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IZA DP No. 12123

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ABSTRACT

Long-Term Responses to Large Minimum Wage Shocks: Sub-Minimum and Super-Minimum Workers in Slovenia

This study examines long-term effects of a minimum wage increase using an innovative identification strategy based on categorising workers according to their predicted marginal revenue products. It finds that the increase had a large and persistent disemployment effects on low-paid workers and that it triggered substitution toward more productive workers. As a consequence, the sub-minimum workers as a group lost average earnings, hours and employment compared to other workers. The adverse employment effect occurred both through a higher probability of transition from employment to non-employment and through a decreased probability of transition from non-employment to employment.

JEL Classification: J38, J31

Keywords: minimum wage, employment, unemployment, hours, earnings, Slovenia

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1 INTRODUCTION

Few issues in economics have been investigated more intensively than the effect of minimum wages on employment.[1] Yet studies continue to generate inconsistent results. Recent highly cited studies of the impacts of rising minimum wages include Giuliano (2013), who reported an increase in teenage employment, Allegretto, Dube and Reich (2011), who reported insignificant results, and Neumark, Salas and Wascher (2014) and Meer and West (2016), who reported significant but modest reductions in employment. One source of imprecision in the estimated employment effects is that it is rare to have a large fraction of workers for whom the minimum wage binds. For example, Autor, Manning and Smith (2016) noted that until the recent increases in the passage of state minimum wages, the minimum wage was binding for less than 5% of the US labour market from 1986–2012.

Another reason for inconsistent findings is that studies of the minimum wage are rarely conducted at the level of the individual worker, yet the impact of the wage policy depends critically on whether the worker's wage is affected by the policy. Workers whose wages and skills are below the newly-set minimum wage, referred to as the sub-minimum group, will face rationed demand for their work when the minimum wage is implemented. However, workers whose wages and skills are above the new minimum, called the super-minimum group, will experience rising demand for their services. In aggregate data, the sub-minimum and super-minimum groups are indistinguishable from one another and so the aggregate employment effect is mixing groups that gain and lose.

Related to this issue is that only the sub-minimum group receives an exogenously increased wage. The minimum wage does not directly raise wages for the super-minimum group, and so the minimum wage change will measure their changing labour costs with error. The measurement error will bias the coefficient in an unknown direction, but classic measurement error biases the magnitude of the effect downward.

The minimum wage also generates sample sorting issues that complicate measurement. Workers whose skill levels are no longer competitive at the higher wage will atypically exit employment and some may exit the labour force. Meanwhile, the substitution toward more skilled workers may induce more skilled workers to enter the labour market and become employed. The rising skill composition of the labour force could change labour turnover, the intensity of training offered by firms, and firm productivity. Past studies have not been able to track the labour force participation, employment and unemployment outcomes of sub-minimum and super-minimum

[1] Google Scholar listed over 1.6 million results to a search including key words 'minimum wage' and 'employment'.

workers, meaning that the estimated minimum wage effects have been biased by sorting into and out of the sample.

We analyze the effects of a dramatic 22.9% minimum wage increase imposed in Slovenia in March 2010. The initial wage increase was followed by subsequent adjustments tied to inflation, which was rising faster than nominal wages. Consequently, the minimum wage increases continued to outpace average wage growth from 2010 to 2013. Between 2008 and 2015, the real gross minimum wage increased by 32.4% while real average wages increased by 7%. In 2015, with the minimum-to-average wage ratio of 49.3% Slovenia, together with France, ranked first among all 22 EU Member States that mandate a national minimum wage (see Eurostat, 2018 and OECD.Stat, 2018).

This paper makes use of several strategies that should improve the accuracy of our estimates. First, we follow individuals over a 5-year period after the initial increase in the minimum wage. As shown by Meer and West (2016), the effects of a minimum wage increase may not be fully apparent over a single year, and so a long time span will provide a better window for capturing the minimum wage employment response. Second, our database includes individuals who leave employment as well as those who remain employed. Studies that only observe the minimum wage effects among the employed have a selection bias in that they miss the effect of the minimum wage on the employment prospects of the unemployed or the workers who separate from employment. Third, our study examines the entire labour market. Studies that follow an individual firm or subset of firms risk capturing the response of employers who are more able to pass costs on to customers while their competitors are shedding workers or exiting altogether. Focusing on the restaurant sector, for example, may miss the minimum wage effect if tipped employment masks the effect of minimum wages on hourly costs. Finally, we distinguish the effects of the minimum wage on the sub-minimum group whose marginal revenue products lie below the new minimum wage versus the effects on the super-minimum group whose marginal revenue products exceed the new minimum. The minimum wage will cause a substitution effect away from the sub-minimum toward the super-minimum workers, and so studies that conflate the two groups will understate the disemployment effect of the minimum wage. In addition, this study will examine whether demand for a worker rises or falls when he or she is in a firm where the cost of hiring the other workers in the firm is rising due to the minimum wage increase.

A key advantage from our use of longitudinal data is that we estimate a worker's marginal revenue product based on a wage regression run in the year prior to the imposition of the minimum wage. In that way, we have a measure of each worker's marginal revenue product before the minimum wage was imposed, even if the individual was not employed at that time. This strategy enables us to look at how the minimum wage affected the entire labour force over 5 years, whether initially employed, unemployed, or idle.

We find that Slovenia's 2010 minimum wage increase had a large and persistent disemployment effect over the next five years on workers whose 2009 marginal revenue products are predicted to be below the minimum wage. The effect is largest for the least skilled and gets smaller as skill level rises. Workers whose co-workers received mandated minimum wage pay increases experienced a boost in relative demand as firms substituted away from sub-minimum toward super-minimum workers. The disemployment effect for the sub-minimum population occurred both through a higher probability of transition from employment to non-employment and through a decreased probability of transition from non-employment to employment. The adverse minimum wage effect occurs for all low-skilled workers, whether experienced or first-time market entrants. Although sub-minimum workers who remain employed received large earnings increases, the sub-minimum workers as a group lost average earnings, hours and employment compared to workers whose estimated marginal revenue products were immediately above threshold.

The structure of the paper is as follows. Section 2 provides literature review on minimum wage effects on employment, hours and earnings. We continue with an overview of minimum wage developments in Slovenia (Section 3). Section 4 presents the identification of relevant samples, Section 5 provides a detailed description of empirical strategy and Section 6 presents data. Section 7 explains the regression framework and describes the results. The final section concludes.

2 LITERATURE REVIEW

Despite a voluminous theoretical and empirical literature on the minimum wages, there is little consensus on the magnitude or even direction of the effects on labour market outcomes. Early empirical studies, which were mostly based on time-series analysis and studying the effects of the changes in the national minimum wage on aggregate employment, mostly report negative employment effects (see Brown, Gilroy and Kohen, 1982). In the beginning of 1990s, this consensus was challenged by the "new minimum wage research" stream of studies that applied quasi-experimental approaches and found no or positive effects of minimum wage increase on employment (Card, 1992a, 1992b; Card and Krueger, 1994; Katz and Krueger, 1992). These results triggered a new wave of research, with findings that have remained polarized.[2]

Some of the studies within the new wave of research report of no or positive effects of the minimum wage increase. For example, Card and Krueger (2000) in their replication of a 1994 study confirmed positive, although not always statistically significant, effect on employment in New Jersey, with elasticities ranging between 0.005 and 0.15. Giuliano (2013) reported positive effects for teenage employment in the US, as did Fang and Gunderson (2009) for older workers

[2] A discussion of these findings can be found in Neumark and Wascher (2010, 2017); Neumark, Salas and Wascher (2014); Neumark (2017); and Allegretto, Dube, Reich and Zipperer (2013, 2017).

in Canada. Positive and/or statistically insignificant effects of minimum wages on employment probabilities were found also by studies for the UK (Stewart, 2004; Dickens, Riley and Wilkinson, 2009, 2012; and Bryan, Salvatori and Taylor, 2013).

It does appear that minimum wages reduce employee turnover. Using matched employer-employee Portuguese data, Portugal and Cardoso (2006) found that the 1987 50% youth-specific minimum wage increase reduced teenagers' share of separations by 15%. Since the share of teens hired in new firms also fell, overall teen employment did not change significantly. Comparing provinces in Canada in the 1979–2008 period, Brochu and Green (2013) showed that minimum wage increases lead to reduction of both separation and hiring rates. Dube, Lester and Reich (2016) used a border discontinuity design to show that minimum wages had a sizeable negative effect on employment flows in the US. Dickson and Papps (2016) showed that minimum wage increases in the UK reduced both the likelihood of changing jobs or exiting employment and the likelihood of an unemployed worker finding a job.

There is also the third, most voluminous group of studies that finds small, significant disemployment effects of minimum wages. According to Neumark (2017), the typical elasticity of employment effects for low-skilled workers with respect to mandated wage increases ranges between −0.1 and −0.2, with some estimates even smaller in magnitude.[3] Studies that focus on sub-minimum wage workers generally find that rising minimum wages lower employment. Abowd, Kramarz, Margolis and Philippon (2000) found that minimum wage increases in France significantly lowered future employment probabilities of workers with wages initially lower than the new minimum wage. While the previous paper did not find significant effect for the US, Currie and Fallick (1996) reported that employed individuals who were directly affected by the minimum wage increase were 3–4% less likely to be employed a year later. Similar findings are reported for young workers in the US and Canada by Zavodny (2000) and Campolieti, Fang, Gunderson (2005).

Only a few studies examine the effect of minimum wage on hours worked or on earnings. Gramlich (1976) found that minimum wage increases in the US caused teens and adult males to move from full-time to part-time employment, whereas adult females shifted from part-time to full-time jobs. Orazem and Mattila (2002) and Neumark, Schweitzer and Wascher (2004) reported that minimum wage increases in the US reduced hours worked by low-wage workers, in line with findings on young workers by Couch and Wittenburg (2001) and Sabia (2009) for the US; by Shannon (2011) for Canada; and by Machin, Manning and Rahman (2003) for residential care workers in the UK. Jardim et al. (2017) showed that the Seattle minimum wage increase resulted in a 9.4% fall in overall work hours for low-skill workers. As for the effects on earnings, Orazem and Mattila (2002) and Neumark, Schweitzer and Wascher (2004) also found that

[3] Examples include Thompson (2009); Dube, Lester and Reich (2010); Neumark, Salas and Wascher (2014); Clemens and Wither (2014); Powell (2016); and Meer and West (2016).

because labour demand for low-skill workers was elastic, minimum wage increases resulted in an overall loss of earned income for low-wage workers.

3 MINIMUM WAGE DEVELOPMENTS IN SLOVENIA, 2009–2015

In March 2010, Slovenia adopted a new Minimum Wage Act that increased the statutory minimum wage by 22.9%.[4] That was the most dramatic increase since the introduction of a minimum wage in 1995. The new law also automatically increased the minimum wage in subsequent years by the annual increase in the consumer price index and allowed additional increases to reflect wage, employment or GDP growth. Because after 2009 wages rose more slowly than consumer prices, the minimum wage rose sharply relative to the average market wage. In real terms, from 2008–2015 the minimum wage grew by 32.4% and real average wages just by 7%. While in 2009 the minimum-to-average wage ratio was 41.2%, it was pushed to 47.6% by the 2010 law and it peaked at 51.5% in 2013 before declining modestly (Figure 1).

The March 2010 increase of the minimum wage brought Slovenia to the forefront of the EU countries ranked by the ratio of minimum to average gross wage. In 2015, with the ratio of 49.3% Slovenia, together with France, ranked first among all 22 EU Member States that mandate a national minimum wage, exceeding the median of EU Member States by 9 percentage points (OECD.Stat, 2018; Eurostat, 2018).

Such a large mandated wage increase threatened the profitability of some firms. As a result, the February 2010 Minimum Wage Act allowed individuals employers to negotiate, with the consent of unions, a gradual transition to the new mandated minimum wage to be completed by December 31st, 2011.[5] The graduated increase was chosen by 1.5% of firms, constituting 9% of employment. Even the graduated minimum wage increase was a large cost shock.[6]

The persistent minimum wage increases over 2010–2013 directly affected a growing share of the workforce. In 2009, before the law implementation, 5.4% of workers were paid the minimum

[4] The minimum wage amount increased from 597 to 734 Euro gross per month.

[5] A gradual increase of the minimum wage could be adopted by firms for which immediate transition would lead to large losses that would jeopardise the existence of these firms, or to layoffs of a large number of workers for business reasons.

[6] The ratio of the minimum wage to the average for firms with gradual adjustment schedule was 43.2% in 2010 and 45.8% in 2011, but these firms faced the full cost of the minimum wage by 2012.

wage.[7] At the 2013 peak, 10.5% of workers earned the minimum wage, with the share of minimum wage workers declining to 8.2% by 2015.

4 IDENTIFYING THE MINIMUM WAGE EFFECT ON SUB- AND SUPER-MINIMUM WORKERS

(a) Identifying the minimum wage effect for individual workers

A unique feature of this study is measuring the minimum wage's effect on the demand for individual workers over a long period. The advantage is that we can measure how the minimum wage affects each individual's employment even if he or she changes sectors or transitions into or out of employment. To accomplish this, we need to measure each individual's marginal revenue product in the absence of the minimum wage. This marginal revenue product is treated as the baseline labour demand for each worker. We can infer the effect of the minimum wage increase by observing how the minimum wage alters labour market outcomes due to its distortionary effect on the cost of hiring the worker compared to the baseline demand.

There are four advantages to this strategy. First, the approach assigns a baseline productivity level and associated labour demand both to employed workers and to workers who are not employed. This allows us to study the minimum wage effects on both the employed and the non-employed, avoiding selection issues common in past studies of the minimum wage that focus only on the employed. Second, the strategy allows us to follow workers who switch sectors and so we can avoid the selection problems inherent in studies that focus on a single firm or a single sector. This allows us to capture workers who reemploy in other sectors. Third, workers who lose their jobs lose the value of their job tenure, meaning that as unemployed workers, their marginal revenue products fall below what it was when still employed. Consequently, we can show the effect of lost tenure on the probability of finding work after job loss, something not previously studied. Finally, we can distinguish the minimum wage effects on the employment of workers in two groups, those whose skills are above the minimum wage and those below.

In equilibrium, a free labour market will equate wages and marginal revenue products, and so we can use a variant of the Mincer (1974) earnings function to predict a worker's marginal revenue product before the minimum wage increase was imposed. In year τ, each worker i is paid wage $W_{i\tau}$ and has a vector $X_{i\tau}$ of observable skills (education, work experience, firm tenure, occupation, gender) and a vector $Z_{i\tau}$ of local labour market strength indicators. We can estimate the worker's marginal revenue product in year τ using the fitted values from

$$(1)\ W_{i\tau} = X'_{i\tau}\beta^X_\tau + Z'_{i\tau}\beta^Z_\tau + e_{i\tau},$$

where β^X_τ and β^Z_τ are the coefficients translating observed workers' skills and market characteristics into their period τ log wages and $e_{i\tau}$ is a random error term with zero mean. As a

[7] The minimum wage worker was defined as a worker whose hourly wage is equal to the statutory minimum wage in that year +/– 2.5%.

practical measure, we used wage levels and not the typical log wage as the dependent variable. Predicted wages based on the logarithmic specification tended to overpredict wages at the bottom tail of the distribution and so the 'linear in levels' specification performed better for the group most likely affected by the changing wage laws. We fix period τ to be March 2009, one year before the new minimum wage came into effect. We then use the period τ earnings structure, to measure each worker's marginal revenue product for the subsequent years.

We apply the strategy in two ways that yielded similar results. The first fixes the sample of workers to be those employed in March 2009 and fixes their measured skills to be those observed as of March 2009. In that case, worker *i*'s marginal product from 2010–2015, our observation period, will be

(2A) $\widehat{\omega_{i09}} = X'_{i09}\widehat{\beta^X_{09}} + Z'_{i09}\widehat{\beta^Z_{09}}$.

With this strategy, we fix skills and market conditions at their 2009 levels because firm wage and employment decisions and worker labour supply and human capital investment decisions may change in response to the initial minimum wage shock. Consequently, measures of the worker marginal revenue product may respond endogenously to the minimum wage in subsequent years.

The disadvantage of the first tactic is that it fixes the sample to those employed in March 2009 and so it ignores labour market entry in subsequent years. It also ignores changing skill content that occurs regardless of the minimum wage policy through general and firm-specific work experience. As an alternative, holding fixed the March 2009 wage structure we can compute the pre-minimum wage marginal product at current skills using

(2B) $\widehat{\omega_{it}} = X'_{it}\widehat{\beta^X_{09}} + Z'_{it}\widehat{\beta^Z_{09}}$.

Hence, the marginal revenue product could rise or fall as workers acquired additional schooling, changed occupation, gained work experience, or gained or lost job tenure. We can use the 2009 wage structure to estimate what new labour market entrants after 2010 would have earned in 2009.[8] We can also adjust for the possibility of falling marginal revenue products for job losers who lose firm-specific skills.

(b) Modelling changes in worker-specific labour demand due to minimum wage increase

Assume that firms are maximizing short-term profit so that capital expenditures have been set. Worker *i* in firm *k* has a known marginal revenue product of labour in year $\tau + 1$ that is equal to his expected wage, $\widehat{W_{i\tau+1}}(R_{\tau+1})$. The expected wage depends on the worker's skills, but also on exogenously set government regulations, $R_{\tau+1}$. One government regulation is the minimum wage. The firm decides on how much time to employ worker *i* as opposed to all other workers ~*i*

[8] Because all individuals registering with the public employment office are required to specify a suitable occupation for job-search purposes, marginal revenue products can be computed also for first-time job seekers.

at wage $\widehat{W_{\sim\iota\tau+1}}(R_{\tau+1})$. The firm faces an exogenously set market price that reflects current sector demand, $P_{k\tau+1}$. Firm profits in year $\tau+1$ will be

(3) $\Pi_{k\tau+1} = P_{k\tau+1}F(L_{i\tau+1}, L_{\sim i\tau+1}) - \widehat{W_{\iota\tau+1}}(R_{\tau+1}) \cdot L_{i\tau+1} - \widehat{W_{\sim\iota\tau+1}}(R_{\tau+1}) \cdot L_{\sim i\tau+1}$.

The key exogenous variables are prices and government employment regulations that will vary with time. Hence, the reduced form solution for wages and employment will depend on how prices and regulations are changing over time. In particular, the reduced form demand for the i^{th} worker's labour in firm *k* will be

(4) $L^k_{i\tau+1} = L[P_{k\tau+1}, \widehat{W_{\iota\tau}}(R_{\tau+1}), \widehat{W_{\sim\iota\tau+1}}(R_{\tau+1})]$

and the change in the demand for the i^{th} worker's labour will be

(5) $\frac{dL^k_{i\tau+1}}{d\tau+1} = L_P \frac{\partial P_{k\tau+1}}{\partial\tau+1} + L_{W_i}\left[\frac{\partial\widehat{W_{\iota\tau+1}}}{\partial R_{\tau+1}}\frac{\partial R_{\tau+1}}{\partial\tau+1}\right] + L_{W_{\sim i}}\left[\frac{\partial\widehat{W_{\sim\iota\tau+1}}}{\partial R_{\tau+1}}\frac{\partial R_{\tau+1}}{\partial\tau+1}\right]$.

In other words, the change in the demand for the i^{th} worker's employment depends on how changes in government employment regulations affect the wages for the i^{th} worker and the wages for all other workers in the firm, holding constant the changing demand for firm output as reflected in the market price for the firm.

Equation (5) requires a measure of how the minimum wage is affecting the cost of employing each worker *i.* Suppose that the minimum wage, $MW_{\tau+1}$ is to be implemented in year $\tau+1$.

We approximate the change in the cost of employing worker *i* using equation (2A) or (2B) as

(6) $\left[\frac{\partial\widehat{W_{\iota\tau}}}{\partial R_{\tau+1}}\frac{\partial R_{\tau+1}}{\partial\tau+1}\right] = g(\widehat{\omega_{\iota\tau}}, \frac{MW_{\tau+1}}{\widehat{\omega_{\iota\tau}}})$.

The cost of employing worker *i* thus reflects the worker's marginal revenue product in the absence of the minimum wage and the proportional tax over that marginal revenue product as expressed by the ratio of the minimum wage to the worker's marginal revenue product.

The minimum wage directly raises the price of employing workers whose wages were initially below the new minimum wage. We refer to these as the sub-minimum group. Other workers will have marginal revenue products that exceed the minimum wage. We refer to these workers as the super-minimum workers. We would expect that firms will substitute away from sub-minimum workers and toward super-minimum workers in response to an increase in the minimum wage. Studies that combine employment of sub- and super-minimum workers in studies of minimum wage effects conflate the two opposite effects and bias their assessments toward zero.

5 DATA

(a) Defining the minimum wage shock and the change in firm-specific output demand

The estimation of equations (5) requires a measure of the minimum wage effect on wages of all the other workers in the firm – what we call the minimum wage shock – as well as of firm-specific output demand. Below we explain how we construct these two variables.

Firm-specific minimum wage shock: We designate anyone for whom $\widehat{(\omega_{\iota\tau})} < (MW_{\tau+1})$ to the sub-minimum group (*sm*), and the super-minimum workers (*Sm*) for whom $\widehat{(\omega_{\iota\tau})} > (MW_{\tau+1})$ to the super-minimum groups. Workers in the *sm* group are subject to the direct increase in their wages as a result of the change in minimum wage law, and workers in the *Sm* group are not directly affected. It is possible that *Sm* workers get wage increases after the minimum wage is implemented, but their wage increases would reflect endogenous firm compensation responses to the exogenously imposed minimum wage.

To measure the exogenous cost to the firm of the minimum wage law, we impose the predicted wage structure in year τ on all workers in the firm. We do this rather than taking the actual wage bill to ensure that we are holding invariant the wage structure across all firms in the base period. This strategy will also allow us to measure the minimum wage shock that newly entering firms would have faced had they been in business before the minimum wage was implemented.

We measure firm *k*'s wage bill in year τ, net of worker *i,* by

$\widehat{WB_{\sim\iota,k\tau}} = (\sum_{\ell=1}^{I} \widehat{W_{\ell k\tau}}) - \widehat{W_{\iota k\tau}}$. Then we compute the change in the wage bill that would have been due to the same workers being employed under the new minimum wage,

$\Delta WB_{\sim i,k\tau}^{sm} = \sum_{\ell=1}^{sm}(MW_{\tau+1} - \widehat{W_{\ell k\tau}})\ \forall\ \ell \in sm, \ell \neq i$, where all of the exogenous change in the wage bill is due to the firm's sub-minimum workers. The proportional cost of the minimum wage bill net of worker *i* to firm *k* is our firm minimum wage shock

$$(7)\ \left[\frac{\partial \widehat{W_{\sim\iota\tau}}}{\partial R_{\tau+1}}\frac{\partial R_{\tau+1}}{\partial \tau+1}\right] = MW_{\sim i,\tau+1}^{k} = \frac{\Delta WB_{\sim i,k\tau}^{sm}}{\widehat{WB_{\sim\iota,k\tau}}}.$$

We expect the largest impact of the law for workers in firms that faced the largest proportional wage increase.

We apply two versions of the firm minimum wage shock. In the first, we compute the minimum wage shock holding the firm's employment base fixed at the March 2009 level. The shock is held fixed for all subsequent periods and it remains attached to the worker even if the worker loses the job or switches to another firm. Because subsequent worker employment decisions may be at least partially in response to the minimum wage increase, this strategy presumes that the initial shock is the exogenous event and that subsequent wage or employment outcomes are

endogenously responding to that event.[9] The previous strategy does not account for the persistently increasing skill levels of incumbent workers or for efforts by the firm to adjust their mix of workers through hiring and firing in ways that might reduce the magnitude of the minimum wage shock. The second strategy allows the composition of the firm's employment mix and the amount of the minimum wage shock to change over time. In that case, the firm minimum wage shock can rise as minimum wages rise or as the firm hires more sub-minimum workers, but it can also fall if workers are upskilling or if the firm lowers its employment of sub-minimum workers.[10]

New labour market entrants would not have a firm in March 2009 and new firm entrants would not have a labour force in 2009. We adopted the following conventions to allow us to include new firms and workers in the analysis. Workers who had prior work experience were assigned the firm minimum wage shock of the last firm at which they worked going back to 2005. Workers who had no prior work experience were assigned the firm minimum wage shock of the firm they would eventually join. New firms were assigned a minimum wage shock that reflects what their initial wage bill compared to what the wage bill would have been had the 2009 minimum wage prevailed.

Firm-specific output demand: As specified in equation (5), worker-specific demand also reflects the heterogeneous sectoral output demand that translates to the demand for labour in the firm. Allowing sectoral demand shocks to vary across similarly skilled workers will help us to distinguish the effects of the minimum wage from the effects of the macroeconomic contractions and expansions.

Changes in firm output will exogenously reflect changes in the minimum wage absorbed by the firm. However, as we shall see, the minimum wage law imposes widely varying costs on firms, even firms in the same market. Our strategy for measuring the exogenous demand shock confronting the firm is to evaluate changes in output for all the other firms in the same two-digit market, excluding the own firm. Formally, let firm *k* be in industry *I.* Changes in the composition of demand for workers will be tied to the changing market demand for firms in the same sector. The percentage change in output demand for firm *k* in sector *I* will be

$$(8)\ \frac{\partial P_{k\tau+1}}{\partial \tau+1} = h(dq^{k}_{\sim k,\tau+1}) = \ \ln[(\sum_{j=1}^{I} q^{j}_{I,\tau+1}) - \ q^{k}_{I,\tau+1}] - \ln[(\sum_{j=1}^{I} q^{j}_{I,\tau}) - \ q^{k}_{I,\tau}]\ \forall\, j \in I, j \neq k.$$

[9] See, for example, Neal (1995) for evidence that unemployed workers who reemploy in the same sector get a wage benefit compared to workers who switch sectors.

[10] The two measures of minimum wage shocks are initially quite highly correlated, with the correlation coefficient of the two different firm-level measures amounting to 0.92 in 2010, but with progressive declines (the statistic decreases to 0.71 by 2011 and 0.52 by 2015).

Where $dq^{k}_{\sim k,\tau+1}$ is the proportional change in output demand for all firms in the same sector, excluding firm k's output $q^{k}_{i,\tau+1}$. Equation (8) implies that changes in the value of the worker's marginal revenue product will reflect changing sectoral demand for output.

For non-employed workers, we assigned the output measure for the last firm at which they were employed. For new market entrants, we assigned the output growth measures for the firm at which they would eventually work.

Examining the distribution of the individual-level output growth measures shows that there is substantial variation across firms in the degree to which firms face shocks (Figure 2). Both skilled and unskilled workers work in firms facing adverse shocks, and are similarly affected by broader time trends – most notably, the 2009 recession.

(b) Sample definition

A challenge when assessing the effects of a policy change on employment outcomes is defining a sample in ways that capture the full effect of the policy. That includes the effects due to transitions into the labour force as well as transitions out of it. Moreover, the choice of the proper sample depends on which outcome is being measured. Below we take care of both concerns, selecting samples that capture the effects on transitions to and from the labour force, and carefully fixing the population being studied by preventing individuals from dropping from the sample.

To study transitions from employment to non-employment, we apply two samples as summarized in Panel A of Table 1. Sample 1A is composed of all the incumbents as of March 2009. These workers were employed before firms would have known about the new minimum wage. We follow these workers for five years until March 2014. To avoid confusing transitions with either schooling or early retirement, we restrict the sample to include workers who were at least 30 years of age in March 2009 and not yet 50 by March 2015. Sample 1B includes everyone who had a job at some point between March 2009 and March 2015, an interval that should be long enough to allow individuals interested in working to find work. By including labour market entrants, Sample 1B offers insights about how the change of the law changed incentives for individuals and firms to enter the labour market. Sample 1A holds the population fixed for the entire estimation period so that individuals can move out of and back into employment during the six years.

To study transitions from non-employment to employment, we examine two samples composed of individuals aged between 30 and 50 years of age for the entire period as summarized in Panel B of Table 1. Sample 2A includes individuals who were not employed in March 2009 but who found a job at some point during April 2009 – March 2015. We presume that individuals serious about job search would have been able to find work at least one month in that interval. Sample 2B broadens the definition to include all those not employed in March 2009 who either found a

job by March 2015 or who registered as unemployed during that time. Some of these individuals have never worked and so we cannot use information about their employer, but we can still examine how their estimated marginal revenue products affect their job search outcomes. For both samples, we hold the population fixed for the entire period. Therefore, in each period, individuals can be either employed or not employed with no option to sort out of observation. The econometric evaluation thus assesses how the minimum wage and other factors cause the universe to alter their state from employment to non-employment and vice versa.

(c) Data sources and sample statistics

The data used in this paper were created by linking several administrative databases covering the entire Slovenian workforce for the 2005–2015 period. For every worker, the database contains information on employment, unemployment and wages. Each individual's records are linked via their unique personal identification number. The following administrative data sources are used:

i. *Data on worker earnings*. Provided by the Pension and Disability Insurance Institute of Slovenia. Comprised of earnings information for every employment spell for every individual with earnings.
ii. *Data on worker history*. Compiled by the Statistical Office of Slovenia. Includes beginning and ending dates for every employment spell, employer identification code, occupation, appointment type, and personal characteristics (age, education, and gender).
iii. *Registered unemployment data*. Provided by the Slovenian public employment service. Includes start and end dates for unemployment spells, labour market status after unemployment, and information unemployment insurance benefit receipt. In addition, it includes personal and family characteristics for each unemployment spell.
iv. *Accounting data on enterprises.* Provided by the Agency of the Republic of Slovenia for Public Legal Records and Related Service. Data consist of the yearly profit and loss statements, as well as balance sheets, for all incorporated businesses in Slovenia.
v. *Slovenian Business Registry data set* includes information on the industry, the year the firm started or ended operating, and the firm's type and ownership structure.
vi. *Data on firms that applied for and received permission for the graduated minimum wage.* Provided by the Labour Inspectorate of the Republic of Slovenia. Includes all firms that received consent of the relevant trade union to stagger their adoption of the new minimum wage over a two-year transition period.

We report the key sample means by sample type and year in the Data Appendix. Several useful results come out of the analysis. First, the predicted 2009 wage rises over time. That is because the population of workers is becoming more skilled as the fixed group gains work experience, job tenure, and age as well as potentially adding education and changing occupations. However, workers who lose their jobs face reductions in wages because of the loss of job tenure. For sub-minimum workers who lose their jobs, the rising real minimum wage over the period after 2009 represents a rising challenge to finding work as their predicted marginal revenue products fail to

keep pace with the rising minimum wage. In fact, the average ratio of the minimum wage to the predicted marginal revenue product rises over time.

Second, the probability of employment declined for much of the sample period. Some of this could be a consequence of labour market policies, but it is also the case that Slovenia experienced a recession over the period. It will be necessary to control for changing demand for goods and services over the period to identify the minimum wage effect.

Across all the samples, sample size remained almost constant with some sample attrition amounting to less than 0.1% of the sample. Therefore, the results should not be biased by sorting out of the sample.

6 ESTIMATION AND RESULTS

Putting to use the conceptual and methodological apparatus developed above, this section presents results of estimated models of employment probability, hours worked, wages, and earnings.

Estimation model

To estimate the effects of minimum wage on employment probability of individual worker, we use combine equation (5–8). The first-order approximation can be written

$$(L^k_{i\tau+1}|L^k_{i\tau}=1) = \alpha_0 + \alpha_W\widehat{\omega_{i\tau}} + \alpha_M\frac{MW_{\tau+1}}{\widehat{\omega_{i\tau}}} + \alpha_S MW^k_{\sim i,\tau+1} + \alpha_q dq^k_{\sim k,\tau+1} + \varepsilon_{i\tau+1k}$$

where the sample is conditioned on being employed in the base period τ.[11] Define an indicator variable $E^k_{i\tau+1}=1$ when $(L^k_{i\tau+1}>0\,|L^k_{i\tau}=1)$. Rearranging, we can define a probit equation of the form

$$(9)\ E^k_{i\tau+1} = \begin{cases} 1, & \varepsilon_{i\tau+1k} > -\left(\alpha_0 + \alpha_W\widehat{\omega_{i\tau}} + \alpha_M\frac{MW_{\tau+1}}{\widehat{\omega_{i\tau}}} + \alpha_S MW^k_{\sim i,\tau+1} + \alpha_q dq^k_{\sim k,\tau+1}\right) \\ 0, & otherwise. \end{cases}$$

Probability of employment of worker *i* in firm *k* in period $\tau+1$ is assumed to depend on the worker's predicted baseline marginal revenue product ($\omega_{i\tau}$), the worker's relative minimum wage ($\frac{MW_{\tau+1}}{\widehat{\omega_{i\tau}}}$), firm *k*'s minimum wage shock ($MW^k_{\sim i,\tau+1}$), and the firm's sectoral output shock ($dq^k_{\sim k,\tau+1}$). The model is estimated using samples 1A and 1B, as well as samples 2A and 2B (the

[11] The base period is τ = March 2009 for sample 1A. For Sample 1B, the condition is $\sum_{\tau=March\ 2009}^{March\ 2015} L^k_{i\tau} > 0$. For the transitions from nonemployment to employment, the condition is $(L^k_{i\tau}=0\ \&\ \sum_{\tau=March\ 2009}^{March\ 2015} L^k_{i\tau} > 0$ for τ = March 2009 for Sample 2A. For Sample 2B, the condition is $(L^k_{i\tau}=0\ \&\ \sum_{\tau=March\ 2009}^{March\ 2015} L^k_{i\tau} \geq 0$.

latter sample includes also workers who were not employed in the entire period of observation, and thus the estimation does not include firm-level shock measures). For each year, the estimated regression includes 12 monthly observations on employment status for each individual. Regressions also include monthly dummy variables and correct for clustering at the individual employee level.

Effects on employment probability: remaining employed

Table 2 presents our results using Sample 1A composed of everyone in Slovenia who held a job a year before the minimum wage was increased. The estimation reflects the probability of being employed, possibly at a new employer, conditional on having been employed in March 2009. Panel A allows both the predicted wage and firm-level minimum wage shock to change as worker skills, firm employment and the minimum wages change. Panel B fixes the worker's marginal revenue product at the March 2009 level, and fixes the firm minimum wage shock and the minimum wage at the initially implemented policy levels in March 2010. We estimate the probability of employment with 12 consecutive monthly observations beginning in March of the year and ending in February of the following year. Therefore, the column labeled 2010 shows the coefficients for the first 12 months after the increase of the minimum wage (March 2010 – February 2011). Because the sample is conditioned on March 2009 employment, the coefficients reflect the changing probability of employment since March 2009.

The firm minimum wage shock is the change in the cost of employing all the other workers in the firm due to the minimum wage policy and so it is the cross-wage effect on this worker's employment. The positive coefficients mean that firms facing larger minimum wage shocks are substituting away from the other, now more expensive, workers and toward this worker. The positive effect in 2009 suggests some substitution began in the year before implementation, potentially reflecting an announcement effect. The coefficient remains positive and significant in Panel A which allows the minimum wage shock to grow with subsequent increases. In contrast, the effect dissipates and eventually turns negative in Panel B where only the initial shock is allowed to affect probability of employment. That suggests that eventually, workers may be hurt by working in firms with other workers receiving wage increases due to the minimum wage.

The ratio of the minimum wage to the worker's marginal revenue product always lowers probability of employment. There is a small effect even in the year before the minimum wage increase was implemented, but the effect becomes larger in the first year of the implementation. In Panel A, the negative effect on employment gets progressively larger in magnitude as subsequent minimum wage increases are installed. In Panel B, the effect dissipates but remains statistically significant 5 years after the initial increase.

The worker's predicted marginal revenue product in March 2009 appears in two places, in the ratio of minimum wage to marginal revenue product and then as a separate independent variable. The total effect of the marginal revenue product on conditional employment probability is

$\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}} = f(\cdot)(\alpha_W - \alpha_M \frac{MW_{\tau+1}}{(\widehat{\omega_{i\tau}})^2})$, where $f(\cdot)$ is the normal density function evaluated at sample values. Because the estimated minimum wage effect is $\alpha_M < 0$, the estimated effect of marginal revenue product on employment was positive for the full sample range of values of $\widehat{\omega_{i\tau}}$ as shown in the last row of the table. The impact is largest for the least skilled, meaning that a small increase in skills will have the largest impact on employment prospects for individuals at the bottom of the skill distribution.

The output shock coefficient is the control for the composition of demand for the firm's output. The effect is always positive from 2010 on, and so employees benefit from being in a firm experiencing growth in sectoral demand for its output.

To illustrate the net effect of the minimum wage increase on employment by skill group, in Figure 3 we report the predicted change in employment probability conditional on prior employment. Line AA shows that the increase in the minimum wage lowered employment probability across the skill distribution. However, the decrease in probability of remaining employed was largest for the least skilled. Workers whose predicted marginal revenue products were at or below the new minimum wage faced an estimated drop in probability of remaining employed of 15% or more.

We replicate the analysis using Sample 1B in Table 3. This sample includes everyone in Slovenia who ever held a job between March 2009 and March 2015, and so the estimated coefficients reflect the effect of each variable on the marginal probability of working at that time conditional on ever working over the sample period. For the most part, results are similar to those in Table 2. Workers for whom the minimum wage is high relative to their marginal revenue products had a lower probability of employment. More skilled workers had a higher probability of employment than less skilled workers as indicated by the positive estimates of $\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}}$. And workers in firms experiencing positive sectoral demand had a greater probability of employment. The most notable difference is that the static firm minimum wage shock now suggests that workers are complements with the other workers in the firm, meaning that raising the firm cost of hiring all the other workers in the firm lowers the probability of hiring any given worker. However, when the firm wage shock is allowed to rise as subsequent minimum wage increases are imposed, we still have the result that super- and sub-minimum workers are substitutes.

Effects on employment probability: exiting non-employment

The effect of minimum wage effect on transition from non-employment to employment is evaluated using Sample 2A which includes all individuals who were not employed in March 2009 but who held a job at least one month between April 2009 – March 2015. We use the same structure implied by equation (9), with the firm-specific shocks applied from either the last firm at which they worked (for workers with prior experience) or from the firm at which they would

eventually work (for those without prior experience). The coefficients can be viewed as the probability of working in each year, conditional on not having been employed in March 2009. The results are reported in Table 4.

The first interesting finding is that those not employed in March 2009 were unlikely to find work with firms that had large minimum wage shocks. Individuals for whom the ratio of the minimum wage to their marginal revenue product is large face a long and persistent lower probability of finding work. Unemployed with higher marginal revenue products and from sectors with positive demand shocks exited unemployment more rapidly.

The results in Table 4 do not include registered unemployed or for workers who lose their jobs after March 2009. Sample 2B includes everyone who was in the labour force between March 2009 – March 2015 including registered unemployed and job losers after March 2009. This sample will include individuals without a definable firm, and so we cannot include the firm minimum wage shock or the sectoral output shock. In Table 5, we include the abbreviated regression that only includes individual information as regressors. In Panel A, we run the conditional probability regression using sample 2A. The effect of minimum wages on success at finding a job is not as large as in Table 4 and it falls to insignificance by 2013, and so it is likely that the specification understates the negative effects of the minimum wage on success at finding work. When we apply the specification to Sample 2B, the minimum wage effects are more similar to those in Table 4. The minimum wage has a negative and persistent effect on finding work. Workers with higher marginal revenue products have greater success finding work.

Returning to Figure 3, we simulate the effect of the minimum wage on the probability of exiting non-employment by estimated marginal revenue product. The result is Line BB. The minimum wage increase lowers the probability of exiting nonemployment at all marginal revenue products. The negative effect on job search success is largest for the least skilled. For jobseekers with marginal revenue products at or below the new minimum wage, probability of finding a job fell by more than 5%. Those at the upper tail of the skill distribution had only a marginal reduction in the probability of finding work.

Employment, wage, hours and earnings effects of the minimum wage increase

It is not common for studies of the minimum wage to follow workers over time including those who have lost jobs. Hence, the estimated minimum wage effects are typically focused on individuals who are employed. Because of the longitudinal nature of our data, we can incorporate the minimum wage effects on all workers who were employed at any time from March 2009 – March 2015, whether or not they remain employed throughout, entered employment, or exited employment.

To demonstrate the heterogeneity of the minimum wage effects by groups just above or just below the minimum wage, we divide our individuals into three labour market groups. The sub-

sub-minimum (*j = ssm*) group has predicted 2009 marginal revenue products at or below the prevailing minimum in 2009. The sub-minimum (*j = sm*) group has predicted 2009 marginal revenue products between the old and new minimum wage. The super-minimum group (*j=Sm*) has predicted 2009 marginal revenue products above the new minimum wage. To focus on workers on either side of the minimum wage threshold, we limit the super-minimum group to those whose marginal revenue products are no more than 125% of the new minimum. We can illustrate the potential effects of the minimum wage changes on employment by illustrating the relative changes in employment outcomes for these three groups as the minimum wage rises.

Let $E_{ij\tau}$ be the employment status of the i^{th} individual in minimum wage group *j* in year τ. Changes in employment relative to year τ would be $\left(E_{ij\tau+p}\right)/E_{ij\tau}$, where *p* is the length of the sample period over which the effects are to be captured. Less commonly measured but perhaps more important is to examine changes in employment at the intensive rather than the extensive margin if firms ration labour by altering hours rather than employment. The corresponding proportional change in hours of work will be $(H_{ij\tau+p})/H_{ij\tau}$. Obviously, there is a direct effect of the minimum wage on all covered workers and so wages for those workers will rise if they remain employed in the formal labour market. However, many scholars (Card and Krueger, 1995; Manning, 2003; and Neumark, Schweitzer and Wascher, 2004) have found that wages for other workers may rise also as a result of the wage increase at the bottom the wage distribution. These wage changes represent an endogenous response to the policy, and so it is useful to examine how changes in the minimum wage affect the entire wage distribution. We designate the observed proportional wage change by $(W_{ij\tau+p})/W_{ij\tau}$.

We can combine all of these three outcomes into a single metric of annual earnings that combines employment, hours, and wage outcomes. Annual earnings can fall even if hourly wages rise if labour demand for low-skill hours of work is in the elastic range. Proportional changes in annual earnings are given by $(Y_{ij\tau+p})/Y_{ij\tau}$. This last measure is the one that will best allow us to explore how changes in the minimum wage affect income inequality in the population.

We present the results in Figures 4–7. Focusing first on employment outcomes in Figure 4 for already employed workers, our results show that following the March 2010 minimum wage increase, the relative employment of all groups falls – a finding attributable to the worldwide recession. However, the largest declines were for both sub-minimum groups. The super-minimum group is the most successful and increasingly so as the minimum wage continued to rise relative to the average wage. At the same time, the sub-sub-minimum group does not increase probability of finding employment even as the economy goes into recovery. This illustrates the findings in Tables 2–5 that the minimum wage lowered employment prospects of individuals with marginal revenue products below the minimum.

As illustrated in Figure 1, the minimum wage that was tied to inflation outpaced average wage growth for the labour force as a whole. Consequently, wages for the sub-minimum groups rose more rapidly than wages for the super-minimum group (Figure 5). Meanwhile, relative hours worked declined for sub-minimum workers at rates comparable to their job loss (Figure 6). For the super-minimum group, the hours decline is moderately larger in magnitude than the wage growth, and so real annual earnings fall about 5% (Figure 7). For the sub-minimum group, the hours decrease is much larger than the wage increase and so real annual earnings fall at least 30%. The decline is 35% for the sub-sub-minimum group.

Figures 4–7 hold fixed the population of all ever-employed in 2009–2015 and so the results are not clouded by sorting into or out of employment. Unlike past minimum wage studies that did not have access to the universe of all potential workers, our population allows members of the super-minimum and sub-minimum groups to enter the labour force during the period and yet we monitor their earnings and hours worked before they enter. Similarly, we continue monitoring individuals who lose their jobs, even if they drop out of the labour force. We believe these estimates provide a more complete measure than previously possible of the impact of the minimum wage on the population as a whole.

7 CONCLUDING REMARKS

Our study finds large and persistent negative employment effects of the minimum wage increase on low-skilled workers. The employment losses occurred both from a higher probability of transition from employment to non-employment and from a lower probability of transition from non-employment to employment. Moreover, although workers who earned below the new minimum wage and remained employed experienced earnings gains, we find that earnings for the sub-minimum group as a whole fell compared to the super-minimum group. The paper makes use of several strategies that improve the accuracy of its estimates, including (i) examining the entire labour market, (ii) following individuals over a 5-year period after the initial increase in the minimum wage, and (iii) using an innovative way of identifying minimum-wage workers regardless whether they are employed, unemployed, or idle, thus avoiding the selection bias that arises from failing to consider employment prospects of the unemployed or the workers who separate from employment.

Our study sheds new light on an ongoing debate about the costs and benefits of the minimum wage. It shows that Slovenia's March 2010 increase of the minimum wage, while increasing earnings of workers that retained employment after the wage increase, reduced employment of the low-skilled workers more than proportionally. As a result, the policy failed to redistribute earnings to low-skill workers as a whole. A likely contributing factor to the loss of employment and earnings in the Slovenia case is the sheer size of the minimum wage adjustment. In real terms, the minimum wage rose by almost one-third and the ratio of the minimum wage to the average wage rose from 41.2% to 51.5% over 4 years.

The large minimum wage increase triggered substitution away from minimum wage workers and lowered the likelihood that low-skill workers would be hired. We find evidence that part of the substitution is due to a shift in relative demand toward more super-minimum workers as the minimum wage continued to rise relative to average wages. Future analysis could explore other aspects of the declining demand for low-skill labour. The large minimum wage increase may have altered firm investment decisions in toward greater use of automation or other capital-intensive production methods. Firms may also have responded to the minimum wage hike by cutting back on output or by ceasing production.

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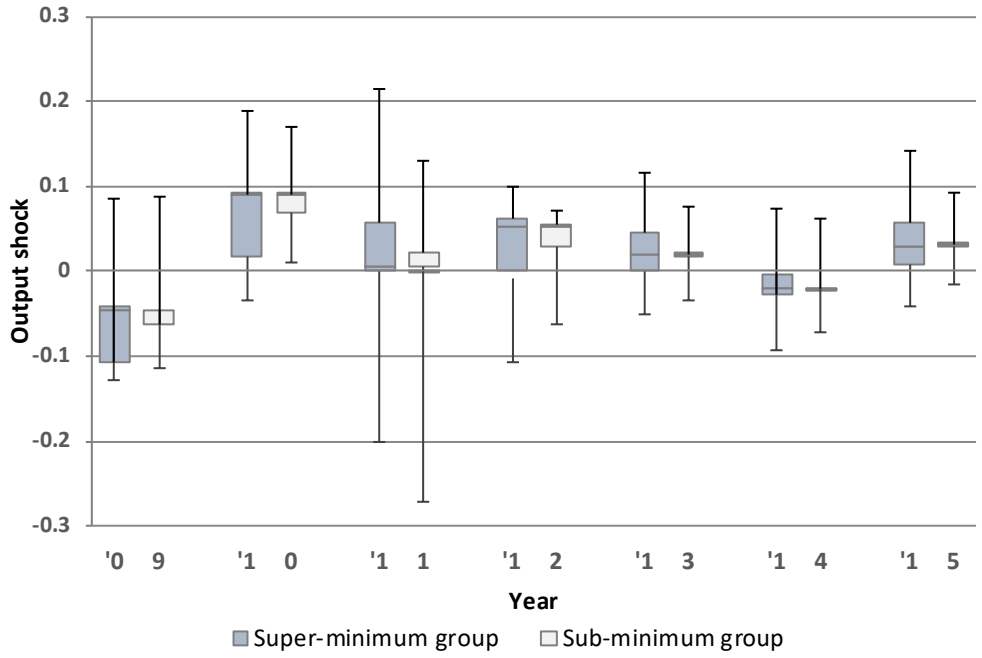
Figure 1: The ratio between the minimum and average gross wages, and cumulative indices of real minimum and real average gross wage growth, 1995–2015

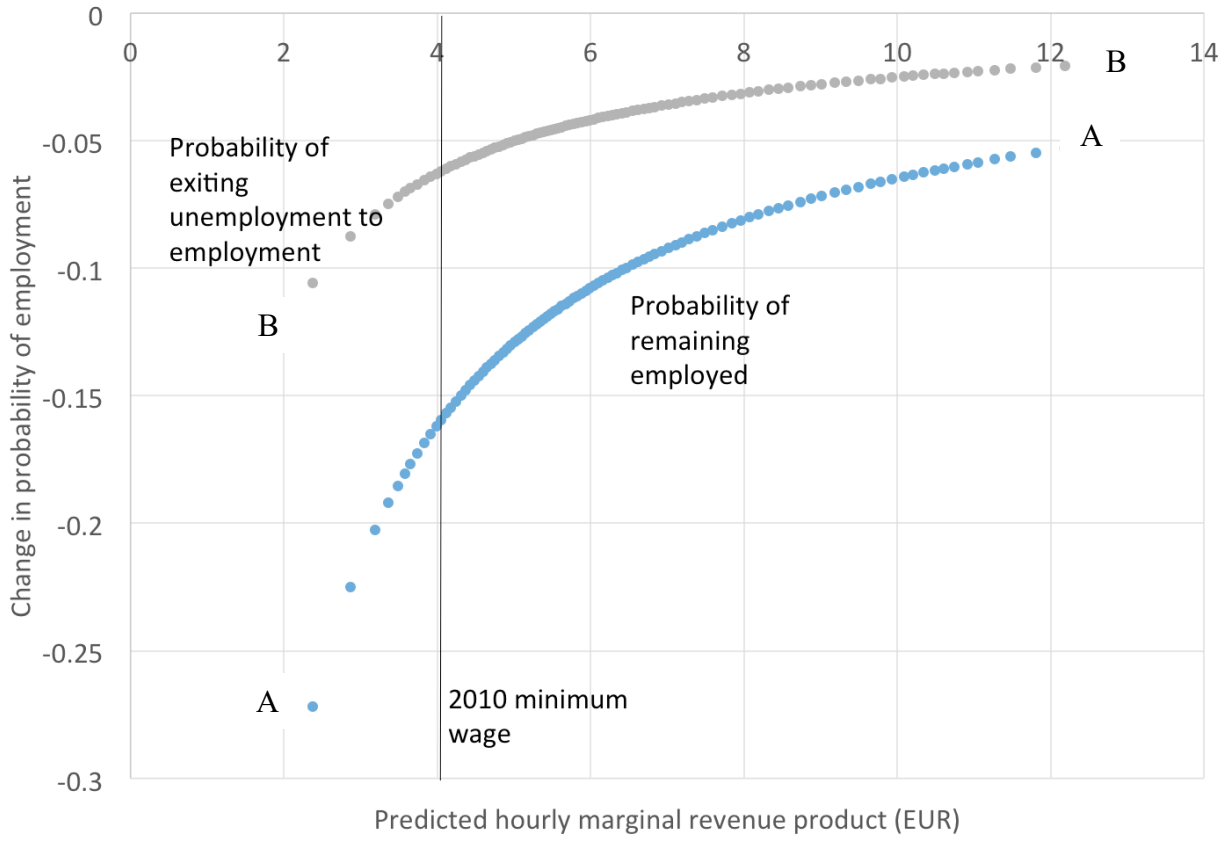
Source: Authors' calculation based on data from Statistical Office of the Republic of Slovenia (2018) and overview of minimum wage legislation.

Figure 2: Distribution of output shocks by minimum wage groups, 2009–2015



Note: Plotted are 5th, 25th, 50th, 75th, and 95th percentiles of the individual-level output shock measure.
Source: own calculations.

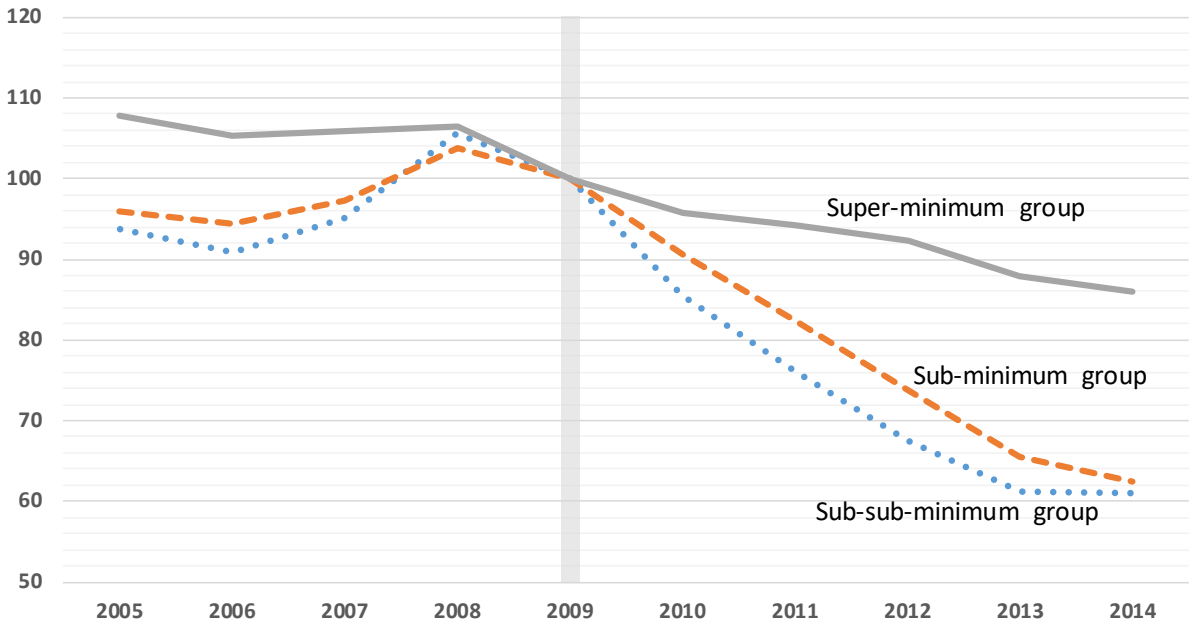
Figure 3: Change in probability of exiting unemployment or remaining employed by predicted marginal revenue product



Note: The probability of remaining employed is calculated using coefficients for 2010 using Sample 1B (see Table 3, Panel A); the probability of exiting unemployment to employment is calculated using coefficients for 2010 using Sample 2A (see Table 5, Panel A)

Source: own calculations.

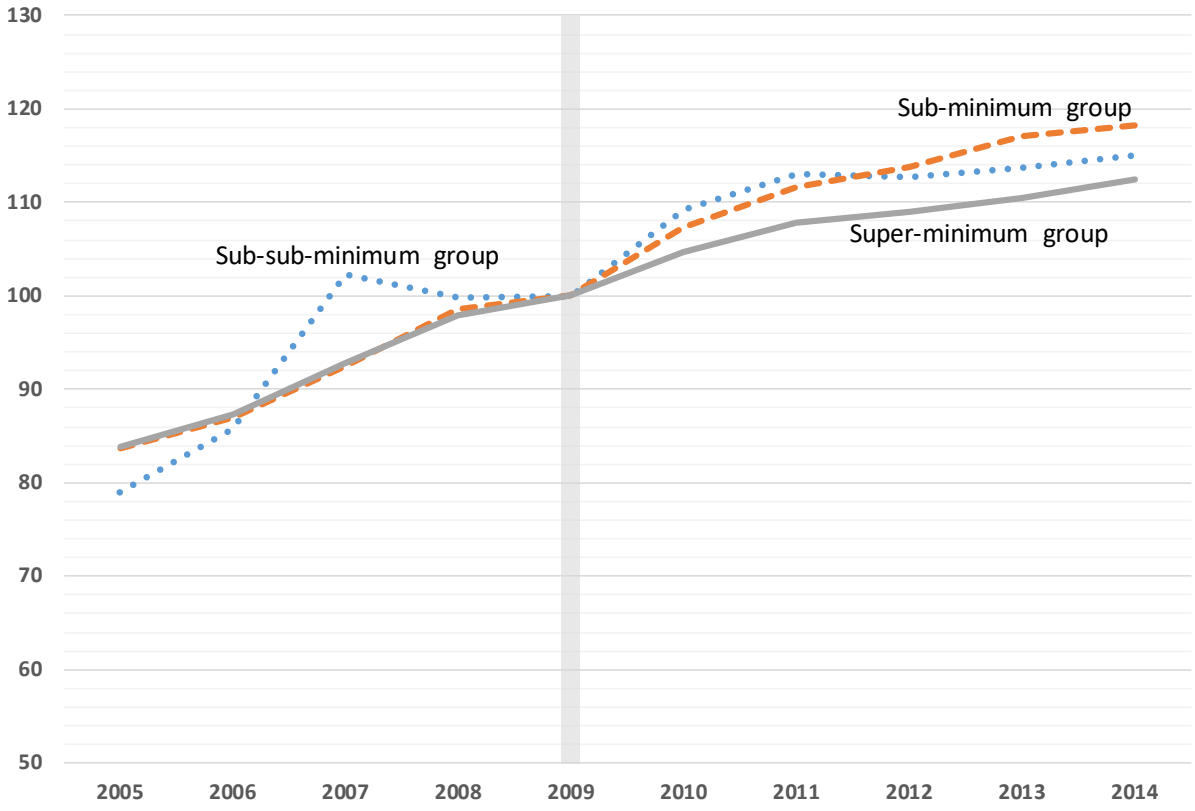
Figure 4: Relative employment by predicted wage groups (2009=100), Sample 1B – March 2009 incumbents and subsequent entrants



Note: Relative employment is defined via an index where the 2009 value for each group is equal to 100 by definition. The sub-sub-minimum group includes workers whose predicted 2009 marginal revenue products were at the prevailing minimum wage in 2009, the sub-minimum group whose predicted 2009 marginal revenue products were between the old and new minimum wage, and the super-minimum group whose predicted 2009 marginal revenue products are above the new minimum wage but no more than 125% of the new minimum.

Source: own calculations based on combined unemployment, employment and earnings registry data, Statistical Office of the Republic of Slovenia.

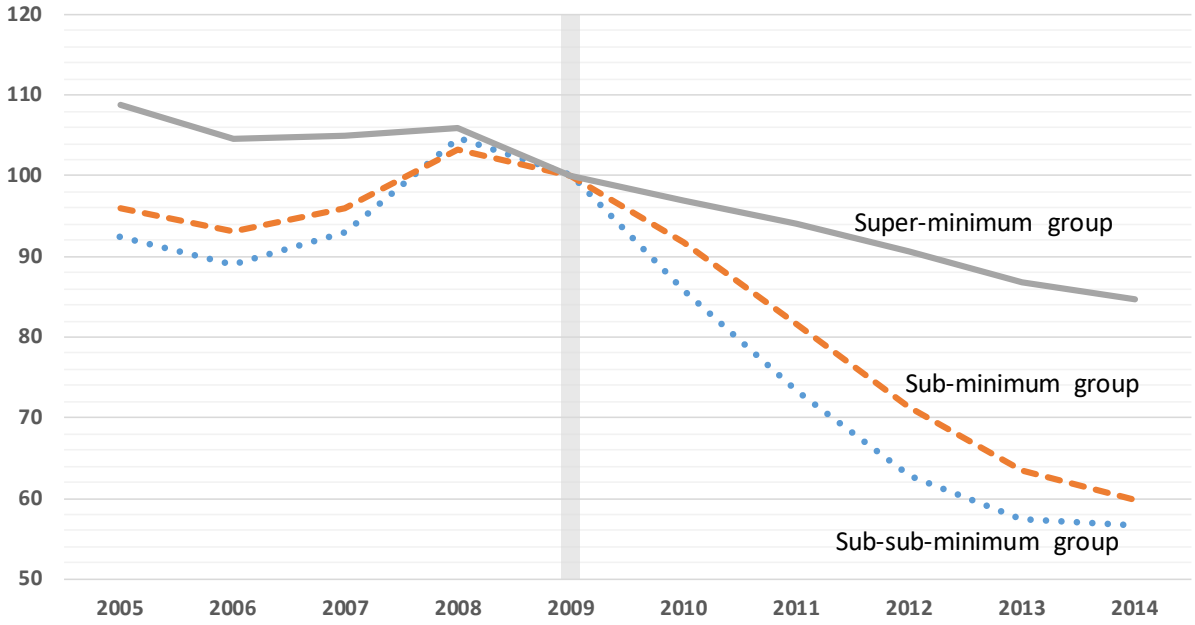
Figure 5: Relative wages by predicted wage groups (2009=100), Sample 1B – March 2009 incumbents and subsequent entrants



Note: Relative wages are defined via an index where the 2009 value for each group is equal to 100 by definition. The sub-sub-minimum group includes workers whose predicted 2009 marginal revenue products were at the prevailing minimum wage in 2009, the sub-minimum group whose predicted 2009 marginal revenue products were between the old and new minimum wage, and the super-minimum group whose predicted 2009 marginal revenue products are above the new minimum wage but no more than 125% of the new minimum.

Source: own calculations based on combined unemployment, employment and earnings registry data, Statistical Office of the Republic of Slovenia.

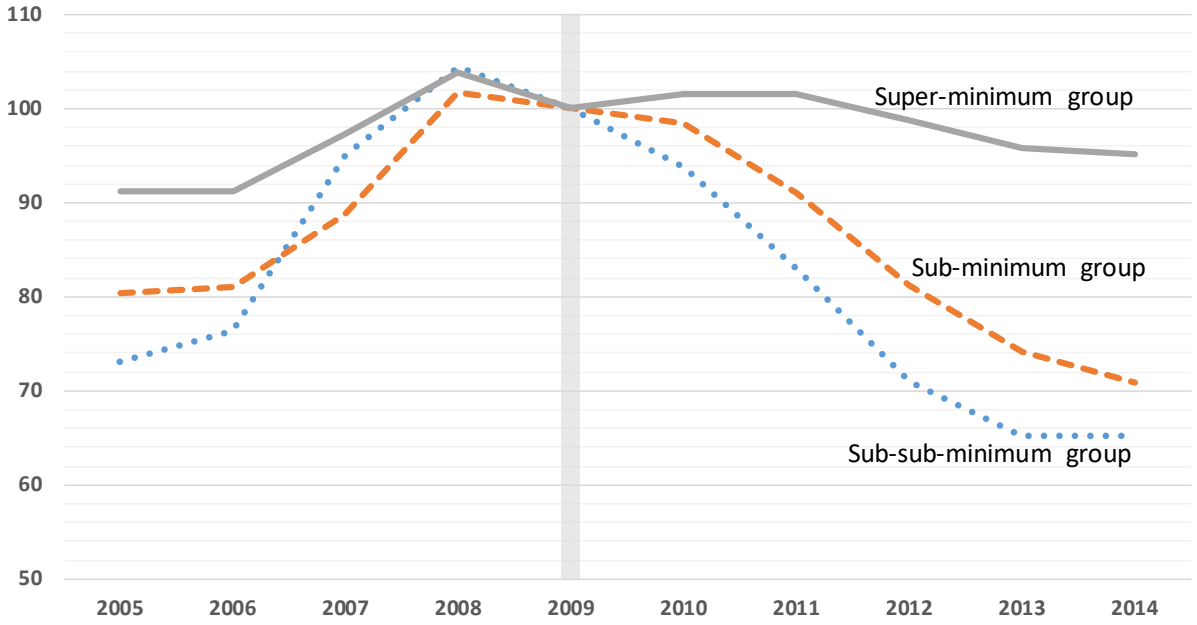
Figure 6: Relative hours worked by predicted wage groups (2009=100), Sample 1B – March 2009 incumbents and subsequent entrants



Note: Relative hours worked are defined via an index where the 2009 value for each group is equal to 100 by definition. The sub-sub-minimum group includes workers whose predicted 2009 marginal revenue products were at the prevailing minimum wage in 2009, the sub-minimum group whose predicted 2009 marginal revenue products were between the old and new minimum wage, and the super-minimum group whose predicted 2009 marginal revenue products are above the new minimum wage but no more than 125% of the new minimum.

Source: own calculations based on combined unemployment, employment and earnings registry data, Statistical Office of the Republic of Slovenia.

Figure 7: Relative earnings by predicted wage groups (2009=100), Sample 1B – March 2009 incumbents and subsequent entrants



Note: Relative earnings are defined via an index where the 2009 value for each group is equal to 100 by definition. The sub-sub-minimum group includes workers whose predicted 2009 marginal revenue products were at the prevailing minimum wage in 2009, the sub-minimum group whose predicted 2009 marginal revenue products were between the old and new minimum wage, and the super-minimum group whose predicted 2009 marginal revenue products are above the new minimum wage but no more than 125% of the new minimum.

Source: own calculations based on combined unemployment, employment and earnings registry data, Statistical Office of the Republic of Slovenia.

Table 1: Criteria for formation of samples

Sample	Criteria for sample definition	
	Labour market status	*Age restriction*
A. Transitions from employment to non-employment		
Sample 1A: March 2009 incumbents	Employed in March 2009	At least 30 in March 2009 and below 50 in March 2015
Sample 1B: March 2009 incumbents and subsequent entrants	Employed at least one month during March 2009 – March 2015	30–50 in the current year
B. Transitions from non-employment to employment		
Sample 2A: Successful jobseekers	Not employed in March 2009, who found a job during April 2009 – March 2015	At least 30 in March 2009 and below 50 in March 2014
Sample 2B: All jobseekers	Not employed in March 2009, either found a job or registered as unemployed by March 2015	At least 30 in March 2009 and below 50 in March 2014

Table 2: Employment probability, sample 1A: individuals employed in March 2009

Panel A: Using dynamic firm-level minimum wage shock values

Dependent variable: probability of employment, $E_{i\tau+1k}$	before increase	after increase				
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Firm minimum wage shock, α_S	0.325***	0.533***	0.406***	0.362***	0.297***	0.19***
	(0.0261)	(0.0237)	(0.0182)	(0.018)	(0.0163)	(0.0153)
Ratio of minimum wage to predicted marginal revenue product, α_M	-0.113***	-0.287***	-0.352***	-0.427***	-0.503***	-0.543***
	(0.0023)	(0.0039)	(0.0041)	(0.0046)	(0.005)	(0.0052)
Predicted marginal revenue product, α_W	<0.001	-0.009***	-0.013***	-0.015***	-0.018***	-0.023***
	(0.0002)	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0005)
Output shock, α_q	0.026***	0.144***	0.121***	0.174***	0.069***	0.539***
	(0.0034)	(0.005)	(0.005)	(0.0097)	(0.0111)	(0.0104)
Effect of the MRP on employment probability, $\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}}$	0.009	0.018	0.021	0.026	0.031	0.029
Observations	4,633,950	4,633,611	4,633,207	4,633,129	4,633,458	4,633,455
Pseudo R-squared	0.104	0.106	0.105	0.105	0.111	0.124

Panel B: Using static firm-level minimum wage shock values from 2009

Dependent variable is probability of employment: $E_{i\tau+1k}$	before increase	after increase				
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Firm minimum wage shock - values from March 2009, α_S	0.398***	0.443***	0.139***	0.037**	-0.03	-0.108***
	(0.0189)	(0.0229)	(0.0179)	(0.0182)	(0.0187)	(0.0185)
Ratio of minimum wage to predicted MRP - values from March 2009, α_M	-0.132***	-0.219***	-0.147***	-0.11***	-0.082***	-0.069***
	(0.0021)	(0.0037)	(0.0039)	(0.0041)	(0.004)	(0.004)
Predicted marginal revenue product, α_W	-0.003***	-0.002***	0.009***	0.017***	0.024***	0.025***
	(0.0002)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Output shock, α_q	0.027***	0.147***	0.128***	0.193***	0.098***	0.557***
	(0.0033)	(0.0051)	(0.0097)	(0.0111)	(0.0104)	(0.0102)
Effect of the MRP on employment probability, $\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}}$	0.010	0.019	0.023	0.027	0.031	0.031
Observations	4,633,521	4,633,355	4,632,751	4,632,593	4,632,905	4,632,891
Pseudo R-squared	0.121	0.096	0.083	0.081	0.084	0.094

Notes: Reported above are marginal effects from equation (9): $E_{i\tau+1k} = \begin{cases} 1, -\varepsilon_{i\tau+1k} > (\alpha_0 + \alpha_W \widehat{\omega_{i\tau}} + \alpha_M \frac{MW_{\tau+1}}{\widehat{\omega_{i\tau}}} + \alpha_S MW^k_{\sim i,\tau+1} + \alpha_q dq^k_{\sim k,\tau+1}) \\ 0, \quad otherwise. \end{cases}$ Regressions are estimated on individual-level monthly data. Years are defined to begin in March of each year to coincide with the March 2010 minimum wage increase. Monthly dummies were included in all specifications. Standard errors clustered by individuals are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Employment probability, sample 1B: March 2009 incumbents and subsequent entrants

Panel A: Using dynamic firm-level minimum wage shock values

Dependent variable: probability of employment, $E_{i\tau+1k}$	before increase	after increase				
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Firm minimum wage shock, α_S	-1.415***	-0.113***	0.114***	0.156***	0.222***	0.172***
	(0.0227)	(0.0125)	(0.0118)	(0.0119)	(0.0119)	(0.0115)
Ratio of minimum wage to predicted marginal revenue product, α_M	-0.498***	-0.646***	-0.648***	-0.641***	-0.678***	-0.66***
	(0.0053)	(0.0051)	(0.0053)	(0.0054)	(0.0052)	(0.0052)
Predicted marginal revenue product, α_W	-0.001**	-0.018***	-0.019***	-0.016***	-0.017***	-0.018***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0005)
Output shock, α_q	-0.148***	0.145***	0.144***	0.224***	0.077***	0.824***
	(0.0071)	(0.0068)	(0.006)	(0.0105)	(0.0122)	(0.0108)
Effect of the MRP on employment probability, $\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}}$	0.046	0.050	0.052	0.054	0.058	0.055
Observations	7,519,635	7,579,351	7,621,123	7,640,283	7,644,909	7,634,062
Pseudo R-squared	0.187	0.179	0.167	0.157	0.156	0.161

Panel B: Using static firm-level minimum wage shock values from 2009

Dependent variable is probability of employment: $E_{i\tau+1k}$	before increase	after increase				
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Firm minimum wage shock - values from March 2009, α_S	-0.275***	-0.294***	-0.474***	-0.486***	-0.441***	-0.353***
	(0.0123)	(0.0131)	(0.0131)	(0.0131)	(0.013)	(0.0123)
Ratio of minimum wage to predicted MRP - values from March 2009, α_M	-0.561***	-0.526***	-0.336***	-0.251***	-0.196***	-0.156***
	(0.0046)	(0.0054)	(0.0044)	(0.0039)	(0.0036)	(0.0033)
Predicted marginal revenue product, α_W	-0.011***	-0.005***	0.016***	0.028***	0.037***	0.039***
	(0.0005)	(0.0006)	(0.0005)	(0.0004)	(0.0004)	(0.0004)
Output shock, α_q	-0.127***	0.146***	0.137***	0.225***	0.089***	0.817***
	(0.007)	(0.0067)	(0.0059)	(0.0103)	(0.012)	(0.0107)
Effect of the MRP on employment probability, $\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}}$	0.048	0.050	0.051	0.054	0.057	0.055
Observations	7,519,078	7,578,917	7,620,082	7,639,026	7,643,511	7,632,548
Pseudo R-squared	0.190	0.172	0.149	0.137	0.132	0.134

Notes: Reported above are marginal effects from equation (9): $E_{i\tau+1k} = \begin{cases} 1, & -\varepsilon_{i\tau+1k} > (\alpha_0 + \alpha_W \widehat{\omega_{i\tau}} + \alpha_M \frac{MW_{\tau+1}}{\widehat{\omega_{i\tau}}} + \alpha_S MW^k_{\sim i,\tau+1} + \alpha_q dq^k_{\sim k,\tau+1}) \\ 0, & otherwise. \end{cases}$ Regressions are estimated on individual-level monthly data. Years are defined to begin in March of each year to coincide with the March 2010 minimum wage increase. Monthly dummies were included in all specifications. Standard errors clustered by individuals are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Transitions from unemployment, sample 2A: not employed in March 2009

Dependent variable: probability of employment, $E_{i\tau+1k}$	after increase				
	2010	**2011**	**2012**	**2013**	**2014**
Firm minimum wage shock, α_S	-0.756***	-0.523***	-0.462***	-0.185***	-0.098***
	(0.0353)	(0.0304)	(0.0297)	(0.0285)	(0.0275)
Ratio of minimum wage to predicted marginal revenue product, α_M	-0.646***	-0.251***	-0.255***	-0.17***	-0.223***
	(0.0144)	(0.0144)	(0.0139)	(0.0145)	(0.0142)
Predicted marginal revenue product, α_W	0.005**	0.006***	0.02***	0.021***	0.02***
	(0.0021)	(0.0022)	(0.0022)	(0.0022)	(0.0022)
Output shock, α_q	0.255***	0.414***	0.743***	0.478***	1.1***
	(0.0307)	(0.0251)	(0.0462)	(0.0587)	(0.0473)
Effect of the MRP on employment probability, $\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}}$	0.054	0.057	0.054	0.065	0.065
Observations	693,713	693,705	693,591	693,484	693,509
Pseudo R-squared	0.044	0.042	0.041	0.044	0.051

Notes: Reported above are marginal effects from equation (9): $E_{i\tau+1k} = \begin{cases} 1, & -\varepsilon_{i\tau+1k} > (\alpha_0 + \alpha_W \widehat{\omega_{i\tau}} + \alpha_M \frac{MW_{\tau+1}}{\widehat{\omega_{i\tau}}} + \alpha_S MW^k_{\sim i,\tau+1} + \alpha_q dq^k_{\sim k,\tau+1}) \\ 0, & otherwise. \end{cases}$ Regressions are estimated on individual-level monthly data. Years are defined to begin in March of each year to coincide with the March 2010 minimum wage increase. Monthly dummies were included in all specifications. Standard errors clustered by individuals are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Transitions from unemployment excluding exogenous shocks, samples 2A–2B

Panel A: Sample 2A - Successful jobseekers

Dependent variable: probability of employment, $E_{i\tau+1k}$	**2010**	**2011**	**2012**	**2013**	**2014**
Ratio of minimum wage to predicted marginal revenue product, , α_M	-0.174***	-0.111***	-0.026***	-0.013	0.001
	(0.0144)	(0.0118)	(0.0094)	(0.0092)	(0.0088)
Predicted marginal revenue product, α_W	0.021***	0.031***	0.045***	0.051***	0.055***
	(0.0022)	(0.002)	(0.0018)	(0.0017)	(0.0017)
Effect of the MRP on employment probability, $\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}}$	0.055	0.053	0.050	0.054	0.055
Observations	712,769	712,750	712,627	712,510	712,522
Pseudo R-squared	0.036	0.032	0.031	0.036	0.039

Panel B: Sample 2B - All jobseekers

Dependent variable: probability of employment, $E_{i\tau+1k}$	**2010**	**2011**	**2012**	**2013**	**2014**
Ratio of minimum wage to predicted marginal revenue product, , α_M	-0.226***	-0.179***	-0.106***	-0.101***	-0.102***
	(0.0139)	(0.0127)	(0.0102)	(0.0104)	(0.0106)
Predicted marginal revenue product, α_W	0.017***	0.03***	0.045***	0.052***	0.057***
	(0.0022)	(0.0021)	(0.0019)	(0.0019)	(0.002)
Effect of the MRP on employment probability, $\frac{\partial E_{i\tau+1k}}{\partial \widehat{\omega_{i\tau}}}$	0.067	0.070	0.069	0.074	0.079
Observations	904,517	904,498	904,375	904,249	904,250
Pseudo R-squared	0.058	0.057	0.057	0.066	0.072

Notes: Table contains marginal effects from probit estimates of employment probability using individual-level monthly data. In addition to the criteria mentioned in each heading, the population is limited to individuals who were at least 30 years old in 2009 and no more than 50 years old in 2015. Years are defined to begin in March of each year to coincide with the March 2010 minimum wage increase. Monthly dummies were included in all specifications. Standard errors clustered by individuals are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 1: Summary Statistics for Samples 1A and 1B

Panel A: Sample means for key variables, Sample 1A - March 2009 incumbents

	before increase	after increase				
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Probability of employment in next month	0.963	0.933	0.920	0.902	0.888	0.883
Firm minimum wage shock	0.002	0.006	0.008	0.009	0.010	0.010
Firm minimum wage shock - values from March 2009	0.006	0.006	0.006	0.006	0.006	0.006
Ratio of minimum wage to predicted marginal revenue product	0.574	0.659	0.682	0.689	0.698	0.698
Ratio of minimum wage to predicted marginal revenue product - values from March 2009	0.655	0.655	0.655	0.655	0.655	0.655
Predicted marginal revenue product	6.866	6.972	7.082	7.157	7.227	7.266
Output shock	0.012	0.018	0.010	0.009	0.006	0.009
Number of observations	4,709,008	4,708,595	4,707,958	4,708,173	4,708,502	4,708,503

Panel B: Sample means for key variables, Sample 1B - March 2009 incumbents and subsequent entrants

	before increase	after increase				
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Probability of employment in next month	0.848	0.833	0.826	0.812	0.800	0.800
Firm minimum wage shock	0.005	0.009	0.011	0.012	0.014	0.014
Firm minimum wage shock - values from March 2009	0.008	0.008	0.009	0.009	0.009	0.009
Ratio of minimum wage to predicted marginal revenue product	0.609	0.705	0.733	0.744	0.756	0.758
Ratio of minimum wage to predicted marginal revenue product - values from March 2009	0.697	0.700	0.704	0.708	0.713	0.720
Predicted marginal revenue product	6.596	6.659	6.730	6.775	6.823	6.852
Output shock	0.012	0.017	0.010	0.009	0.007	0.007
Number of observations	7,681,181	7,733,350	7,767,616	7,779,386	7,776,173	7,757,901

Notes: Years are defined to begin in March of each year to coincide with the March 2010 minimum wage increase.

Appendix Table 2: Summary Statistics for Samples 2A – 2B

Panel A: Sample means for key variables, Sample 2A: Successful jobseekers

	before increase	after increase				
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Probability of employment in next month	0.201	0.346	0.430	0.471	0.500	0.551
Firm minimum wage shock	0.026	0.031	0.034	0.036	0.038	0.039
Firm minimum wage shock - values from March 2009	0.030	0.030	0.030	0.030	0.030	0.030
Ratio of minimum wage to predicted marginal revenue product	0.837	0.965	1.000	1.007	1.014	1.007
Predicted marginal revenue product	4.791	4.904	5.005	5.087	5.182	5.256
Output shock	0.013	0.014	0.011	0.009	0.008	0.003
Number of observations	712,784	712,769	712,750	712,627	712,510	712,522

Panel B: Sample means for key variables, Sample 2C: All jobseekers

	before increase	after increase				
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Probability of employment in next month	0.158	0.273	0.339	0.372	0.394	0.434
Firm minimum wage shock,	0.024	0.028	0.032	0.033	0.035	0.035
Firm minimum wage shock - values from March 2009	0.027	0.027	0.027	0.027	0.027	0.027
Ratio of minimum wage to predicted marginal revenue product	0.887	1.026	1.065	1.075	1.087	1.082
Predicted marginal revenue product	4.581	4.671	4.753	4.820	4.895	4.954
Output shock	0.013	0.013	0.010	0.009	0.008	0.002
Number of observations	904,530	904,517	904,498	904,375	904,249	904,250

Notes: In addition to the criteria mentioned in each heading, the population is limited to individuals who were at least 30 years old in 2009 and no more than 50 years old in 2015. Years are defined to begin in March of each year to coincide with the March 2010 minimum wage increase.