Minimum Wage and Unemployment: An Empirical Study on OECD Countries[#]

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Abstract: With ongoing increasing minimum wage and political debates underway, minimum wage and its impacts on the labor market are one of the most important items on policymakers' agendas worldwide. In this paper, we attempt to explain how labor demand and supply respond to minimum wage increases. In our model, firms can hire either skilled or unskilled workers to maximize their profits. With data from 25 OECD countries over 15 years from 2000 to 2014, we find that a higher minimum wage decreases labor demand but does not affect labor supply. Our empirical results also suggest that relatively modest increases in minimum wages have limited impacts on employment. On average, 10 percent increase in the minimum wage decreases employment by 0.7 percent, thereby increasing unemployment rate by 0.64 percent.

Keywords: Minimum Wage, Unemployment, Skilled and Unskilled Labor.

I. INTRODUCTION

With ongoing increasing minimum wage and political debates underway, minimum wage and its impacts on the labor market are one of the most important items on policymakers' agendas worldwide.

Minimum wages are increasing. On April 4, 2016, California Governor Jerry Brown signed legislation raising California's mandatory minimum wages from $10 to $15 per hour by the year 2022. On the same day, New York Governor Andrew Cuomo also signed similar legislation which is increasing minimum wages for workers in New York City from $9 to $15 by the year of 2019. In addition, there are also proposals that suggest increasing the federal minimum wage to alleviate income inequality.[1]

Since the international convention for the creation of a global minimum wage by the International Labor Organization (ILO) in 1928, setting the right minimum wage has been one of the important economics subjects over the last century.

The minimum wage varies across countries; countries with a relatively low minimum wage try to increase it in order to support low-income families. For example, activists in South Korea vigorously try to increase their minimum wage from about $5.22 to about $8.66 per hour.

Those in support of increasing the minimum wage claim that higher minimums not only reduce income inequality between the rich and the poor, but also boost the economy through more consumption by low-income workers. In contrast, those in opposition to increasing the minimum wage argue that a higher minimum wage increases the labor costs of employers, resulting in increased unemployment rates.

Academically there have been a large volume of research efforts relating minimum wages and employment. Empirical results, however, are mixed among these studies. For example, Card (1992) and Card and Krueger (1994) find that increases in minimum wages increase employment, whereas Neumark and Wascher (2007) conclude that minimum wage increases reduce employment. More recently, Dube *et al*. (2010), Allegretto *et al*. (2011), and Giuliano (2012) find no impact of minimum wage changes on employment.

Based on the previous studies, in this paper, we seek to find the correlation between minimum wages and employment. The contributions of our study are twofold. First, with the classical labor demand and supply framework, we introduce a firm who can hire skilled workers, unskilled workers, or both types of

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[1]For example, President Obama, from $7.25 to $9 per hour; Rep. George Miller and Sen. Tom Harkin, from $7.25 to $10.10 per hour.

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Table 1: Minimum Wage*

Australia	$10.8	Ireland	$10.3	Portugal	$4.8
Belgium	$10.7	Israel	$5.8	Slovak	$3.7
Canada	$8.2	Japan	$7.3	Slovenia	$7.5
Chile	$3.4	Korea	$6.1	Spain	$5.5
Czech Rep	$3.8	Luxembourg	$12.4	Turkey	$5.3
Estonia	$3.6	Mexico	$1.0	UK	$9.0
France	$11.5	Netherlands	$10.4	USA	$7.3
Greece	$5.2	New Zealand	$9.6		
Hungary	$4.4	Poland	$5.3		

*2014 Constant Prices at 2014 USD PPPs, OECD.Stat.

workers. In this model, a change in minimum wages not only affects the labor market outcome of unskilled workers, but also alters the employment ratio of unskilled to skilled workers. In this way, minimum wage increases eventually lead to changes in average market wages that control employment. Second, compared to previous empirical studies with micro-level data, we extend the scope of research to international comparison. With data on 25 members of the Organization for Economic Co-operation and Development (OECD), we find that 1 percent increase in the minimum wage decreases labor demand by 0.07 percent and increases unemployment rate by 0.064 percent. If a minimum wage increases from $10 to $15 per hour, then our model predicts about 3 percent higher unemployment rate as a result.

The rest of the paper is organized as follows. In section II, we review previous studies testing the relationship between minimum wages and employment. Section III presents the model being used in this paper and section IV shows our empirical model and results. Section V concludes.

II. LITERATURE REVIEW

Conventional economic theories teach us that a hike in minimum wages increases the wage cost of unskilled workers and this higher cost increases unemployment. Using External evidence from the Labor Department Survey (1970), for example, Welch and Cunningham (1978) show that 1 percent increase in minimums reduces employment of those 14-15 by 4.04 percent, by 2.38 percent for those 16-17, and by 1.35 percent for 18-19 year-old youths. In addition, Grossman (1983) introduces a model showing how changes in minimums affect various occupational wages. With a given fixed capital stock, his theoretical model suggests substitution effects between skilled and unskilled workers. Empirically, however, large standard errors make inference of his model weak even though his equations produce right signs.

In 1990s, a series of seminal empirical research efforts by Card (1992) and Card and Krueger (1994, 1995) make quite a splash in this field of study because those empirical studies suggest that increases in the minimum wage increase employment. Based on their own telephone survey of fast-food restaurants in New Jersey and Pennsylvania, Card and Krueger find that the 1992 increase in the New Jersey minimum wage does not decrease employment of fast-food restaurants in New Jersey. Later Card and Krueger conclude and write "*On average, however, our findings suggest that employment remains unchanged, or sometimes rises slightly, as a result of increases in the minimum wage*." in their 1995 book.

Using the minimum wage of Puerto Rico from 1951 to 1987, Castillo-Freeman and Freeman (1992) find that imposing the U.S.-level minimum reduces total employment of Puerto Rico by 8 to 10 percent and greatly decreases jobs in low-wage sectors with a substantial hike in minimums. In his 1994 paper, in contrast, Krueger re-investigates the effects of increases in the minimum wage of Puerto Rico and concludes that the empirical evidence of decreasing employment is weak and fragile. Aggregate time series analyses produce strong negative effects of the minimum wage hike on employment in Puerto Rico whereas cross-industry analyses present weak empirical results on negative employment effects in Puerto Rico.

More recent studies after the year of 2000 suggest that modest increases in the minimum wage have little to no effects on employment.[2] Kertesi and Kollo (2003)

[2]Schmitt (2013) offers an excellent summary of current minimum wage debates.

show that a dramatic 57 percent hike in the Hungarian minimum wage in 2001 has no significant impact on employment with large firms while the small firm sector loses about 3 percent of its jobs in less than a year. In addition, Metcalf (2008), Dube *et al*. (2010), Allegretto *et al*. (2011), and Giuliano (2012) find no effect of employment from minimum wage changes. After replicating Card and Krueger's 1994 experiment thousands of times, in their 2010 seminar paper, Dube *et al*. conclude and write "*Our evidence does not suggest that minimum wages reduce employment once controls for trends in country-level sectoral employment are incorporated. Rather, employment appears to exhibit an independent downward trend in states that have increased their minimum wages relative to states that they not, thereby predisposing estimates towards reporting negative outcomes.*"

In contrast, Neumark *et al*. (2004) find that increases in minimums increase wages of workers who initially earn near the minimum wages but their hours and employment decline. In addition, Kalenkoski and Lacombe (2007) suggest that empirical results without considering spatial correlation may underestimate the negative effect of the minimum wage on employment. Using country-level data and spatial econometrics techniques, they find that a 10 percent increase in the minimum wage decreases youth employment by 3.2 percent. From reviewing existing literatures, Neumark and Wascher (2007) conclude "*a solid majority of studies find that minimum wage increases reduce employment, while very few provide convincing evidence that it increases employment.*"

III. THE MODEL

Minimum Wage

There are two types of labor, skilled and unskilled. Skilled labor (L_s) earns a competitive market wage (W_c) and is assumed to be homogeneous; unskilled labor (L_u) earns a minimum wage (W_m) and is also considered to be homogeneous. A price taking representative firm can hire skilled workers, unskilled workers, or a combination of both types of labor to produce its output (Y). The firm's total labor cost (TLC) is defined as

$$TLC = W_c L_s + W_m L_u \tag{1}$$

and the average wage cost (W) of the firm is

$$W = TLC / T = s W_c + u W_m \tag{2}$$

where T is the total number of workers, s is the ratio of the number of skilled workers to T, and u is the ratio of the number of unskilled workers to T.

The total differential of the equation (2) can be written as

$$dW = s\, dW_c + u\, dW_m \tag{3}$$

therefore the amount of change in the average wage cost due to a marginal change in the minimum wage is

$$(dW/dW_m) = s\,(dW_c/dW_m) + u \tag{4}$$

where (dW_c/dW_m) is the spillover effect of minimum wage changes on the market wage of skilled labor. If there is no spillover effect, then a marginal change of the minimum wage will affect the average wage by u.

According to the *BLS REPORTS* of April 2016, in 2015 there were 2.6 million workers earning wages at or below the federal minimum wage, comprising 3.3 percent of all hourly paid workers in the U.S.[3] Without the spillover effect, increasing the minimum wage by one dollar will increase the average wage of American workers by approximately three cents.

Labor Demand

A firm can use skilled workers (L_s), unskilled workers (L_u), or both types of labor to produce its output (Y); skilled workers are assumed to be more efficient than unskilled workers. The production function of this firm is

$$Y = f(K, L_s, L_u) = AK^{\alpha}(\xi L_s + L_u)^{\beta}, \quad (\alpha+\beta=1,\ \xi>1) \tag{5}$$

where K is the quantity of capital employed and ξ is an efficiency parameter of skilled labor. The production function exhibits constant returns to scale in all three inputs.[4]

The profit function of a firm with this 3-input production function can be defined as

$$\pi = p\, f(K, L_s, L_u) - RK - W_c L_s - W_m L_u \tag{6}$$

where R is the rental price of capital. Then the first order conditions (FOCs) are

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[3] United State Bureau of Labor Statistics, "Characteristics of Minimum Wage Workers, 2015", Report 1061, April 2016.

[4] $A(\Phi K)^{\alpha}(\xi\Phi L_s+\Phi L_u)^{\beta}$, ($\Phi$ is a scale parameter.)
$= A(\Phi^{\alpha}K^{\alpha})(\Phi(\xi L_s+L_u))^{\beta}$
$= A\Phi^{\alpha}K^{\alpha}\Phi^{\beta}(\xi L_s+L_u)^{\beta}$
$= A\Phi^{\alpha+\beta}K^{\alpha}(\xi L_s+L_u)^{\beta}$
$= A\Phi K^{\alpha}(\xi L_s+L_u)^{\beta}$, $(\alpha+\beta=1)$
$= \Phi Y$

$$\partial\pi/\partial K = p\alpha A((\xi L_s+L_u)/K)^{\beta} - R = 0 \quad (7.1)$$

$$\alpha A((\xi L_s+L_u)/K)^{\beta} = r$$

$$\partial\pi/\partial L_s = p\xi\beta A(K/(\xi L_s+L_u))^{\alpha} - W_c = 0 \quad (7.2)$$

$$\xi\beta A(K/(\xi L_s+L_u))^{\alpha} = \omega_c$$

$$\partial\pi/\partial L_u = p\beta A(K/(\xi L_s+L_u))^{\alpha} - W_m = 0 \quad (7.3)$$

$$\beta A(K/(\xi L_s+L_u))^{\alpha} = \omega_m$$

where r is the real rental price of capital, ω_c is the real market wage of skilled workers, and ω_m is the real minimum wage of unskilled workers. From equations (7.2) and (7.3), we can write that the efficiency parameter (ξ) is equal to the ratio of ω_c to ω_m.

$$\xi = (\omega_c/\omega_m) \quad (8)$$

Using the equation (7.2), we can derive the demand function for both skilled and unskilled workers.[5]

$$D(L_s) = (\omega_c/\xi\beta AK^{\alpha})^{(1/\beta-1)}(\xi/1+\xi^2) \quad (9.1)$$

$$= (\omega_m/\beta AK^{\alpha})^{(1/\beta-1)}(\xi/1+\xi^2)$$

$$D(L_u) = (\omega_c/\xi\beta AK^{\alpha})^{(1/\beta-1)}(1/1+\xi^2) \quad (9.2)$$

$$= (\omega_m/\beta AK^{\alpha})^{(1/\beta-1)}(1/1+\xi^2)$$

Combining the labor demand functions for skilled workers (9.1) and for unskilled workers (9.2), the firm's total labor demand function in terms of the minimum wage (ω_m) can be written as

$$D(L) = (1+\xi/1+\xi^2)(\omega_m/\beta AK^{\alpha})^{(1/\beta-1)} \quad (10)$$

Labor Supply

The typical static consumption-leisure optimality condition produces the labor supply function. A representative household chooses consumption and labor supply to maximize her utility function given by

$$u(c,L) = \ln c - (1/2)(1/\theta)L^2 \quad (11)$$

subject to

$$c + S = \omega L$$

where c is consumption, θ is a magnitude parameter of labor supply, and S is the quantity of saving. Combined with equations (2) and (8), the constraint can be re-written as

$$c + S = (s\xi+u)\omega_m L \quad (12)$$

thus the objective function can be defined as

$$u(L) = \ln((s\xi+u)\omega_m L - S) - (1/2)(1/\theta)L^2 \quad (13)$$

The FOC of the equation (13) gives

$$S(L) = \theta((s\xi+u)\omega_m/c) \quad (14)$$

which is the labor supply function in terms of the minimum wage (ω_m).

Unemployment

When the market wage is given, unemployment is defined as the difference between the amount of labor supplied by households and the amount of labor demanded by firms. The labor supply equation (14) and the labor demand equation (10) define unemployment in terms of the minimum wage, ω_m.

$$U = \theta((s\xi+u)\omega_m/c) - (1+\xi/1+\xi^2)(\omega_m/\beta AK^{\alpha})^{(1/\beta-1)} \quad (15)$$

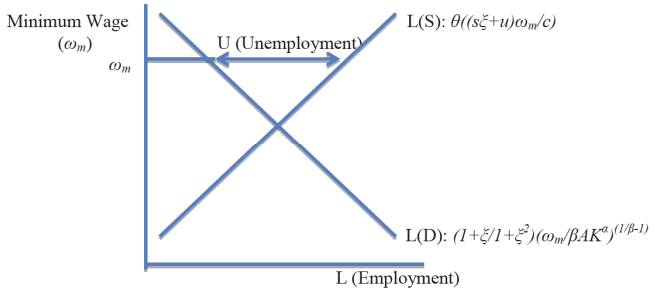

Figure 1: The Labor Market.

IV. EMPIRICAL RESULTS

Empirical Model

To evaluate the impact of the minimum wage on unemployment, we estimate both labor demand and supply functions. To use ordinary least squares (OLS), we take the natural log of each side of equations (10) and (14), which provide the following linear estimation equations

$$\ln(L(D)) = \gamma_0 + \gamma_1\ln(\omega_m) + \gamma_2\ln(A) + \gamma_3\ln(K) + \varepsilon_1 \quad (16)$$

$$\ln(L(S)) = \delta_0 + \delta_1\ln(\omega) + \delta_2\ln(c) + \varepsilon_2 \quad (17)$$

where

$$\gamma_0 = \ln(1+\xi/1+\xi^2) + (1/\beta-1)\ln(\beta);$$

[5]Since $L = L_s + L_u$ and $L_s = \xi L_u$, either equation (7.2) or (7.3) produces the same labor demand functions for skilled and unskilled workers.

Table 2: Countries in the Data Set

Australia	Estonia	Israel	Netherlands	Slovenia
Belgium	France	Japan	New Zealand	Spain
Canada	Greece	Korea	Poland	Turkey
Chile	Hungary	Luxembourg	Portugal	UK
Czech Rep	Ireland	Mexico	Slovak	USA

Table 3: Descriptive Statistics

Variables		Obs.	Mean	Std. Dev.	Min.	Max.
Employment	*L(D)*	367	17630.64	29540.82	180.9	146305.3
Labor Force	*L(S)*	364	18953.89	31541.24	185.2	155921.8
TFP	*A*	300	13198.4	64862.14	.8351407	354817.1
GFCF	*K*	375	279080.8	565401.9	3609.308	3378732
Consumption	*c*	375	922195.1	2040258	12265.28	1.15e+07
Minimum Wage	ω_m	375	13484.94	6065.049	2087	25628
Average Wage	ω	323	34475.53	12788.9	11850	61511

$\delta_0 = ln(\theta)$;

$\omega = (s\xi+u)\omega_m$, which is the average wage;

ε_1 and ε_2 are Gaussian white noise error terms.

Data

Our data set contains 25 OECD countries over 15 years from 2000 to 2014. These 25 countries are selected by the data availability on their minimum wages.[6] The name of each country is given in Table **2**.

The data set is unbalanced and descriptive statistics for the data set are presented in Table **3**. The *L(D)* variable is the total employment of each country and the *L(S)* variable is the total number of people in each country's labor force. Both variables are measured in thousands of people. The variable *A* is the total factor productivity (TFP) reflecting the overall efficiency with which labor and capital inputs are used together in the production process. The gross fixed capital formation (GFCF) variable, *K*, and the household spending variable, *c*, are in millions of constant 2014 dollars. The minimum wage variable, ω_m, is the annual earnings for a full-time minimum wage worker and it is measured in constant 2014 dollars. The average annual wage of each country, ω, is in constant 2014 dollars, too.

Table **4** presents the average annual wage, ω, relative to the minimum wage, ω_m. Since ω is equal to $(s\xi+u)\omega_m$, presented numbers in Table **4** is equivalent to $(s\xi+u)$ in our model. All variables in our data set come from the OECD database and Penn World Table 8.0.[7]

Empirical Results

First of all, we estimate the labor demand equation (16) with four different estimators: the ordinary least squares (OLS), the fixed effects model (FEM), the random effects model (REM), and the Arellano-Bond model (ABM). Empirical results from these four estimators are presented in Table **5**. All coefficients on $ln(\omega_m)$ are statistically negative and significant, meaning that an increase in the minimum wage decreases overall labor demand. Since Lagrangian multiplier (LM) and Hausman tests suggest that the fixed effects model is the most appropriate model with our data, we interpret our empirical results based on coefficients from the FEM. The coefficient on $ln(\omega_m)$ from the FEM is -0.07. Since this number represents the elasticity, this coefficient means that 1 percent

[6]Germany and Italy are excluded. Germany introduces its national minimum wage for the first time in 2014. Currently German national minimum wage is €8.50. Italy does not have a mandatory national minimum wage law. Instead they set minimums through collective bargaining agreements on a sector-by-sector basis.

[7]https://data.oecd.org
http://cid.econ.ucdavis.edu/pwt.html

Table 4: Average Relative to Minimum Wage (2014)

Australia	2.320186	Ireland	2.702703	Portugal	2.531646
Belgium	2.320186	Israel	2.427185	Slovak	2.666667
Canada	2.475247	Japan	2.95858	Slovenia	2.024292
Chile	2.222222	Korea	2.801121	Spain	2.881844
Czech Rep	3.174603	Luxembourg	2.10084	Turkey	2.673797
Estonia	2.873563	Mexico	3.484321	UK	2.512563
France	2.020202	Netherlands	2.386635	USA	3.759398
Greece	2.590673	New Zealand	1.968504		
Hungary	2.487562	Poland	2.493766		

increase in the minimum wage decreases labor demand by 0.07 percent.

The coefficient on the total factor productivity, *ln(A)*, is also statistically negative and significant, which accords with the classical theoretic prediction. The one on the capital stock, *ln(K)*, however, turns out a positive, 0.252, and statistically significant. Since we do not assume that we have a given fixed output level or we are always on the same isoquant, a positive coefficient is not necessarily inappropriate.

Second of all, we estimate the labor supply equation (17) with the same four estimators: OLS, FEM, REM, and ABM. Table **6** displays empirical results from these estimators. Similar to the labor demand case, Lagrangian multiplier (LM) and Hausman tests suggest that the fixed effects model is the most appropriate model with our labor supply equation. The coefficient on *ln(ω)* is a positive, 0.022, but statistically not different from zero. Since ω is equals to $(s\xi+u)\omega_m$, this empirical result shows that a change in the minimum wage does not affect the labor supply statistically. As it shown in Figure 4-1, this result suggests that our labor supply exists the inside of the inelastic region on the labor supply curve.

The coefficient on the real consumption, *ln(c)*, is statistically positive and significant. The classical consumption-leisure framework predicts a negative correlation between consumption and labor supply whereas our empirical result shows a positive correlation between them.

Based on our estimates, we calculate the impact of 1 percent increase in the minimum wage on the overall unemployment rate. All numbers in Table **7** are measured in thousands of people except the change of unemployment rate that is measured in percentage. Since our empirical results find that the minimum wage

Table 5: Minimum Wage on Labor Demand

	OLS	**Fixed**	**Random**	**Arellano-Bond**
$ln(\omega_m)$	-0.537	**-0.070**	-0.192	-0.087
	(17.64)**	**(3.10)****	(5.54)**	(5.12)**
ln(A)	0.001	**-0.279**	-0.085	-0.040
	(0.21)	**(7.09)****	(2.92)**	(1.05)
ln(K)	1.004	**0.252**	0.326	0.135
	(93.06)**	**(20.49)****	(17.77)**	(11.90)**
$L(D)_{(t-1)}$				0.539
				(10.66)**
Constant(γ_0)	2.374	**6.699**	6.927	3.345
	(8.05)**	**(42.75)****	(26.74)**	(11.44)**
R^2	0.97	**0.69**	376.5^W	2387.04^W
N	292	**292**	292	242

The numbers in the brackets are absolute value of *t*-statistics. ** indicates significance at 1% level of significance. ^{W} indicates Wald chi-squares statistics.

Table 6: Minimum Wage on Labor Supply

	OLS	Fixed	Random	Arellano-Bond
ln(ω)	-0.610	**0.022**	-0.468	-0.074
	(27.96)**	**(0.48)**	(10.06)**	(3.02)**
ln(c)	0.983	**0.285**	0.814	0.087
	(178.84)**	**(7.77)****	(33.23)**	(4.80)**
$L(S)_{(t-1)}$				0.858
				(38.51)**
Constant(δ_0)	2.905	**5.108**	3.554	0.941
	(13.26)**	**(14.58)****	(8.25)**	(5.74)**
R^2	0.99	**0.32**	1151.67[W]	3434.46[W]
N	318	**318**	318	276

The numbers in the brackets are absolute value of *t*-statistics. ** indicates significance at 1% level of significance. [W] indicates Wald chi-squares statistics.

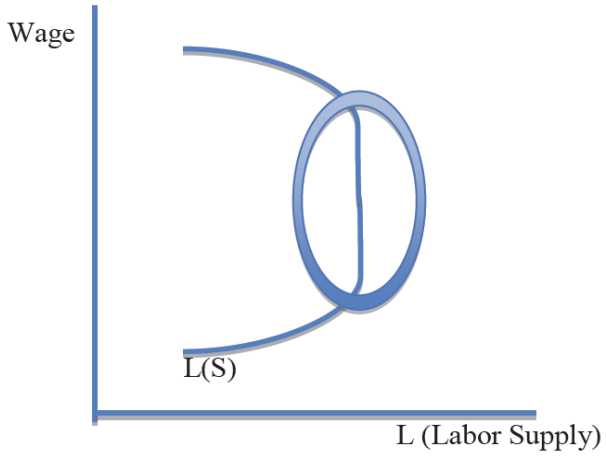

Figure 2: The Labor Supply Curve.

Table 7: Minimum Wage on Unemployment (2014)

Country	Labor Force	Employment	Δ of Employment	Δ of Unemployment Rate (%)
Australia	4357.58	4112.67	-2.8788	0.066
Belgium	4966.85	4543.55	-3.1804	0.064
Canada	19124.5	17802.2	-12.4615	0.065
Chile	8442.72	7903.22	-5.5322	0.066
Czech Rep	5297.88	4974.33	-3.4820	0.066
Estonia	674.4	624.825	-0.4373	0.065
France	29403.1	26376.9	-18.4638	0.063
Greece	4810.65	3536.25	-2.4753	0.051
Hungary	4444.2	4100.83	-2.8705	0.065
Ireland	2156.82	1913.9	-1.3397	0.062
Israel	3778.33	3555.77	-2.4890	0.066
Japan	65867.5	63506.7	-44.4546	0.067
Korea	26535.9	25599.4	-17.9195	0.068

(Table 7). Continued.

Country	Labor Force	Employment	Δ of Employment	Δ of Unemployment Rate (%)
Luxembourg	260.9	245.625	-0.1719	0.066
Mexico	51924.1	49415.4	-34.5907	0.067
Netherlands	8895.75	8236.08	-5.7652	0.065
New Zealand	2446.07	2305.32	-1.6137	0.066
Poland	17428.3	15861.5	-11.1030	0.064
Portugal	5225.58	4499.55	-3.1496	0.060
Slovak	2721.93	2363.02	-1.6541	0.061
Slovenia	1014.83	916.7	-0.6416	0.063
Spain	22954.6	17344.2	-12.1409	0.053
Turkey	28773.5	25930.7	-18.1514	0.063
UK	32637.3	30641.8	-21.4492	0.066
USA	155922	146305	-102.4135	0.066
Average	**21071.1546**	**18904.6176**	**-13.2332**	**0.064**

affects only labor demand not labor supply, we fix the size of each country's labor force and calculate the change of labor demand, which is the change of total employment of each country. On average, 1 percent increase in minimums increases unemployment rate by 0.064 percent. In the U.S., for example, 1 percent increase in the minimum wage decreases employment by 0.07 percent that is 102,414 people which is equivalent to increase the unemployment rate of the U.S. by 0.066 percent.

V. CONCLUSION

In this paper, we attempt to explain how labor demand and supply respond to minimum wage increases. In our model, firms can hire either skilled or unskilled workers to maximize their profits. We find that, empirically, a higher minimum wage decreases labor demand but does not affect labor supply with data from 25 OECD countries over 15 years from 2000 to 2014.

Our empirical results also suggest that relatively modest increases in minimum wages have limited impacts on employment. On average, 10 percent increase in the minimum wage decreases employment by 0.7 percent, thereby increasing unemployment rate by 0.64 percent.

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