substantial spillover effects for workers close to the new minimum wage, but they steadily decline until they disappear above 569 euros, which corresponds to the median income distribution before the increase. Thus, the minimum wage increase not only causally boosted the earnings of workers directly affected by the policy, but also had an extended positive impact on workers above the new minimum wage. The magnitude of spillover effects is in line with the findings in Ferraro et al. (2018b) for Estonia, Cengiz et al. (2019) for Hungary, Gopalan et al. (2021) for the US, or Giupponi et al. (2022) for the UK.[16] The usual explanations for the emergence of spillover effects are based on the existence of search frictions (Flinn, 2006), as well as pay concerns about relative wages within firms to maintain pre-policy wage hierarchies (Dube et al., 2019).[17] A combination of both mechanisms is likely to be behind our findings. However, comparing our baseline results and the wage spillover effects that arise when considering only those workers who remained with the same employer (the bulk of our sample) seems to favor the latter to some extent in our context (see Figure B.2 in the Appendix).[18]

Employment Retention. The results presented above reveal that the January 2013 increase in the minimum wage did raise the earnings of low-wage workers. We now analyze how this increase affected the probability that the affected workers would remain employed.[19] In Figure 5 Panel A, we report estimates from Equation 1 in which we compare employment retention probabilities along the income distribution of individuals

[16]The size of the spillovers contrasts with those of Choi et al. (2021), who use a similar worker-level approach and find effects up to the 77th percentile. However, their strategy abstracts from using income-bin specific counterfactuals, so they may overestimate the magnitude of spillovers. Larger spillover effects, however, could also be related to the bindingness of the minimum wage (Engbom and Moser, 2021).

[17]An additional explanation in some countries is related to collective bargaining agreements that set higher wage floors, indexed to the national minimum wage, for certain workers. However, this mechanism is likely to play a minor role in our setting, given the low relevance of unions and of the coverage of collective bargaining agreements, as discussed in Section 2.

[18]In our sample, 91% of workers who remain employed after the minimum wage hike do so with the same company.

[19]It should be noted that, in our context, the alternative scenario to staying in employment is not necessarily being out of work, but rather not being legally employed in Lithuania, since workers could be leaving the country or companies could be transforming formal employment relationships into the shadow economy.

employed in December $t-1$ in three different periods: 2010-2011, 2011-2012, and 2012-2013. Consistent with the fact that job matches are more fragile among low-wage workers, the figure highlights that individuals at the bottom of the distribution are between 10 and 15 percentage points less likely to be employed one year later compared to workers in the upper tail of the income distribution, i.e., those whose income is above 1,017 euros. Importantly, this result holds regardless of any changes in the minimum wage, as suggested by the comparison between periods.

To investigate these findings in more detail, in Panel B of Figure 5, we net out non-related minimum wage effects from the likelihood that a worker keeps her job one year later. The figure plots employment retention probabilities between 2011-2012 and 2012-2013 relative to pre-policy changes (2010-2011 period), using estimates from Equation 2. In line with the positive evolution of employment documented in Section 2, our results indicate that the January 2013 minimum wage increase did not affect employment prospects of Lithuanian workers, regardless of their exposure to the minimum wage hike. The only exception seemed to be individuals in the lowest income category, who show a probability of employment retention that is almost 3 percentage points lower.[20] Importantly, although our results are predominantly driven by workers staying with the same firm, we find suggestive evidence that the reallocation of low-wage workers to other employers helped mitigate more negative disemployment effects (see Figure B.3 in the Appendix), consistent with the absorption mechanism recently emphasized by Engbom and Moser (2021) and Dustmann et al. (2022).

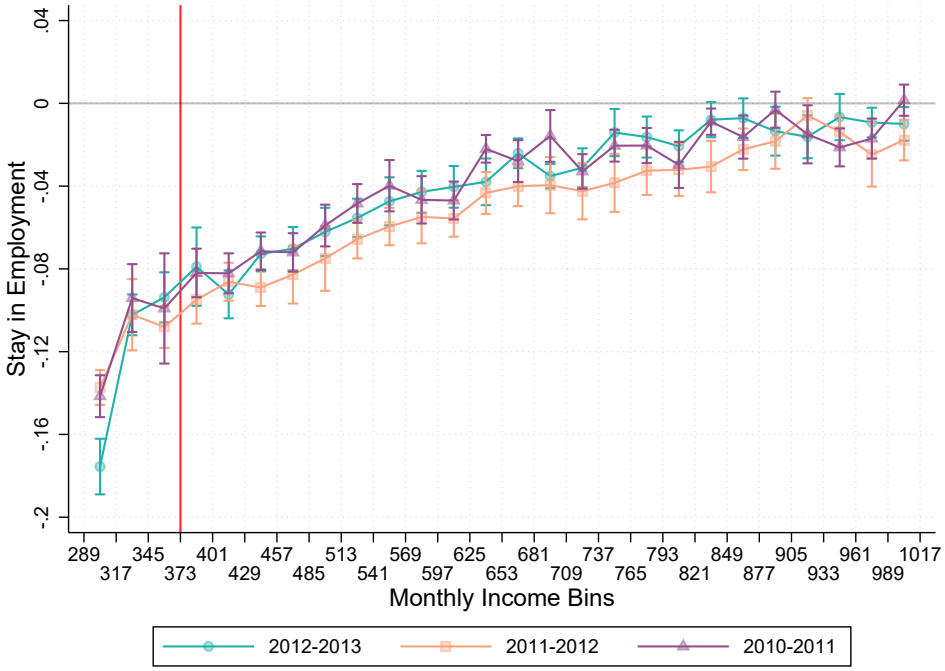
Altogether, our analysis indicates that the sharp increase in the minimum wage enacted in January 2013 significantly boosted the incomes of low-wage workers without critically harming their employment prospects. Our results are thus in line with recent evidence from several countries suggesting that minimum wage legislation may be a useful policy to tackle rising inequality (see among others Cengiz et al., 2019; Engbom and Moser, 2021; Gopalan et al., 2021; Dustmann et al., 2022; Giupponi et al., 2022).

Sensitivity Analysis. In Appendix B, we conduct a series of robustness checks to validate our results. First and foremost, we investigate the validity of our identification strategy by analyzing whether our point estimates, β_k, are close to zero for individuals

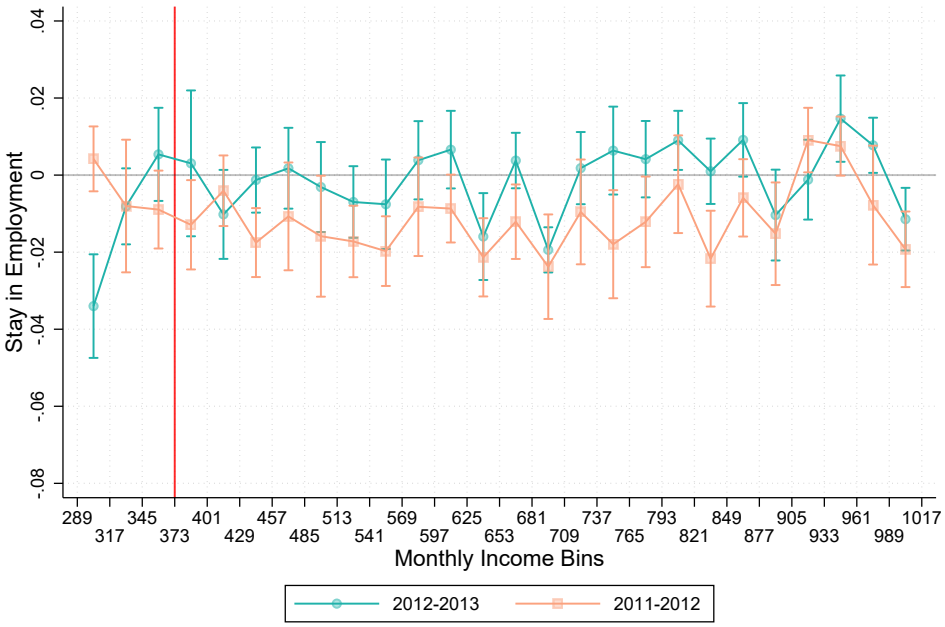
[20]Since workers in this income category earn less than the old minimum wage, they are most likely part-time workers. This suggests that the minimum wage bites harder among part-time workers, translating into higher income growth but also larger employment losses. This would be consistent with evidence pointing to minimum wage effects being concentrated on most vulnerable workers, e.g., part-timers or temporary workers (see Dickens et al., 2015; McGuinness and Redmond, 2019, among others).

Figure 5: Minimum Wage Hike and Employment Retention

A. Baseline Changes



B. Changes Relative to 2010-2011



Notes: Panel A plots employment retention probabilities for individuals employed in December in $t-1$ against the initial income group separately for the periods 2010-2011, 2011-2012, and 2012-2013. Estimates correspond to α_k parameters from Equation 1. Panel B reports *excess* employment retention probability by starting income category for periods 2011-2012 and 2012-2013 relative to the employment retention probability between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

located sufficiently high in the income distribution in December 2012, i.e., our reference income group $k = [1017, \infty)$, the group of workers for whom the minimum wage should not have any effect. The results in Figure B.4 show that, once income-bin specific components are accounted for using the estimates from the pre-policy period (2010-2011), both the income and employment effects are zero. This falsification test supports the causal interpretation of our findings (Cengiz et al., 2019; Dustmann et al., 2022). Second, we evaluate the responses of income and employment to the minimum wage increase at different horizons. As expected, we find that income effects are more prominent the closer the reference period is to the introduction of the policy and, if anything, employment effects emerge as time passes (Meer and West, 2016), but both effects appear to stabilize after one year. We also test the sensitivity of our results to the sample selection. Figures B.6 and B.7 show that our results are not due to the main job being the one reporting higher income, as our results hold when multiple jobs are included or the one reporting the lowest income is selected as the main job. In Figures B.8 and B.9, we show that ranking individuals by their income in December does not critically affect our results, as they remain qualitatively the same when classifying individuals by their average income between October and December or using the income reported in September. Finally, including transportation industry plays no role in our identified effects (see Figure B.10).

5.2 Implied Employment Elasticities

To compare our findings with those in the literature, we calculate the implied elasticities of employment with respect to the minimum wage (MWE), as well as the own wage of the affected group (OWE). To do so, we first group workers into 3 broader income categories: workers who earned less than the new minimum wage at baseline ([159,373)), workers who earn more but close to the minimum wage at baseline ([373,569)), and workers who earn between [569,1017) at baseline, and exploit as *reference* category workers who earn more than 1017 euros at baseline. Using these income groups, we re-estimate our empirical model to obtain point estimates of *excess* income growth and employment retention. The results of this exercise are reported in Column 1 and 2 of Table 3 and are in line with our baseline modeling strategy: minimum wage workers experienced an 11% increase in their income with no impact on employment retention probabilities.

The point estimates for affected workers, i.e., those earning less than 373 euros in December 2012, then allow the elasticities of interest to be calculated. Note that these

Table 3: Grouped Estimates and Implied Elasticities

	(1) Income	(2) Employment	(3) MWE	(4) OWE
Income ∈ [159,373)	0.1115***	-0.0037	-0.0207	-0.0329
	(0.0046)	(0.0060)	(0.0336)	(0.0525)
Income ∈ [373,569)	0.0378***	-0.0022	-	-
	(0.0055)	(0.0033)		
Income ∈ [569,1017)	0.0103**	0.0013	-	-
	(0.0035)	(0.0012)		

Notes: Column (1) and (2) report the *excess* income growth and employment retention, respectively, between December 2012 and December 2013 relative to December 2010 and December 2011 for three groups of workers relative to the reference category: workers who earned less than the new minimum wage at baseline ([159,373)), workers who earn more but close to the minimum wage at baseline ([373,569)), and workers who earn between [569,1017) at baseline, and the *reference* category are workers who earn more than 1017 euros at baseline. Estimates correspond to coefficients β_k in Equation 2, where workers are grouped into three bins only. All specifications include as controls age, sex, and indicators for municipality and sector of activity. Column (3) and (4) stand for minimum wage (MWE) and own-wage employment (OWE) elasticities, respectively. MWE is the ratio between the estimated employment response of affected workers (income at baseline below 373 euros) and the minimum wage increase in January 2013. OWE is the ratio between the estimated employment response of affected workers and the estimated wage response for that group of workers. Standard errors are clustered at the municipality level. MWE and OWE standard errors are computed using the delta method. *** p<0.01, ** p<0.05, * p<0.1.

implied elasticities represent a lower bound (in absolute value), as our estimates do not take into account the potential negative effect of minimum wage hikes on hires (Portugal and Cardoso, 2006; Dube et al., 2016), which could further dampen employment (Gopalan et al., 2021).[21] With this limitation in mind, we compute the MWE as the ratio between the estimated employment response of affected workers (11.5%) and the minimum wage increase (17%). The resulting estimate (Column 3 in Table 3) is statistically insignificant and equals -0.021 (s.e. 0.034). Our MWE estimate falls within the range of estimates found in previous studies, as documented by Belman and Wolfson (2014) in the meta-analysis of the literature, and is on the lower side, implying smaller employment losses than the median MWE reported in the literature that is equal to -0.05.[22]

Our empirical strategy also allows us to calculate the employment elasticity with

[21]The strong labor demand and associated employment gains documented in Section 2.2, together with the preliminary evidence in Section 3.2 of the effect of the minimum wage on the distribution of jobs before and after the increase, suggests that the job creation margin may be less salient in our context.

[22]It should be noted that approximately half of the studies reviewed in the meta-analysis focused on teens, a subgroup with a higher proportion of workers earning minimum wage, which could produce greater negative effects.

respect to the own-wage (the labor demand elasticity in a competitive market). This measure provides a better comparison with the literature, as it normalizes the response of employment with respect to the average wage change of the affected workers, thus taking into account how binding the minimum wage increase is. The own-wage elasticity (OWE) in Column 4 of Table 3 is computed as the ratio of the estimated employment response of the affected workers to the estimated wage response for that group of workers. Our calculation yields an estimate equal to -0.033, and the standard error (0.053) discards own wage elasticities beyond -0.137 at the 95 percent confidence level. The results imply that wage gains dominated employment losses of affected workers (e.g., Harasztosi and Lindner, 2019; Cengiz et al., 2019). This estimate is in line with the OWE estimates collected by Dube (2019) who reports a median OWE estimate equal to -0.04 across studies that consider all low-wage workers.

Our findings must be interpreted within our specific context. On the one hand, non-compliance with legislation (Goraus-Tanska and Lewandowski, 2019) and the shadow economy (Putniņš and Sauka, 2015) were widespread in Lithuania during the period under analysis. Therefore, if low-wage workers were employed mainly by firms that pay envelope wages, our results could be explained by these firms reducing the size of the envelope without affecting employment levels, as documented by Gavoille and Zasova (2021) for Latvia. On the other hand, firms have different mechanisms for adjusting to an increase in the minimum wage that do not necessarily imply the dismissal of workers (Clemens, 2021). In this regard, a survey of a representative sample of Lithuanian firms asking how they had adjusted to the minimum wage increase in January 2013 pointed to cutting non-labor costs and investing in productivity-enhancing technologies as the most common channels of adjustment made by companies.[23] Likewise, if firms are primarily concerned with demand rather than costs (Lester, 1946), the labor cost shock could have been absorbed directly, or at least partially, by price growth in the booming economy.[24] Finally, recent studies based on general equilibrium models to analyze the welfare effects of the minimum wage show that its negative impact on employment is increasing in the ratio between the minimum wage and the average or median market wage (Ahlfeldt et al., 2022; Berger et al., 2022). In this respect, the fact that the ratio of the minimum wage

[23]The survey was conducted in 2014, within the framework of the Wage Dynamics Network (WDN3) coordinated by the European Central Bank, using a harmonized questionnaire covering the period 2010-2013. The questions pertaining to Lithuania concerned the increase in the minimum wage in January 2013. See Bodnár et al. (2018) for further details.

[24]This would be consistent with existing evidence suggesting a significant pass-through of minimum wage increases to consumer prices (e.g., Harasztosi and Lindner, 2019; Renkin et al., 2020).

to the average wage in the economy was relatively low before the minimum wage increase may partially explain the limited disemployment effects (Manning, 2013).

5.3 Heterogeneous Responses

In this sub-section we look at potential heterogeneous effects of the minimum wage increase on worker-level outcomes. Our heterogeneity analysis is based on demographic groups and types of companies, as well as specific labor markets defined by the location or industry in which firms operate. For each specific group, we re-do our estimation strategy and extend our regression model to include an interaction term between the group of interest and the income categories at baseline using three income bins only, as in Table 3. The results are presented in Figure 6, where the first row refers to our baseline results and the following rows correspond to the group-specific effects calculated from the extended models as the sum of the baseline effect and the interaction term for treated workers (e.g., workers in income category $[159, 373)$ at baseline).

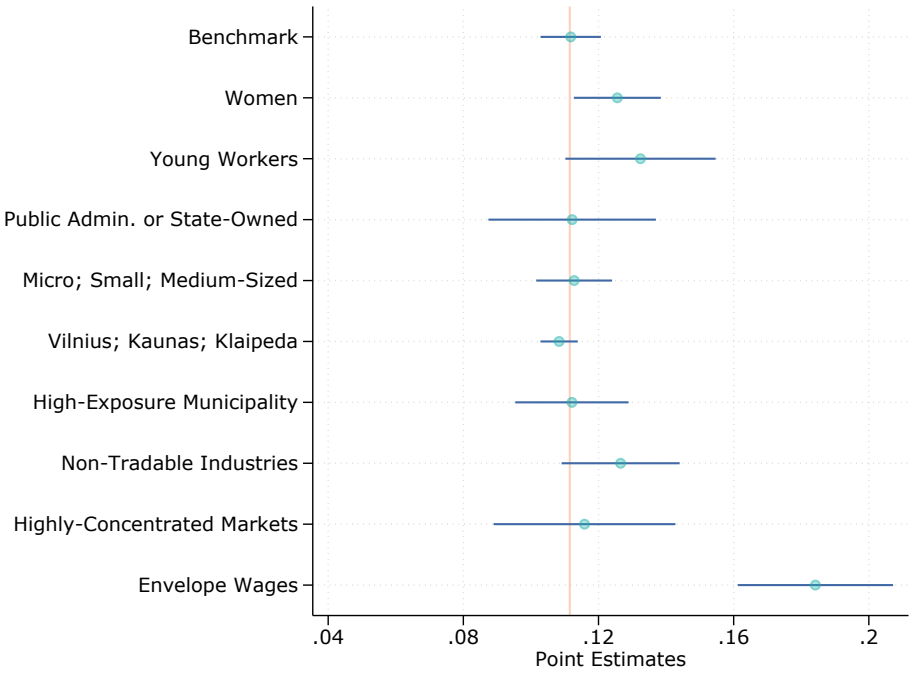
Worker's Demographics. The estimates in Figure 6 show that, although low-wage women experience similar (near-zero) employment effects following the minimum wage (Row 2, Panel B), their wage gains are larger than those of low-wage men (Row 2, Panel A), probably because more men are closer to the new minimum wage than women.[25] We turn to examine young workers (individuals aged 18-24) and find that young people seem to especially benefit from income effects (Row 3, Panel A), as they are over-represented among low-wage individuals and are more likely to have a part-time job. However, we find suggestive evidence that young people seem to be more affected in terms of employment: the probability of not being employed one year after the minimum wage increase is almost 2 percentage points higher compared to prime-age individuals (Row 3, Panel B). Our results suggest that young people are the most vulnerable group of workers if firms decide to reduce employment (e.g., Currie and Fallick, 1996; Pereira, 2003; Neumark and Wascher, 2004; Kreiner et al., 2020).[26]

[25] This fact is consistent with recent evidence from Germany suggesting that the minimum wage could reduce the gender wage gap, provided that in low-wage segments women are still underpaid compared to men (Caliendo and Wittbrodt, 2022).

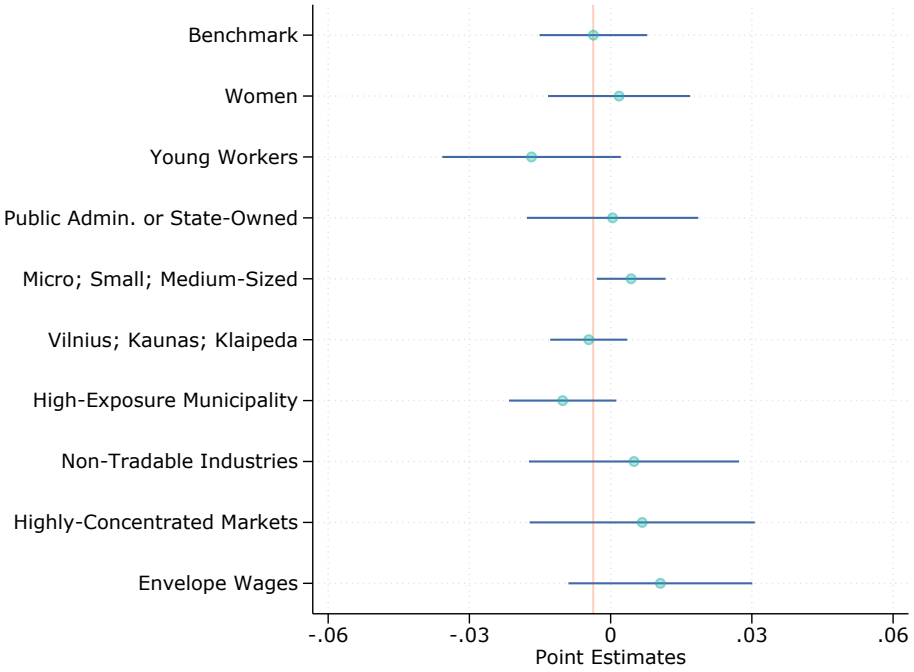
[26] van Bezooijen et al. (2021) exploit discontinuities in age-specific minimum wages and policy changes along the step-function in the Netherlands and show that young workers are not more likely to lose their jobs compared to slightly older individuals. This highlights that the comparison group is an important dimension when evaluating the impact of minimum wage on young workers (Zavodny, 2000).

Figure 6: Heterogeneous Responses to Minimum Wage Hike

A. Income Growth



B. Employment Retention



Notes: Panel A (Panel B) reports *excess* income growth (employment retention) for the period 2012-2013 relative to 2010 and 2011. Estimates correspond to coefficients β_k in Equation 2, where workers are grouped into three bins only, as in Table 3. Row (1) shows the benchmark estimate for workers whose income fall into the [159,373) bin. Rows (2) to (8) show group specific effects (e.g., women) from separate models that extend our benchmark specification to include interaction terms between each income category and the variable of interest. The reported effect refers to the sum of the baseline effect (from the extended model) plus the interaction term for treated workers. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the point estimates from our benchmark model, i.e. without interaction terms.

Firm's Characteristics. We now turn to examine the impact of the minimum wage along firm observed characteristics, i.e., ownership and size. In terms of income effects, we find no differential effect of the minimum wage income growth for either public administration/state-owned firms (Row 4, Panel A), or firms with fewer than 50 employees (Row 5, Panel A) compared to other firms in the economy. However, in terms of employment, the results seem to point to a less negative effect for this group of firms. Among government controlled-firms, the average effect is zero. This result is expected, as firing workers as a response to their own decision to increase the minimum wage would involve a high political cost for the government. In contrast, more surprising might be the results for micro, small and medium-sized firms: we observe slightly positive employment effects despite having a higher exposure to the minimum wage. This result can be rationalized, however, if the use of envelope wages is particularly strong among some firms in this size category, as they can absorb the labor cost shock by legalizing evaded wages leaving employment levels barely unchanged (Gavoille and Zasova, 2021). An alternative, albeit complementary, explanation is related to differences in input composition across the firm size distribution, to the extent that larger firms are more likely to substitute labor for capital, displacement effects may be stronger in those firms (Harasztosi and Lindner, 2019).

Local Labor Markets. As pointed out by Card (1992), the impact of the minimum wage may vary across regions due to disparities in wage levels. In other words, minimum wage increases may have a greater impact in low-wage areas compared to high-wage areas and, therefore, the labor market responses may be heterogeneous. We investigate this possibility by looking both at the three largest cities in Lithuania, i.e, Vilnius, Kaunas, and Klaipėda, which account for 40% of low-wage workers in the country, as well as high-exposure municipalities classified based on the minimum wage gap measure typically used in the literature (e.g., Card and Krueger, 1994; Dustmann et al., 2022).[27]

Our results for the biggest (highest income) cities are presented in Figure 6 Row

[27]The gap measure for each municipality m at time t is defined as

$$GAP_{mt} = \frac{\sum_{i \in m} max\{0, MW - w_{it}\}}{\sum_{i \in m} w_{it}}$$

where w_{it} refers to the monthly income of worker i at time t, and MW stands for the minimum wage enacted in January 2013. This measure captures both the number of workers below the new minimum wage in a given municipality and their distance from that level. Using this measure, high-exposure municipalities are those with a GAP above the median at baseline period t.

6. We find that both income gains (Panel A) and employment effects (Panel B) are of similar magnitude as the rest of the country. The income effects are also very similar when comparing low- and high-exposure municipalities (Row 7, Panel A), suggesting that the minimum wage increase pushed up income of low-wage workers similarly in both group of regions. However, our identified employment effects among high-exposure municipalities seem to indicate that, if anything, employment retention probabilities of low-wage workers were *slightly* lower in these areas, consistent with the magnitude of disemployment effects being increasing on the bite of the minimum wage (Cengiz et al., 2019; Ahlfeldt et al., 2022; Berger et al., 2022). This suggests that although minimum wage policy can potentially address regional income inequalities, one has to consider the effect on employment in those regions that are the most affected by the policy.

Market Structure. One of the main determinants behind the differences found in the literature regarding the effects of the minimum wage is market structure (Manning, 2021). To shed light on this margin, we look at the sectors where firms operate. For instance, a substantial literature suggests that in industries where firms are able to pass through minimum wage costs on to consumers, employment losses are likely to be smaller (Aaronson et al., 2008; Lemos, 2008; Harasztosi and Lindner, 2019; Ashenfelter and Jurajda, 2022). By the same token, in non-competitive labor markets where firms face an upward-sloping labor supply, changes in the minimum wage may have very different implications relative to a traditional neoclassical framework (Stigler, 1946; Manning, 2013).

To investigate the first of these dimensions, we rely on a complementary database including firms' balance-sheet information (e.g., sales, imports, exports) between 2000 and 2015 and the 2-digit industry where the companies operate. We use this dataset to classify industries according to their exposure to international trade, where non-tradable industries refer mostly to retail and hospitality services, construction, and public administration, and examine the worker-level effects of the minimum wage increase in these industries relative to tradable sectors.[28] The idea is that firms participating in international trade are subject to greater competitive forces and are therefore less able to pass on increases in labor costs to prices. Similarly to Harasztosi and Lindner (2019), our findings in Row 8 of Figure 6 are in line with that hypothesis: in non-tradable sectors, in-

[28]We define industries as tradable using the ratio of import plus exports to sales. Hence, we define tradable (non-tradable) industries those with a ratio higher (lower) than 10%, similar to Mian and Sufi (2014). In the case of public administration, these firms are directly assigned to the non-tradable group.

come effects are greater (Panel A) and the employment effects, if any, are less pronounced (Panel B).[29]

To examine the role of labor market concentration, we perform the following exercise. First, we consider as the relevant labor market the pair municipality-industry where concentration would proxy for firm's labor market power.[30] Second, within each of these cells, we calculate the Herfindahl-Hirschman Index (HHI) using the year-end firm size information included in our main data source in markets where we observe at least 4 firms.[31] Third, we define highly concentrated markets as those with an HHI above 0.25, and compare the worker-level effects of the minimum wage increase in these highly concentrated markets compared to less-concentrated ones.[32] Provided that our concentration measure is a good proxy for monopsony power, our results in Figure 6 indicate that low wage employment in a highly concentrated market appear to have higher employment retention probabilities (Row 8, Panel B).[33] However, there are no substantial differences with respect to income growth (Row 9, Panel A). Therefore, in markets where firms have monopsony power, minimum wage hikes may result in fewer employment losses, or even produce employment gains, as recent empirical literature has documented (e.g., Azar et al., 2019; Okudaira et al., 2019).

Envelope Wages. During the period of the minimum wage hike analyzed, envelope wages and, in general, the shadow economy were prevalent in Lithuania (Putniņš and Sauka, 2015). In this regard, the existing literature highlights important interactions between minimum wage legislation and payroll tax evasion (Tonin, 2011; Bíró et al., 2022). For instance, firms that evade payroll taxes can absorb the impact of minimum wage increase just by declaring unreported wages (Gavoille and Zasova, 2021). To shed light

[29] Gopalan et al. (2021) document that employment in tradable sectors appears to be more affected, as job creation declined more in tradable sectors compared to non-tradable sectors following an increase in the minimum wage.

[30] We use municipality-industry cells to define the relevant labor market for workers given the frictions associated with geographic mobility or industry switching. This choice is inspired by the study by Azar et al. (2020), which provides a detailed analysis of labor market concentration definitions for the US. Importantly, the public sector is not considered in the analysis of market concentration.

[31] We use Social Security records to compute the HHI and not the auxiliary data coming from firms' balance-sheets because the latter does not include information on firm's location. Moreover, we select markets with at least 4 firms to get a meaningful measure of concentration based on the HHI, given that we do not observe all firms in a sector in our data.

[32] This threshold follows the US Department of Justice/Federal Trade Commission 2010 horizontal merger guidelines and it is commonly used in the literature.

[33] It is important to note that our measure of concentration is not perfect, as we do not observe all firms in a given market. This implies that we may be classifying non-concentrated industries as highly concentrated and, therefore, our estimates would be biased downward.

on how our results might be related to the use of envelope wages, we categorize workers according to the likelihood that their firms use envelope wages, using information from inspection reports for the 2009-2014 period (Labour and Tax Inspectorates, 2015). More precisely, we consider as the plausible group of companies paying envelope wages those firms with less than 20 employees operating in any of the following sectors: construction, retail trade, accommodation and food services, and personal services. The results of this exercise are reported in Figure 6. The wage effects (row 10, panel A) experienced by low-wage workers in this group of firms is roughly equal to the magnitude of the minimum wage increase (17.7%), consistent with evidence that low-wage workers are overrepresented in the prevailing minimum wage level (Gavoille and Zasova, 2022).[34] As for the probability of retaining employment (Row 10, Panel B), the results are suggestive of lower job losses in this group. Taking the wage and employment effects together, the findings point to wage underreporting as a potential adjustment mechanism to the minimum wage hike: firms that are (plausibly) paying envelope wages are able to absorb the labor cost shock by legalizing underreported wages without affecting employment relative to employees of non-evading firms.

6 Conclusions

This paper analyzes the labor market effects of a historically large increase in the minimum wage in Lithuania. Our results indicate that the minimum wage hike significantly increased the earnings of low-wage workers and had spillover effects that extended up to the median of the pre-treatment earnings distribution. Importantly, employment responses point that the increase in the minimum wage did not undermine the employment prospects of workers. However, we find suggestive evidence that young workers, as well as individuals in highly exposed municipalities, or in the tradable sector, might have been negatively affected. In addition, we document that employment losses were smaller in concentrated industries as well as among tax-evading firms.

Our results provide an indication that minimum wage policy can be an effective tool to address income inequality by boosting the wages of individuals in the lower tail of the income distribution without affecting their employment. However, our heterogeneity analysis suggests there is room for more nuanced policy. For instance, minimum wage lev-

[34] In our sample, around two thirds of the workers in the envelope wage group earn the pre-policy minimum wage (317 euros) or less, compared to 9% for non-envelope wage observations.

els that vary across workers, sectors, or cities have the potential to maximize the benefits of the policy while minimizing its costs. In this respect, an interesting policy to consider is that of group-specific minimum wages set by collective bargaining agreements used in several European countries (Card and Cardoso, 2022), but that are not common in Central or Eastern European economies. Moreover, our results for firms plausibly paying envelope wages suggest that the minimum wage can act as a fiscal backstop: increasing taxation and making some employment more formal (Bíró et al., 2022). However, policymakers should be aware that too high minimum wages may also have the opposite effect: firms may decide to shift part of the labor force to the shadow economy to mitigate the burden of higher labor costs. In this regard, the trade-off between wages and employment is more likely to appear when the minimum wage bites deep into the distribution (Ahlfeldt et al., 2022; Berger et al., 2022). Therefore, setting binding limits on where the minimum wage should fall relative to the average or median market wage, as Lithuania established in 2017, seems like a policy to consider to mitigate the potential employment costs of minimum wage increases.

Importantly, although we find no overall adverse effects on the labor market outcomes of low-wage workers, our results do not necessarily imply that they are not negatively affected. Firms may respond to minimum wage increases through other margins that may adversely affect them (Clemens, 2021). For instance, firms may absorb the shock by increasing prices (Lemos, 2008). Therefore, an important question for future research is not only to examine the potential pass-through, but also to understand whether low-wage workers are the consumers of the products that potentially become more expensive, which is not yet clear (Leonardi, 2015; MaCurdy, 2015).

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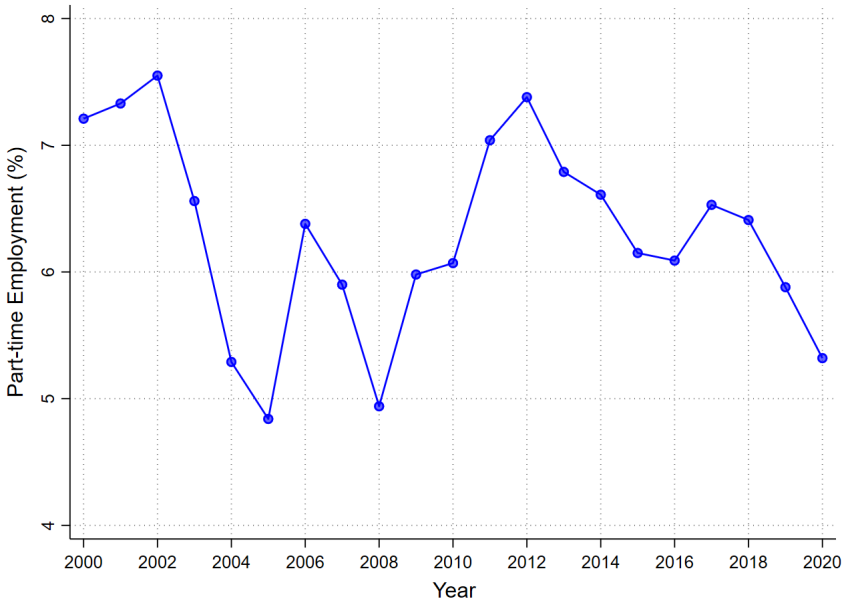
A Supplementary Material

Table A.1: Minimum Wage Studies in Central and Eastern Europe and Other Countries

Paper	Country	Year	Nominal Minimum Wage Changes	
			No. of Steps	Change (%)
Central and Eastern Europe				**Group median: 10.3**
Ferraro et al. (2018a)	Estonia	2013-2016	4	10.9; 10.3; 10.3; 9.9
Gavoille and Zasova (2022)	Latvia	2014-2015	2	12.3; 12.5
Harasztosi and Lindner (2019)	Hungary	2001-2002	2	56.9; 25.0
Grossmann (2021)	Czech Republic	2013-2017	4	6.3; 8.2; 7.6; 11.1
Eriksson and Pytlikova (2004)	Czech Republic	1998-2001	5	22.6; 12.5; 11.1; 11.1; 10.8
	Slovak Republic	1998-2001	4	20.0; 11.8; 11.1; 10.0;
Albinowski and Lewandowski (2022)	Poland	2004-2018	15	20.3; 13.3; 8.2; 8.1; 6.7
Vodopivec (2015)	Slovenia	2010	1	22.9
Jovanovic et al. (2021)	Macedonia	2017	1	19.0
Other Selected Studies				**Group median: 10.2**
Clemens and Wither (2019)	US	2007-2009	3	13.6; 12.0; 10.7
Gopalan et al. (2021)	US	2014-2015	5	17.2; 12.5; 12.5; 10.3; 10.1
Cengiz et al. (2019)	US	1979-2016	138	10.1
Giupponi et al. (2022)	UK	2016-2019	4	7.5; 4.9; 4.2; 4.4
Choi et al. (2021)	Ecuador	2008	1	17.6

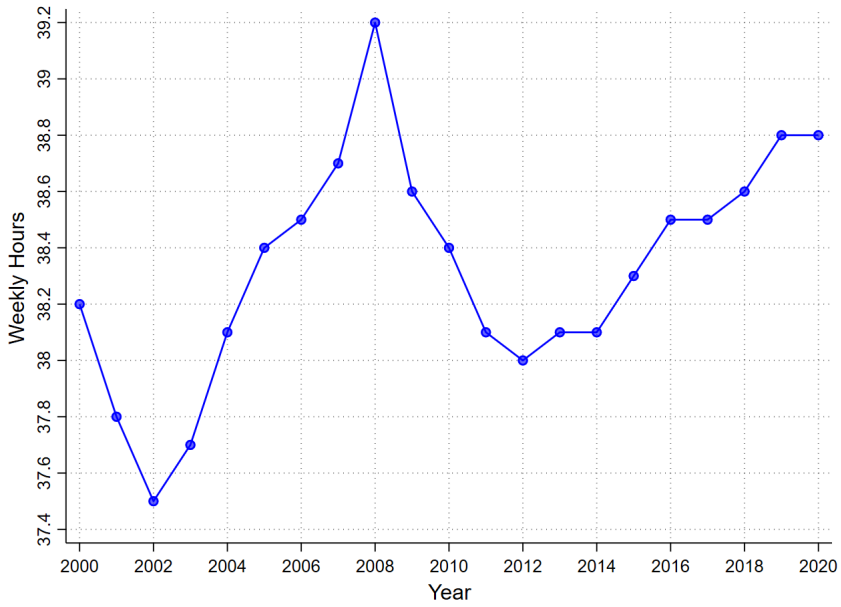
Notes: This table reports changes in the minimum wage used in studies investigating its labor markets effects in Central and Eastern Europe along with other recent papers in selected countries. Steps refer to the number of steps used in each study. For Albinowski and Lewandowski (2022), we report the 5 largest increases in their study, but we exploit the 15 changes when computing the median for the group. For Cengiz et al. (2019), we report the average real minimum wage hike from the 138 minimum wage changes used in their study.

Figure A.1: Part-Time Employment, 2000-2020



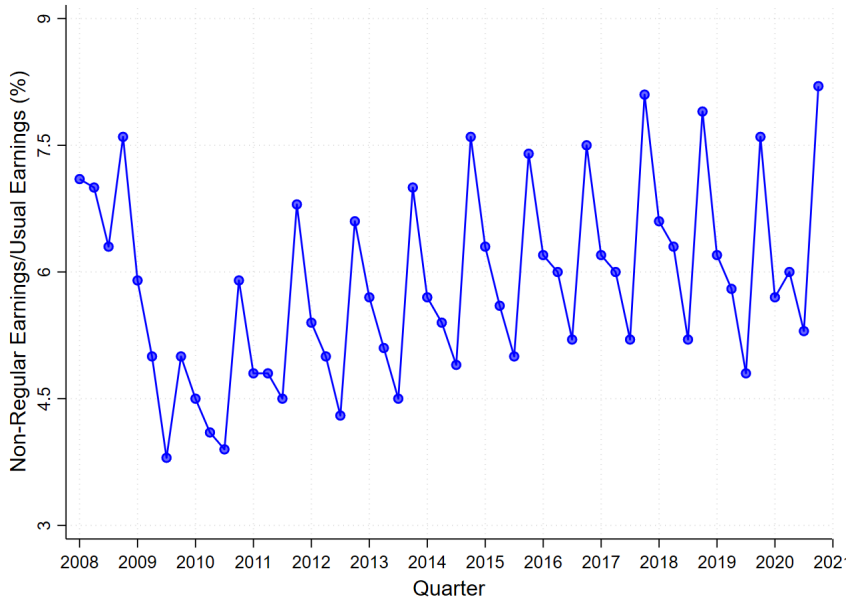
Source: Statistics Lithuania. Notes: The figure displays part-time employment as a percentage of total wage-employment.

Figure A.2: Usual Hours Worked per Week, 2000-2020



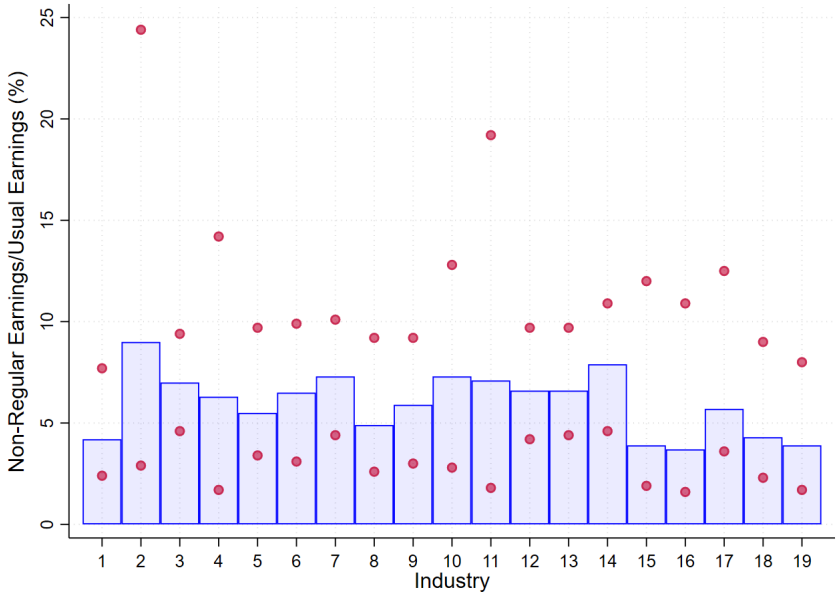
Source: Statistics Lithuania. Notes: The figure displays average hours worked per week in a job.

Figure A.3: Non-Regular Earnings, 2008-2020



Source: Statistics Lithuania. Notes: The figure displays non-regular earnings (bonuses, allowances, and other payments not perceived each month) as a percent of usual gross monthly earnings.

Figure A.4: Non-Regular Earnings by Industry, 2008-2020



Source: Statistics Lithuania. Notes: The figure displays industry-specific average, min, and max values of non-regular earnings (bonuses, allowances, and other payments not perceived each month) as a percent of usual gross monthly earnings over the period 2008-2020. Industries: 1. Agriculture, 2. Mining and Quarrying , 3. Manufacturing, 4. Electricity, gas, steam and air conditioning supply, 5. Water supply; sewerage; waste management and remediation activities, 6. Construction, 7. Wholesale and retail trade; repair of motor vehicles and motorcycles, 8. Transportation and storage, 9. Accommodation and food service activities, 10. Information and communication, 11. Financial and insurance activities, 12. Real estate activities, 13. Professional, scientific and technical activities, 14. Administrative and support service activities, 15. Public administration and defence; compulsory social security, 16. Education, 17. Human health and social work activities, 18. Arts, entertainment and recreation, 19. Other services.

B Additional Results and Robustness Checks

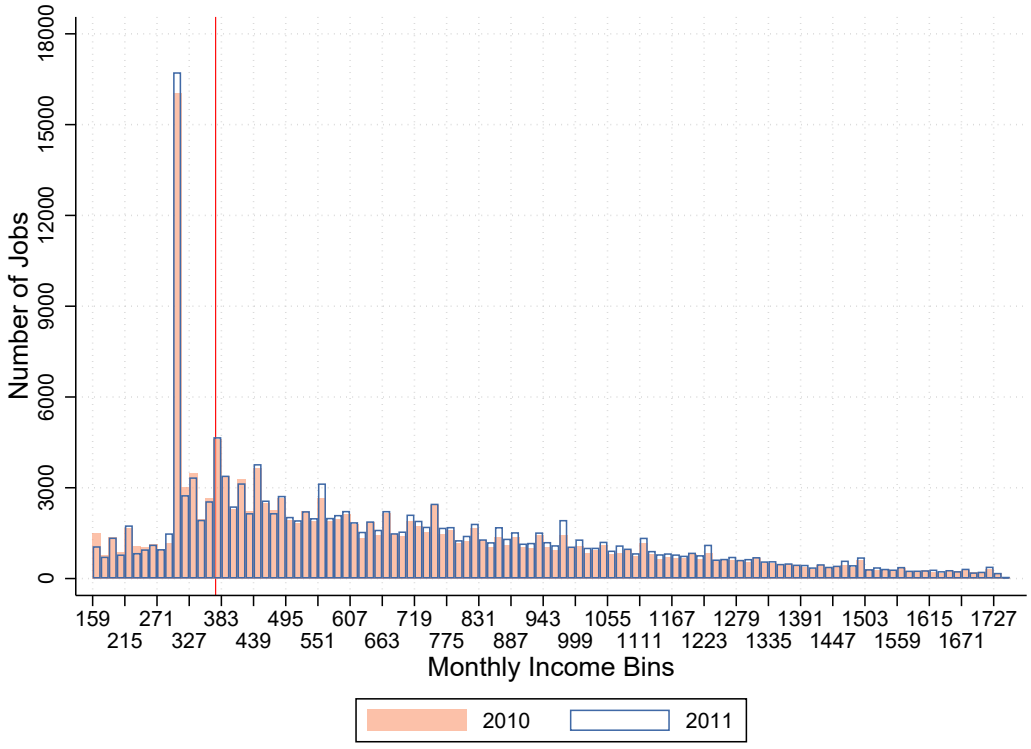
Table B.1: Who Are the Minimum Wage Workers?

	(1) 2012	(2) 2011	(3) 2010
Employed in $t-1$	-0.1708***	-0.1646***	-0.1704***
	(0.0048)	(0.0049)	(0.0058)
Female	0.0493***	0.0515***	0.0547***
	(0.0020)	(0.0020)	(0.0022)
Age ∈ [18-24]	0.0301***	0.0039	0.0331***
	(0.0035)	(0.0033)	(0.0039)
Age ∈ [25-44]	-0.0311***	-0.0284***	-0.0284***
	(0.0019)	(0.0020)	(0.0021)
Lithuanian	-0.0443***	-0.0350***	-0.0445***
	(0.0088)	(0.0098)	(0.0106)
Public Admin/State-Owned Firms	-0.0507***	-0.0522***	-0.0472***
	(0.0042)	(0.0042)	(0.0045)
Young Firms	0.0803***	0.0672***	0.0520***
	(0.0030)	(0.0032)	(0.0035)
Micro, Small, and Medium-Sized Firms	0.2352***	0.2151***	0.2236***
	(0.0020)	(0.0021)	(0.0022)
Vilnius; Kaunas; Klaipeda	-0.0815***	-0.0824***	-0.0830***
	(0.0019)	(0.0020)	(0.0021)
Agriculture; Mining	-0.0445***	-0.0235***	-0.0025
	(0.0075)	(0.0076)	(0.0080)
Manufacturing	-0.0567***	-0.0398***	-0.0249***
	(0.0060)	(0.0062)	(0.0066)
Electricity; Waste Management	-0.1585***	-0.1390***	-0.1218***
	(0.0081)	(0.0081)	(0.0085)
Construction	-0.0204***	-0.0236***	0.0157**
	(0.0066)	(0.0068)	(0.0072)
Wholesale Trade	-0.0864***	-0.0620***	-0.0477***
	(0.0063)	(0.0065)	(0.0069)
Retail Trade; Accommodation and Food Services	0.0375***	0.0650***	0.0945***
	(0.0061)	(0.0063)	(0.0066)
Information and Communication Tech	-0.1572***	-0.1316***	-0.1034***
	(0.0079)	(0.0081)	(0.0086)
Finance; Insurance; Real Estate Activities	-0.0784***	-0.0715***	-0.0528***
	(0.0072)	(0.0073)	(0.0077)
Professional Services; Administrative and Support Services	-0.0427***	-0.0267***	-0.0054
	(0.0061)	(0.0063)	(0.0066)
Public Administration; Education; Human Health	-0.0909***	-0.0706***	-0.0591***
	(0.0057)	(0.0058)	(0.0060)
Constant	0.4422***	0.4109***	0.4236***
	(0.0114)	(0.0124)	(0.0135)
Observations	192,798	182,576	170,732
R-squared	0.1380	0.1207	0.1216

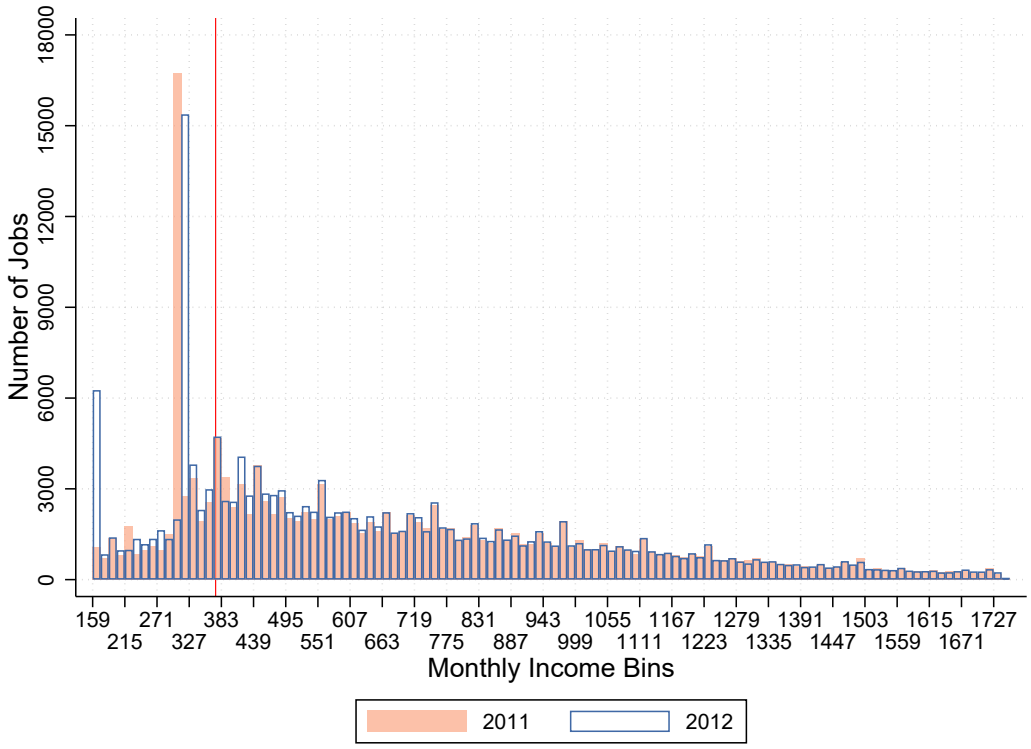
Notes: This table reports the point estimates of a linear probability model where the dependent variable is a dummy equal to one if a worker earns a monthly income below the minimum wage introduced in 2013 (373 Euros) in December of a given year. We regress the indicator for three different years prior to the introduction of the minimum wage on the following indicator variables: employed in previous year, sex, age groups (excluded category: older than 44), Lithuanian nationality, firm age (young firms: less than 5 years of activity), firm size (micro, small, and medium enterprises: firm size smaller than 50), location (three biggest locations: Vilnius, Kaunas, Klaipeda), and industry groups (excluded categories: other type of services).

Figure B.1: Income Distribution in Selected Years

A. December 2010 vs December 2011

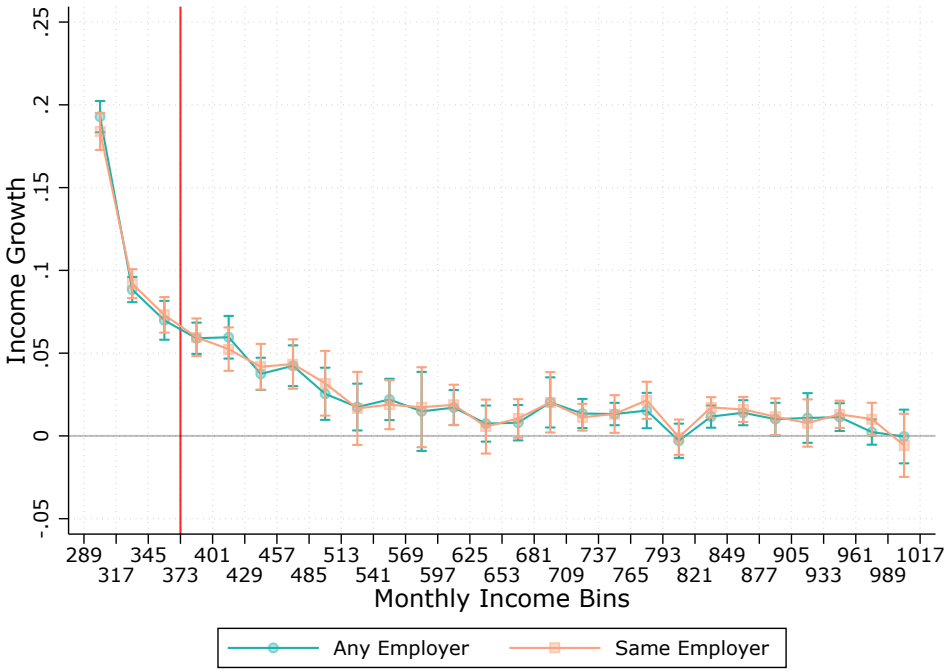


B. December 2011 vs December 2012



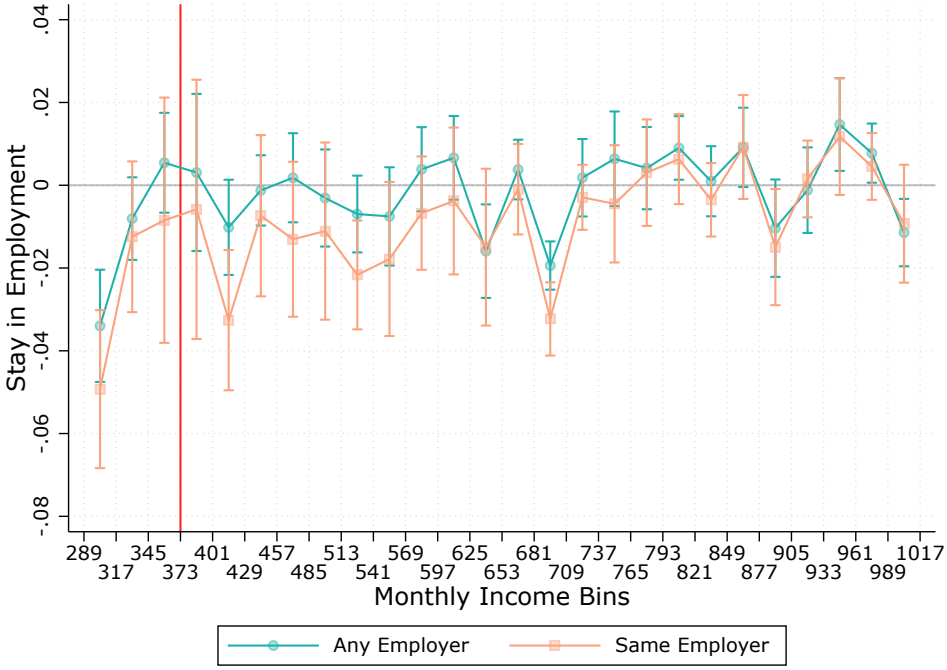
Notes: Figure displays the frequency distribution of monthly income in select pre-policy periods. Panel A compares the income distribution between December 2010 and December 2011 and Panel B looks at December 2011 and December 2012. Income refers to monthly insured labor income in nominal terms. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

Figure B.2: Minimum Wage Hike and Wage Spillovers



Notes: Figure reports *excess* income growth by starting income category for the period 2012-2013 relative to the income growth between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. Any Employer corresponds to all workers employed in $t+1$ independently of being in the same employer as in t, whereas Same Employer refers only to workers employed by the same company between t and $t+1$. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

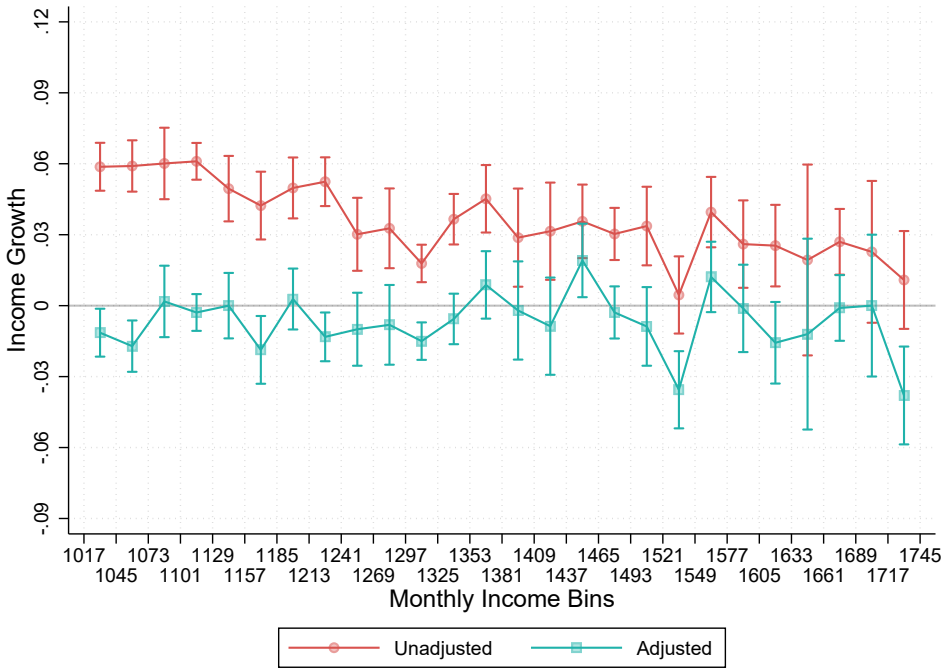
Figure B.3: Minimum Wage Hike, Employment Retention, and Reallocation



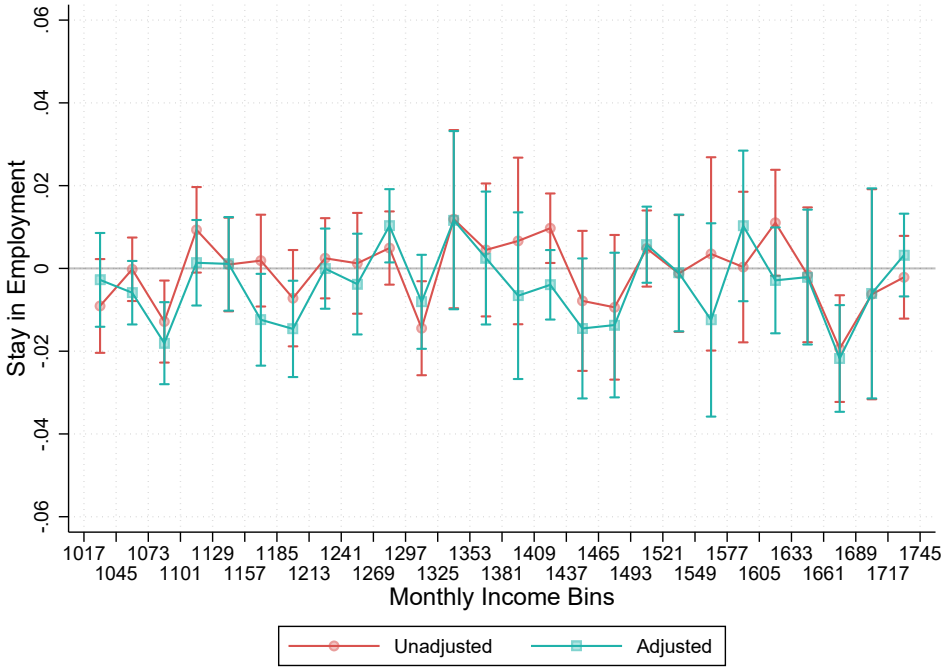
Notes: Figure reports *excess* employment retention probability by starting income category for the period 2012-2013 relative to the employment retention probability between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. Any Employer refers to the overall probability of remaining employed one year after the minimum wage hike, whereas Same Employer stands for the probability of being employed in the same firm as in December 2012. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

Figure B.4: Minimum Wage Responses in the Upper Tail

A. Income Growth



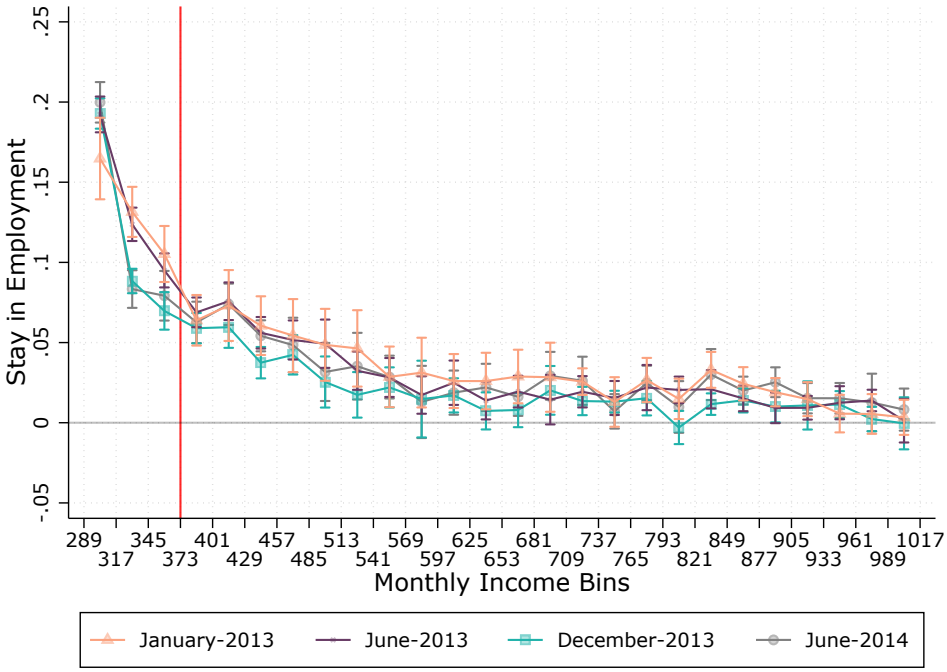
B. Employment Retention



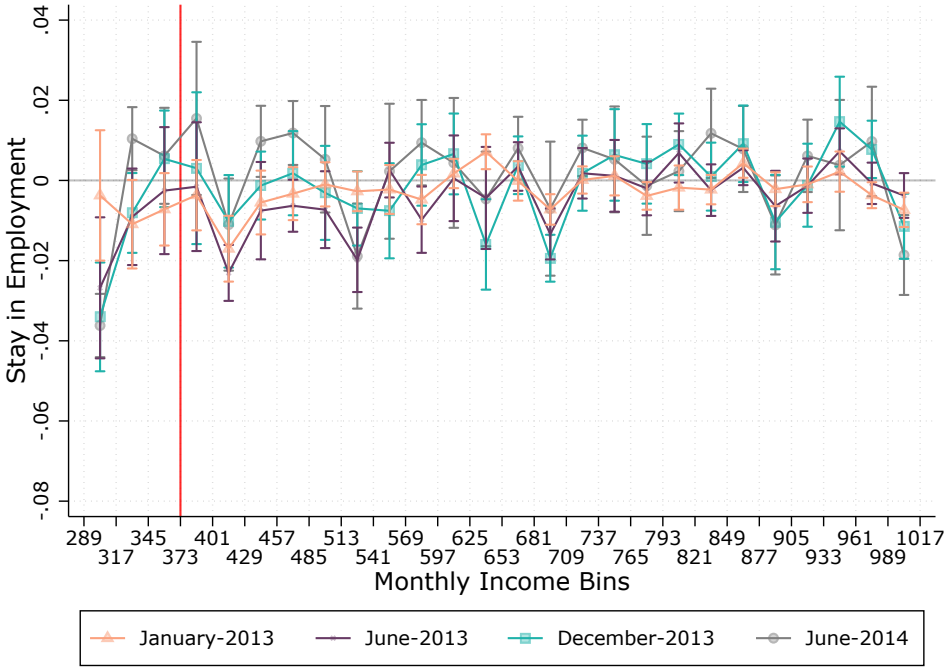
Notes: The figure shows the response to the minimum wage increase of outcome variables for individuals in the upper tail of the income distribution in December 2012. Panel A and Panel B report income and employment responses between December 2012 and December 2013, respectively. Unadjusted plots changes in the outcome variable, i.e., estimated of α_k parameters from Equation 1. Adjusted plots *excess* changes in the outcome variable relative to changes between December 2010 and December 2011, i.e., estimated β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level.

Figure B.5: Robustness: Time Horizon

A. Income Growth



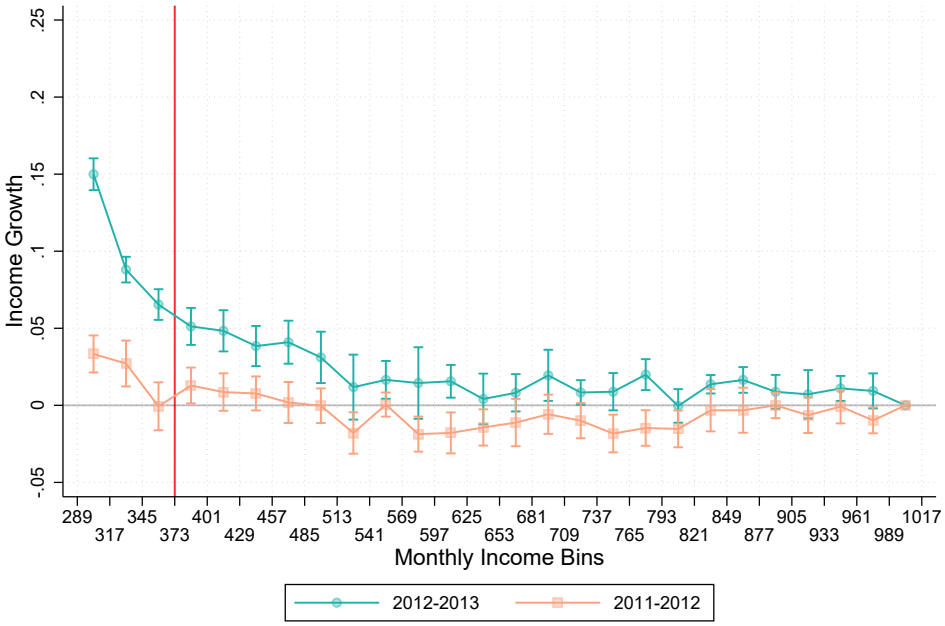
B. Employment Retention



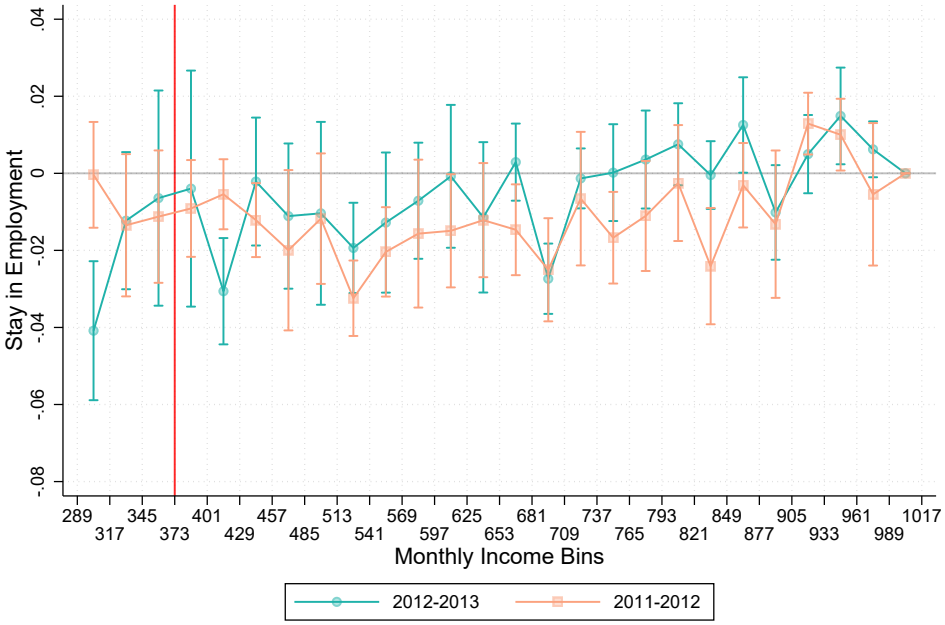
Notes: The figure shows changes in outcome variables at four different horizons, one month (January 2013), six months (June 2013), twelve months (December 2013), and eighteen months (June 2014), for individuals employed in December in 2012 against the initial income group. Panel A reports *excess* income growth by starting income category for the period 2012-2013 (postpolicy) relative to income growth between 2010 and 2011. Panel B reports *excess* employment retention probability by starting income category for the period 2012-2013 relative to employment retention probability between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

Figure B.6: Robustness: Jobs

A. Income Growth



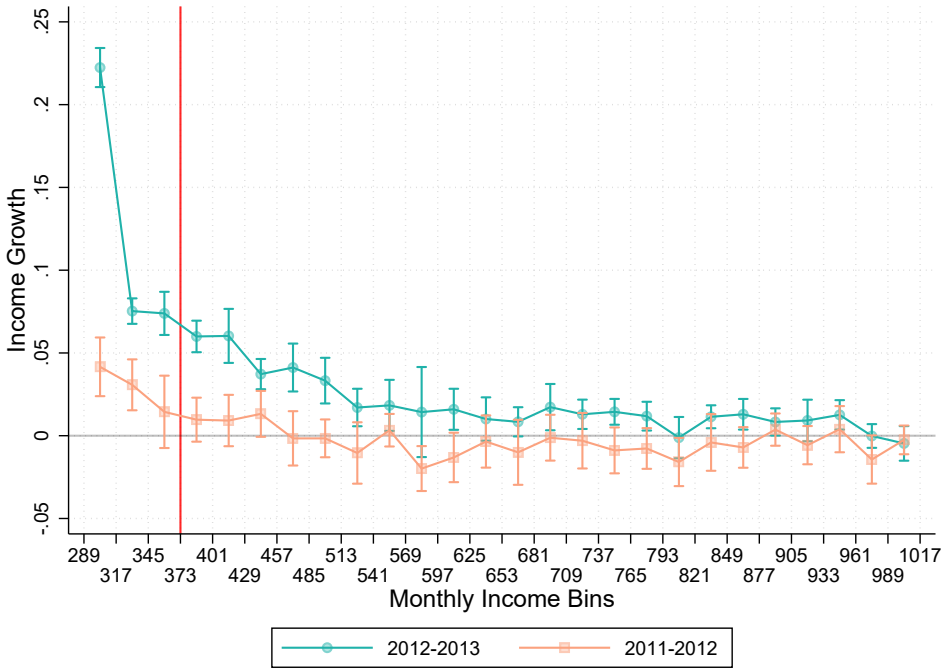
B. Employment Retention



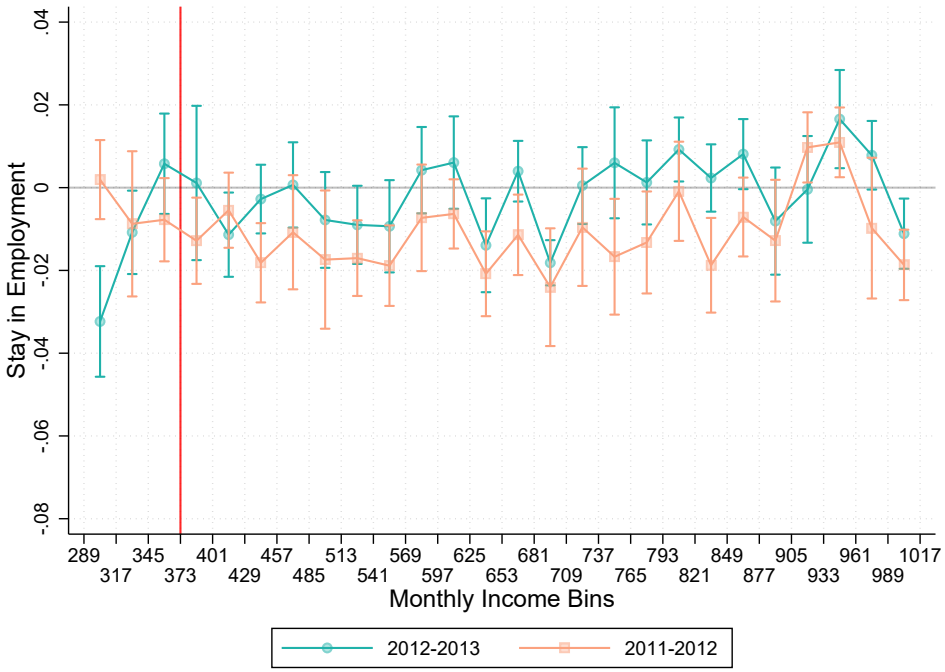
Notes: The figure shows changes in outcome variables for individuals employed in December in $t-1$ against the initial income group. The sample uses jobs instead of workers (baseline sample) as the unit of analysis. Panel A reports *excess* income growth by starting income category for periods 2011-2012 and 2012-2013 relative to income growth between 2010 and 2011. Panel B reports *excess* employment retention probability by starting income category for periods 2011-2012 and 2012-2013 relative to employment retention probability between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

Figure B.7: Robustness: Main Job based on Lowest Income

A. Income Growth



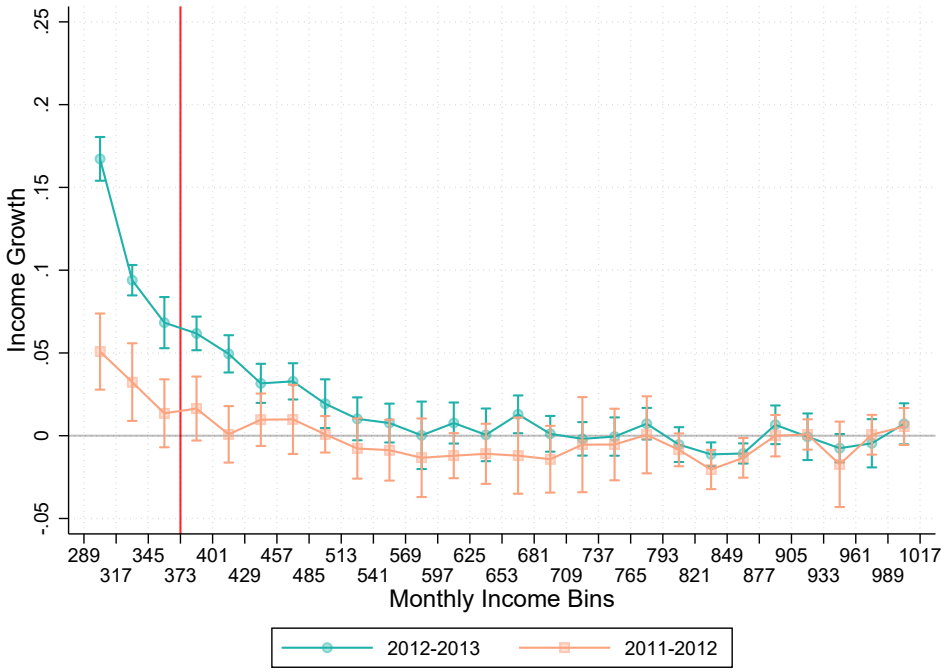
B. Employment Retention



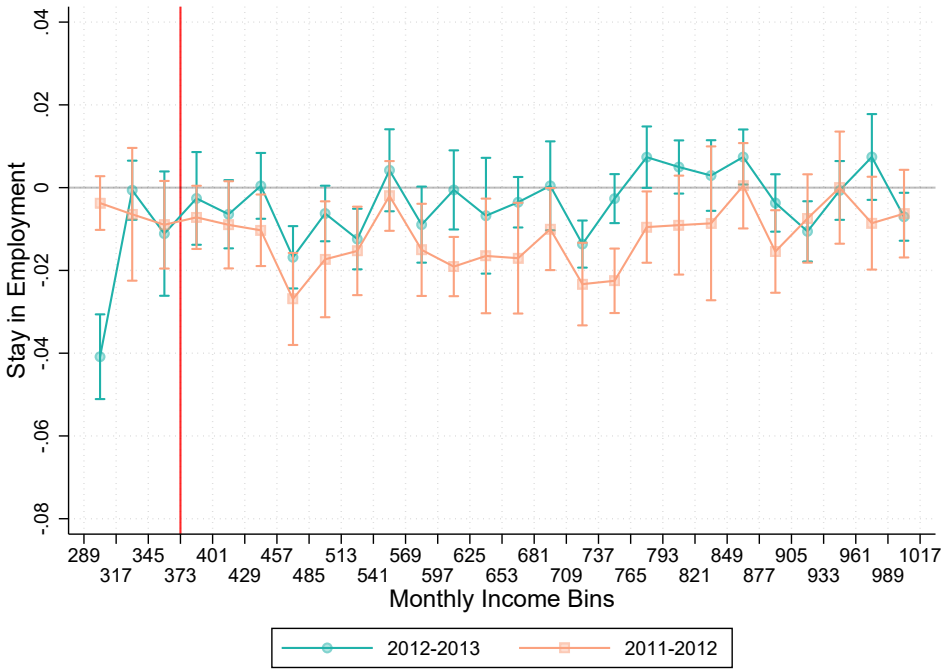
Notes: The figure shows changes in outcome variables for individuals employed in December in $t-1$ against the initial income group. The sample uses the job with the lowest reported income instead of highest one (baseline sample) to select worker's main job. Panel A reports *excess* income growth by starting income category for periods 2011-2012 and 2012-2013 relative to income growth between 2010 and 2011. Panel B reports *excess* employment retention probability by starting income category for periods 2011-2012 and 2012-2013 relative to employment retention probability between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

Figure B.8: Robustness: Average Income in Q4

A. Income Growth



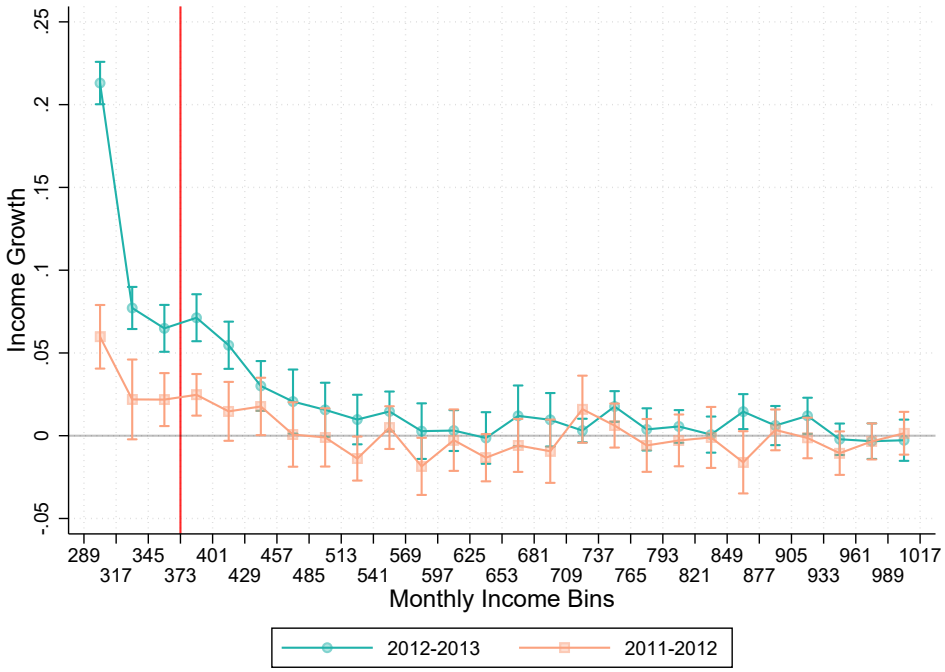
B. Employment Retention



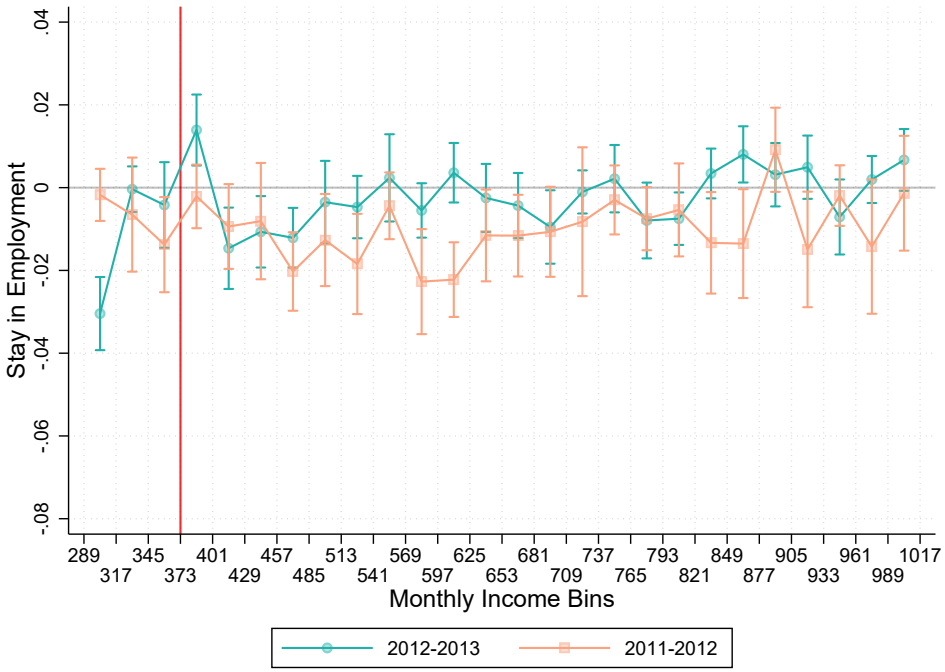
Notes: The figure shows changes in outcome variables for individuals employed in December in $t-1$ against the initial income group. The sample uses the average income between October and December instead of December (baseline sample). Panel A reports *excess* income growth by starting income category for periods 2011-2012 and 2012-2013 relative to income growth between 2010 and 2011. Panel B reports *excess* employment retention probability by starting income category for periods 2011-2012 and 2012-2013 relative to employment retention probability between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

Figure B.9: Robustness: September Income

A. Income Growth



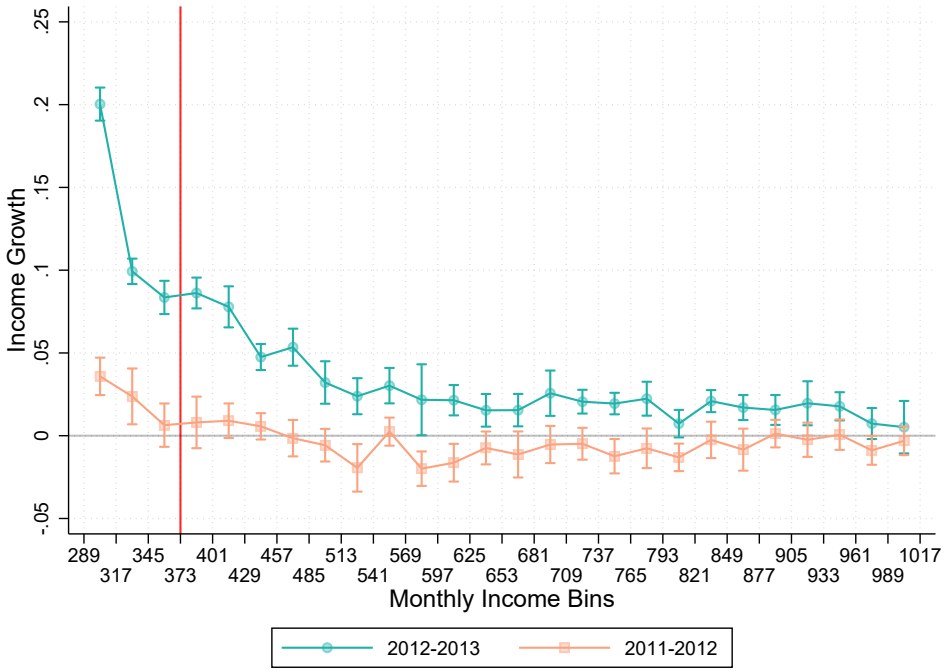
B. Employment Retention



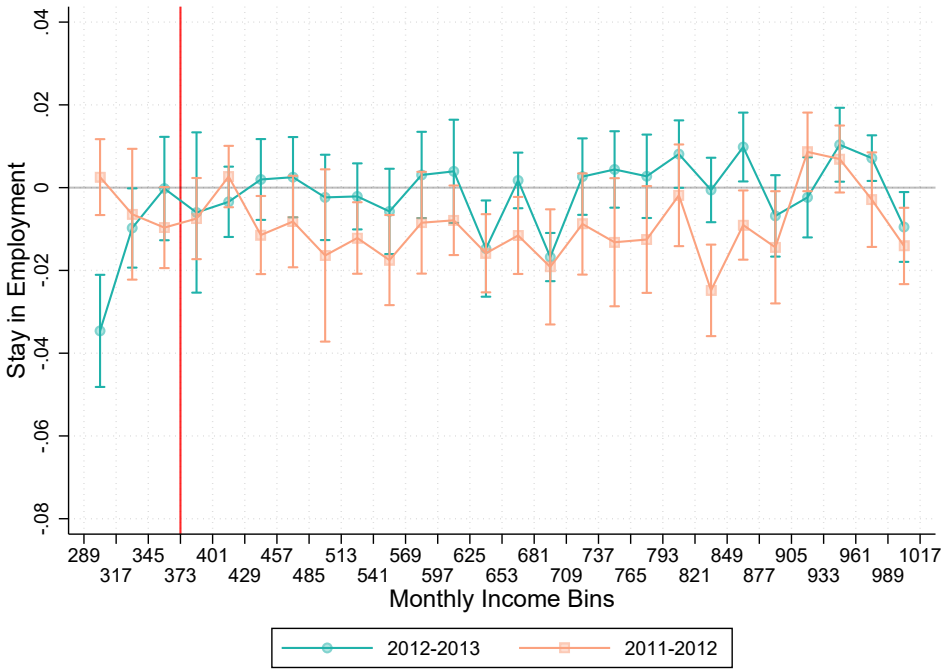
Notes: The figure shows changes in outcome variables for individuals employed in December in $t-1$ against the initial income group. The sample uses the income from September instead of December (baseline sample). Panel A reports *excess* income growth by starting income category for periods 2011-2012 and 2012-2013 relative to income growth between 2010 and 2011. Panel B reports *excess* employment retention probability by starting income category for periods 2011-2012 and 2012-2013 relative to employment retention probability between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.

Figure B.10: Robustness: Including Transportation Industry

A. Income Growth



B. Employment



Notes: The figure shows changes in outcome variables for individuals employed in December in $t-1$ and t against the initial income group. The sample includes the transportation industry in the baseline sample. Panel A reports *excess* income growth by starting income category for periods 2011-2012 and 2012-2013 relative to income growth between 2010 and 2011. Panel B reports *excess* employment retention probability by starting income category for periods 2011-2012 and 2012-2013 relative to employment retention probability between 2010 and 2011. Estimates refer to β_k parameters from Equation 2. All specifications include as controls age, sex, and indicators for municipality and sector of activity. 95% confidence intervals based on standard errors clustered at the municipality level. The vertical line represents the minimum wage level enacted in January 2013, i.e., 373 euros.