How Unauthorized Workers Differ from Permanent Residents: Labor Market Effects of the Minimum Wage on Immigrants

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Abstract

While there are thousands of studies on the labor market effects of the minimum wage, very few of them focus on its effects on immigrants, especially unauthorized immigrants. Lack of reliable data on unauthorized immigrants is a major issue. Sociologists have utilized Survey of Income and Program Participation (SIPP) data to estimate the number of unauthorized immigrants using a question in the SIPP about whether immigrants to the U.S. have obtained permanent residency. In this paper we adopt a similar methodology and assume that lower-educated immigrants without permanent residency are likely to be unauthorized, as distinguished from higher-educated immigrants without permanent residency such as F-1 students and H-1B workers. Based on preliminary analyses, we find that lower-wage permanent residents experience increases in employment when effective minimum wages increase. In contrast, immigrants without permanent residency seem to be less responsive in employment to minimum wage increases.

To explain our findings, we propose a three-sector segmented labor market model with two types of workers. In the destination country, one sector is covered by the minimum wage, while the other (illegal) sector is uncovered by the minimum wage. The two types of immigrants are permanent residents and unauthorized immigrants. We assume that covered sector can only hire permanent residents and that the minimum wage is binding. The uncovered sector can hire both permanent and unauthorized workers, with the wage being market-determined and in equilibrium lower than the minimum wage. Permanent residents who cannot find jobs in the covered sector look in the uncovered sector and can always find a job in equilibrium. The two types of immigrants make decisions to migrate to the destination country. or stay in their originating country, and therefore in equilibrium, the expected returns if they migrate are the same as the reservation wage in their originating country.

Keywords: unauthorized immigrants, minimum wage, Survey of Income and Program Participation

JEL Classifications – J3, J6

1. Introduction

There are thousands of studies going back more than a century on the effects of minimum wages, which date back at least to the establishment of the U.S. Department of Labor in 1913 (Neumark, Salas, and Wascher 2014). However, whether a minimum wage helps or harms low-wage workers is still debatable and remains a contentious issue both in theory (surveyed by Brown, Gilroy, and Kohen 1982) and in empirical studies (surveyed by Neumark and Wascher 2006 on employment effects). The initial debates were largely based on theoretical reasoning while recent work provides more empirical evidence. From the mid 1990's the original focus on employment was branched out to other related aspects of labor market consequences (e.g. wage distribution, working hours, family income, labor force participation, schooling and skills training, health, firm profits, prices and inflation, etc.) as surveyed by Neumark and Wascher (2008).

The largest portion of the empirical literature looks at teenagers, since they account for the largest share of minimum wage earners. However, some research (e.g. Carrington and Fallick 2001; Neumark, Schweitzer, and Wascher 2004) argues that focusing on teenagers may miss the target of the policy because teenagers usually grow out of minimum wage jobs and their low-wage status is temporary. Some teenagers who earn the minimum wage even come from wealthy families. On the other hand, low-skilled adults are more likely to be permanent minimum wage earners. These affected adults disproportionately include women, racial/ethnic minorities, lower educated people, lower income families, and lower income industry workers (e.g. food and catering, retail sector) (Belman, Wolfson, and Nawakitphaitoon 2015).

One group whose wages are likely to be around the minimum wage that has been long neglected is the lower educated immigrants. Only a few studies have examined the labor market effects of the minimum wage on immigrants (e.g. Orrenius and Zavodny 2008; Cadena 2014). One reason for this gap is that most immigrants are by definition not citizens of the U.S., many stay temporarily and have no voting rights, so their wellbeing is not the concern of any domestic constituency and they are often regarded as competing against citizens for jobs and welfare benefits. Another reason is the lack of reliable data on immigrants, especially unauthorized ones. Some economists have tried recently to fill this gap. Borjas (2017) used a newly developed method to impute unauthorized status in the Current Population Surveys (CPS), but the accuracy of the imputed variable depends on the assumption of its relationship with other observable variables. East et al. (2018) used the group of non-citizens with lower education to proxy the unauthorized population using the American Community Survey data. In addition, sociologists have utilized Survey of Income and Program Participation (SIPP) data to estimate the number of unauthorized immigrants using a question in the SIPP about whether immigrants to the U.S. have obtained permanent residency. This method has been applied to produce estimates of unauthorized immigrants at state level (MPI 2015).

Most research on immigrants focuses on the impact of their coming on U.S. citizens and the local economy. Very few concern the immigrants' behaviors and performance themselves. In this study, we focus on the effects of minimum wages on employment, wage rates and working hours for immigrants. This paper contributes to the existing literature in three aspects. First, we develop a theoretical model in which immigrants differ in their legal status (legal permanent residents vs. a combination of authorized and unauthorized nonpermanent residents) instead of one homogeneous workforce in the canonical model. Second, we test the theoretical model using the SIPP data, which is the only nationally

representative database containing information on the permanent residency status of immigrants that can be used to differentiate immigrants by their legal status (Capps et al. 2013). Third, the empirical method we use is a micro (person) level panel analysis. We are among the first to use a micro-level panel model to study the labor market effects of the minimum wage.

The latest Pew Research report estimates that there were 10.7 million unauthorized immigrants in the U.S. in 2016, the lowest level since 2004 (Krogstad, Passel, and Cohn 2018). This declining trend may continue, influenced by the immigration policies of the Trump administration. However, given the still large size of the unauthorized population that is already in the U.S. and participating in the labor market, existing labor market policies such as minimum wage laws inevitably have an impact on these workers. Despite their status, unauthorized immigrants may be hard working employees. Should we aim to legalize their status so that they can assimilate and contribute to economic activities and tax revenues? Or should we try to reduce the possibility of them getting employed so as to encourage them to leave the U.S and discourage others from arriving in the first place? In order to inform these complicated normative questions, we need to first do a positive economic analysis on the effects of minimum wages on their labor market outcomes.

Why should we care about (unauthorized) immigrants' labor market outcomes? Firstly, by estimating the effects of minimum wage on immigrants' employment (extensive margin), working hours (intensive margin) and wages, we send out labor market price and quantity signals, which may be covert and hard to obtain, to the planning-to-be immigrants on possible outcomes of them coming in. A decreasing employment probability and a possibly decreasing wage under increasing minimum wage would lower their willingness to migrate. Secondly, by allowing wages to be endogenous and potentially lower than minimum wage when unauthorized immigrants are employable, our theoretical model shows how immigrants influx drives down the (sectoral) wage to a subminimum level which becomes unappealing to native workers rather than the other way around (i.e. immigrants are recruited to fill in sectors natives not interested in). Thirdly, by building the minimum wage into the theoretical model, we show that in addition to enforcement instruments such as deportation on unauthorized immigrants and fines on violating employers, minimum wage may also be used to deter the incoming unauthorized immigrants (or attract more).

The remainder of this paper is organized as follows. Section 2 provides a brief literature review of the earlier minimum wage research most relevant to this study. Section 3 presents a theoretical model of a segmented three-sector labor market. Section 4 discusses the dataset. Section 5 contains the empirical methods to be used and some preliminary results. And Section 6 draws conclusions.

2. Literature Review

Theoretically, the different predictions of theoretical minimum wage models depend on their assumptions about the structure of the low-wage labor market. Neoclassical theory posits that this labor market is competitive and by raising the wage above the market-clearing level, firms will no longer hire those workers whose marginal revenue product is lower than the minimum wage and these workers will be unemployed. Alternative models assume that there is some type of labor market imperfection (e.g. monopsony, search or transaction costs), so that the employment level is below optimal. Under the monopsony assumption, a minimum wage renders more bargaining power to employees and increases their employment toward the optimal level. Under the search cost assumption, a higher minimum wage

will increase both employers' and employees' incentives to search for better matches and improve the efficiency in matching between labor demand and supply.

Empirically, there are two strands of methods in the "new minimum wage research": state panel data approaches and geographically matched difference-in-difference (DID) analyses. With the publication of a special issue of the Industrial and Labor Relations Review (ILRR) in the early 1990's, four studies formed the basis for this reemerged empirical minimum wage research (i.e. Neumark and Wascher 1992; Card 1992a, 1992b; Katz and Krueger 1992). In state panel analyses, state-level aggregate measures such as the ratio of employment to population are dependent variables, and all the other states are taken as the comparison group nonexclusively. This strand of studies is critiqued by newer studies (such as Dube, Lester, and Reich 2010; Allegretto, Dube, and Reich 2011) for failing to account for spatial heterogeneity. In geographically matched DID analyses, research designs to control for this heterogeneity are used by including only counties/states with the same border or in the same region in one regression, where those neighboring counties/states with no change in minimum wage are taken as the counterfactual control group. Standard panel data analyses usually find negative effects of minimum wages on employment whereas the newer, geographically matched DID studies are more likely to find no effects or even positive effects with little statistical significance.

The different theoretical models of minimum wages can shed light on why these two types of studies tend to disagree in their results. Considering that the national labor market is likely to be competitive, given the mobility of labor and firms across states, it is not surprising that most empirical work using state-level data in a long panel find a negative and significant employment effect. On the other hand, the geographically matched DID analyses usually focus on local labor markets in the short run (as in the classic Card and Krueger 1994 example where observations were obtained several months before and after the change in the minimum wage). These types of "case studies" are likely to capture labor market imperfections, since it is more likely that a firm has monopsony power in the local labor market than in the national market. This can explain why this strand of empirical work usually yields a statistically insignificant employment effect.

2.1 Theoretical models

Our theoretical model is a partial equilibrium labor market model with three sectors (originating country for immigrants, formal sector in the destination country, and informal sector in the destination country). We borrow directly from the two-sector models of the earlier minimum wage studies. While the classic models are more valid historically when there were industries and types of firms covered and uncovered by minimum wage laws, the sectors in the destination country in our model refer to formal/lawful and informal/underground sectors, the latter of which may hire unauthorized immigrants. One seminal study of segmented labor market is Harris and Todaro (1970). The model contains rural and urban sectors and the two sectors are connected by labor migration. They allow for unemployment in the urban sector, and the rural workers make migration decisions comparing expected wages in both sectors. Another more recent study is a segmented Chinese labor market model (Fields and Song 2013). While the Chinese and U.S. labor market have many differences, the market for immigrants (including the unauthorized) in the U.S. has some comparable characteristics with the Chinese rural-urban labor market. Similar to rural workers in China, international migrants to the U.S. need to compare their expected earnings in the U.S. with their opportunity costs in the originating place. Also, immigrants encounter segmented formal and informal markets in the U.S. depending on whether they have lawful

status, much like the case of rural migrants in China who confront two sectors (state-owned sector and private sector). Both countries have requirements for entering the more privileged sector, permanent residency status in the U.S. and urban registered residency status (hukou) in China. The difference is that the restrictions in the labor market are imposed on unauthorized immigrants in the U.S. compared to rural citizens in China.

There are two contrasting views on the effects of the minimum wage on immigrants. Some believe that employers will obey minimum wage laws and hire workers with a marginal revenue product greater than minimum wage; therefore, low-skilled immigrants will be discouraged from arriving in the first place (Bartlett 2013). Others assume that employers may be induced to hire unauthorized immigrants at an unlawful subminimum wage when facing the higher minimum wage payable to natives; therefore, raising the minimum wage may act as a spur to immigration (Tapinos 1999). There are a few attempts from previous literature to theoretically model the effects of minimum wage on (unauthorized) immigration. Hanson and Spilimbergo (1999) concentrated on immigrants' unlawful migration decisions, with minimum wages serving as a measure of low-skill wage levels in both the source country and destination. Epstein and Heizler (Cohen) (2008) mainly model the profit-maximizing behavior of employers, who determine the optimal number of authorized and unauthorized workers, with authorized workers earning the minimum wage and unauthorized ones earning subminimum wage. Our model combines the decisions of immigrants and the behavior of employers and has both authorized and unauthorized immigrants in different sectors, taking into account both the supply and demand side of the immigrant labor market.

2.2 Empirical evidence

Relatively few studies use the SIPP data, which is an individual-level panel dataset, for minimum wage analysis. Some earlier studies at the person level used CPS data, which is a short panel of two consecutive observations in two years (e.g. Neumark and Wascher 1995; Abowd et al. 2000; Zavodny 2000; Hoffman 2014). Participants in the CPS are surveyed for 4 months, rotate out of the panel for 8 months, and surveyed again for 4 months and then exit the panel. In the last month of each rotation, the survey asks questions regarding respondents' employment status, usual working hours and earnings, so two observations on labor market outcomes are available for each person at the maximum. Studies applying CPS use the conditional transition probability generated from the two-year rotation panel as the dependent variable. Only a few studies have used SIPP data. Burkhauser, Couch, and Wittenburg (2000) analyzed the minimum wage using the 1990 SIPP, but adopted the conventional state panel approach rather than isolating samples of targeted individuals based on the wage data. Clemens and Wither (2014) used 2008 SIPP at the individual level, but they are in the strand of DID analysis. They only chose individuals in similar states just like what an aggregate DID would do.

In our paper, we build the empirical panel data model at person level. Each person may change their labor market status during the period of observation (64 months at maximum). Aside from the fixed factors that do not change over time such as gender and race/ethnicity, individual labor market outcomes are expected to change as they age, obtain higher educational attainment, and change family composition or living arrangements. Another important group of factors is the contextual state-level variables including the state minimum wage level. As far as we know, before our study, only one study (Du and Leigh 2018) used a person-level fixed effects panel analysis to study the effects of the minimum wage, in their case effects on work absences due to illness.

Learning from the idea of comparing observations with similarity in the same region to control for unobservable regional effects, in our empirical model we divide observations into subgroups that are more comparable. Since there is no indicator on the legal status of immigrants in the SIPP data, we can only use some other variables to approximate the distinctions of different immigrants and their wage sectors. In our empirical model, we use permanent residence status, their years in the U.S. and their education levels to gauge different proportion of unauthorized immigrants in the sample. For example, we anticipate that lower educated new immigrants to contain large number of unauthorized immigrants who can only find jobs in the subminimum wage sector. As their years in the U.S. increase, the share of unauthorized immigrants may reduce for return migration or change of status through family-based or other legalization process. And their experience and language skills may improve during their stay, so it is expected that their employment in subminimum and slightly-above-minimum wage sectors would both increase.

Earlier empirical work has also decomposed workers into subgroups to show the mechanisms of minimum wage effects. Brochu et al. (2015), in an analysis of minimum wage effects on wage distribution, divided workers into those moving out of employment (leavers), those moving into employment (joiners), and those continuing in employment (stayers). By such a decomposition, they attempted to distinguish between competitive and noncompetitive models and answer questions like: whether leavers are those who formerly earned below the new minimum wage; whether stayers have their wages raised just to the new minimum wage or above it; and whether joiners are hired under new selection rules induced by the minimum wage increase. Another conventional comparison of effects is between minimum wage earners and low wage workers earning slightly above minimum wage (see, for example, Dickens and Manning 2004, and Neumark, Schweitzer, and Wascher 2004). The so-called "ripple effect" or the positive spillover in wages above the new minimum is probably due to labor demand substitution, whereby increases in the minimum wage raise the price of low-skilled minimum wage earners and make higher skilled workers relatively less expensive. Firms would respond to the change in relative prices, substituting away from less-skilled workers and toward more skilled workers.

This paper reconciles the positive and negative effects of minimum wages on employment among immigrants, both theoretically and empirically. Our theoretical and empirical models break the wage sector into covered and uncovered, unlike in most previous studies that only label workers with wages at or above the previous minimum wage and below the new minimum wage as the affected group. The uncovered-wage sector has a natural connection with unauthorized immigrants and seems a reasonable way to describe the labor market faced by immigrants.

3. Theoretical Model

3.1 Model setup

There are three sectors in two locations in this model: a minimum wage covered sector, a minimum wage uncovered sector, and a reservation wage sector. The covered and uncovered sectors are located in the destination country for immigrants while the reservation wage sector is in the originating country. There are two types of immigrant workers in the labor market: permanent workers and unauthorized workers. Lawful temporary nonimmigrant workers such as students and temporary working visa holders are excluded from the theoretical model, since they have some traits of permanent workers (i.e. they are lawfully present) and some traits of unauthorized workers (i.e. they are temporary residents).

The three sectors differ from each other in wages and labor composition. In the covered sector the wage is equal to the minimum wage which is exogenously set by the government. The covered sector complies with the minimum wage law but not necessarily the immigration law. However, we assume that it will only hire permanent workers of relatively low skills but not unauthorized workers with equivalent skills. For simplicity, we do not consider the downgrading employment of better-qualified immigrants, so only lower educated immigrants are modeled. Since the minimum wage may be higher than the market-clearing wage in this sector as well as wages in other sectors, individuals who want to work in the covered sector may be more than the sector could absorb at the minimum wage. Thus, following Harris and Todaro (1970), we assume that covered sector jobs are randomly allocated to permanent job seekers.

The uncovered sector hires both permanent workers and maybe also (unlawfully) unauthorized workers. The presence of subminimum hourly wage workers is not necessarily a violation of minimum wage laws (BLS 2017a). The lawful subminimum wage is designed for individuals such as youth and disabled workers to prevent the loss of employment opportunities for them (DOL 2018), but this may only be a small proportion of the uncovered sector. This means that workers who cannot find jobs in the covered sector could supply their labor to the uncovered sector lawfully and unlawfully. A large part of workers in the uncovered sector are unauthorized workers who are working under the table. They have to accept the unlawful subminimum wage rate because they fear that to report their employers for noncompliance to the minimum wage laws would reveal their own unlawful status.

Employers in the model are not penalized for being in the uncovered sector but, if caught, for hiring unauthorized workers. We further assume that the uncovered sector labor market clears for both permanent workers and unauthorized workers, and that their wages are market-determined. Because of their different immigration status, they have different equilibrium uncovered sector wage levels. Furthermore, there may be two wages for permanent workers in this sector, which are the lawful uncovered wage and the unlawful uncovered wage; the sectoral wage is a weighted combination of the two. Since we assume anyone who do not get employed in the covered sector is able to obtain a job in the uncovered sector, there is no open unemployment in the destination country, which is similar to the assumption of Welch (1974).

The third sector is the labor market in the originating country. This sector provides a reservation wage to both permanent and unauthorized immigrant workers. Due to the possibility of differences in labor productivity between permanent and unauthorized immigrants, we assume that the reservation wages for these two types of immigrants are different, and the reservation wages are invariant with respect to the number of emigrants out of that country.

The two types of immigrants have two possible choices. They can either migrate to the destination and search for jobs there or stay in the originating country and accept the reservation wage. Following Harris and Todaro (1970), immigrants need to move to and be physically located in the destination country in order to search jobs and work there, thus we do not allow for on-the-job search in originating country. In the equilibrium, permanent workers and unauthorized workers have two sets of payoffs for migration and stay. That is, the expected wage in the destination should be the same as the reservation wage in the originating country for both types of workers.

3.2 Model specification

In this subsection, we lay out the equations which incorporate the model features presented in the previous subsection with general and specific functional forms. We also derive closed-form solutions and comparative statics for employment and wage levels of different sectors and different types of immigrant workers. Note that the superscript of the variables refers to immigrant status (i.e. PR stands for permanent workers, UD stands for unauthorized workers), whereas the subscript refers to location or sector (i.e. C stands for covered sector, U stands for uncovered sector, and ST stands for the originating country). Firms within each sector are identical and have the same production function. Efficiency units of labor are the only factor of production in each sector.

3.2.1 Covered sector labor market

The covered sector only employs permanent workers. Let E_C^{PR} and W_C^{PR} denote the total number and the wage of permanent workers in the covered sector, respectively. The price of the output in the covered sector is normalized to 1.

$f_C(\cdot)$ is a strictly increasing and concave production function in the covered sector, with $f_C' > 0$, and $f_C'' < 0$. Firms in the covered sector maximize profit by choosing how many permanent workers to hire, given that W_C^{PR} is set exogenously by the government at minimum wage (W_m). The problem for firms in the covered sector is

(1) $$\underset{E_C^{PR}}{\text{Max}}\, \pi_C = f_C(E_C^{PR}) - W_C^{PR} E_C^{PR}, \text{ where } W_C^{PR} = W_m$$

The profit-maximizing level of employment solves the following equation:

(2) $$f_C'(E_C^{PR}) = W_m$$

3.2.2 Uncovered sector labor market

Let E_U^{PR} and W_U^{PR} denote the total number and the wage of permanent workers in the uncovered sector; E_U^{UD} and W_U^{UD} denote the total number and the wage of unauthorized workers in the uncovered sector. Suppose that a permanent worker is endowed with one efficiency unit of labor; in contrast, an unauthorized worker can provide only β (0<β<1) efficiency units of labor, because permanent workers are assumed to be more aspired and more skilled.

Uncovered sector employers decide how many permanent workers and unauthorized workers to hire. If they hire unauthorized workers, they confront the possibility of being penalized and losing their unauthorized labor. Assume they employ lawful subminimum wage workers with a probability of p_{legl}, and the probability of unauthorized employment being penalized is p_{fn}. In the case where unlawful hiring is done but not caught, the total quantity of efficiency labor contains both permanent and unauthorized workers. In the case where unlawful hiring is caught, only permanent workers can be retained by the firm, and the employer will be penalized an amount FN for each unauthorized worker they hire. If they hire lawful permanent residents only and obtain certificates for employment from the government, they are exempt from penalty.

Again, the product price is normalized to 1. The uncovered sector production function $g_U(\cdot)$ is increasing and concave, with $g_U' > 0$, and $g_U'' < 0$. Firms in the uncovered sector determine on the

number of two types of workers to maximize the expected profit as follows, taking the wage levels as given:

(3) $$\underset{E_U^{PR},E_U^{UD}}{\text{Max}}\ \pi_U = p_{legl}(g_U(E_U^{PR}) - W_U^{PR}E_U^{PR}) + \left(1 - p_{legl}\right)$$

$$\{\left(1 - p_{fn}\right)[g_U(E_U^{PR} + \beta E_U^{UD}) - W_U^{PR}E_U^{PR} - W_U^{UD}E_U^{UD}] + p_{fn}[g_U(E_U^{PR}) - W_U^{PR}E_U^{PR} - FN \cdot E_U^{UD}]\}$$

Solving for the profit-maximizing levels of employment by taking derivatives with respect to E_U^{PR} and E_U^{UD}, we obtain the following relationships between wages and employment levels:

(4) $$W_U^{PR} = [p_{legl} + \left(1 - p_{legl}\right)p_{fn}]g_U'(E_U^{PR}) + [\left(1 - p_{legl}\right)\left(1 - p_{fn}\right)]g_U'(E_U^{PR} + \beta E_U^{UD})$$

and

(5) $$W_U^{UD} = \beta g_U'(E_U^{PR} + \beta E_U^{UD}) - \frac{p_{fn}}{1-p_{fn}}FN$$

The market equilibrium wage for unauthorized workers is likely to be lower than that for permanent workers. From equation (4), we can further define lawful wage $W_{U\_legl}^{PR}$ and unlawful wage $W_{U\_ill}^{PR}$ for permanent workers in the uncovered sector, where

(6) $$g_U'(E_U^{PR}) = W_{U\_legl}^{PR}$$

and

(7) $$g_U'(E_U^{PR} + \beta E_U^{UD}) = W_{U\_ill}^{PR}$$

Thus, W_U^{PR} is a weighted average of permanent worker uncovered lawful and unlawful wages. We assume that $W_{U\_ill}^{PR} < W_{U\_legl}^{PR}$.

3.2.3 Originating country labor market

Wages in the originating country labor market are assumed to be invariant with respect to numbers of the two types of immigrants. We assume that permanent workers earn a wage W_{ST}^{PR} if they do not migrate, and unauthorized workers earn a wage of W_{ST}^{UD} if they do not migrate (ST stands for "stay"). We assume $W_{ST}^{PR} > W_{ST}^{UD}$.

3.2.4 Equilibrium conditions

For immigrant workers, they need to make a decision on whether to migrate or stay. Immigrants with permanent residency have the option to work in the covered sector in the destination labor market. They may migrate in order to have a chance at receiving a covered sector job while overflowing to the uncovered sector. This is more likely if their opportunity cost in the originating country is low. In equilibrium, the expected wage in the destination country equals the reservation wage in the originating country.

Denoting the probability of permanent workers being employed in the covered sector after migration by P_C^{PR}, we have

(8) $$W_{ST}^{PR} = P_C^{PR}W_m + (1 - P_C^{PR})W_U^{PR}$$

where

(9) $$P_C^{PR} = \frac{E_C^{PR}}{E_C^{PR}+E_U^{PR}}$$

Unauthorized workers can only work in the uncovered sector. There is some probability (p_{dep}) that they get apprehended and deported upon arrival. Note that p_{dep} and p_{fn} are two different probabilities, the former being the deportation rate at border and the latter being the detection rate after migrating and becoming unlawfully employed. p_{dep} is likely to be greater than p_{fn}, since the former is a ratio upon total unauthorized immigrants at the border and the latter is a ratio upon total national employment within the destination country (i.e. much more effort is needed to identify the unauthorized workers after they distribute nationwide). Therefore, p_{dep} dominates the decision of unauthorized immigrants when they decide whether to migrate, while their payoff is assumed to be zero when apprehended and deported. The equalization of expected wage in the equilibrium also holds for unauthorized immigrants.

(10) $$W_{ST}^{UD} = (1 - p_{dep})\, W_U^{UD}$$

From equations (8) and (10), we can derive that $W_m > W_{ST}^{PR} > W_U^{PR} > W_U^{UD} > W_{ST}^{UD}$.

3.3 Model solutions in equilibrium

The exogenous variable of interest is W_m since we are interested in how the minimum wage affects labor market outcomes. There are six basic response variables: the employment and wage levels of two types of immigrant workers in the uncovered sector (E_U^{PR}, W_U^{PR}, E_U^{UD} and W_U^{UD}), the employment level of permanent workers in the covered sector (E_C^{PR}), and the probability of permanent workers being employed in the covered sector (P_C^{PR}). Other endogenous variables can be derived from these basic variables, such as total number of permanent workers (E_{CU}^{PR}) and total immigrant workers (E_{CU}^{IMM}). We have six equations (equation 2, 4, 5, 8-10). Therefore, we can solve for the six unknowns and find the sign of the derivatives of these variables with respect to W_m.

3.3.1 Solutions with general functional forms

From equation (2), we obtain permanent worker employment in the covered sector:

(11) $$E_C^{PR} = f_C'^{-1}(W_m)$$

From equation (10), we obtain the unauthorized worker wage in the uncovered sector:

(12) $$W_U^{UD} = \frac{W_{ST}^{UD}}{1-p_{dep}}$$

Plug equation (12) into (5) to get

(13) $$W_{U\_ill}^{PR} = \frac{1}{\beta}\left(\frac{p_{fn}}{1-p_{fn}}FN + \frac{W_{ST}^{UD}}{1-p_{dep}}\right)$$

Writing E_U^{UD}, W_U^{PR}, and P_C^{PR} as functions of E_U^{PR},

(14) $$E_U^{UD}(E_U^{PR}) = \frac{1}{\beta}\left[-E_U^{PR} + g_U'^{-1}\left(W_{U\_ill}^{PR}\right)\right]$$

(15) $$W_U^{PR}(E_U^{PR}) = \left[p_{legl} + \left(1-p_{legl}\right)p_{fn}\right]g_U'(E_U^{PR}) + \left[\left(1-p_{legl}\right)\left(1-p_{fn}\right)\right]W_{U\_ill}^{PR}$$

(16) $$P_C^{PR}(E_U^{PR}) = \frac{f_C'^{-1}(W_m)}{f_C'^{-1}(W_m)+E_U^{PR}}$$

Finally, plug equations (15) and (16) into (8) to obtain an equation for E_U^{PR} as follows:

(17) $$W_{ST}^{PR} = W_m + \frac{E_U^{PR}}{f_C'^{-1}(W_m)+E_U^{PR}}$$
$$\{[p_{legl} + (1-p_{legl})p_{fn}]g_U'(E_U^{PR}) + [(1-p_{legl})(1-p_{fn})]W_{U\_ill}^{PR} - W_m\}$$

We derive the comparative statics of endogenous variables with general functional forms in equations (18) through (21):

(18) $$\frac{dE_C^{PR}}{dW_m} = \frac{1}{f_C''(E_C^{PR})} < 0$$

(19) $$\frac{dW_U^{UD}}{dW_m} = 0$$

$$\frac{dE_U^{UD}}{dW_m} = -\frac{1}{\beta}\frac{dE_U^{PR}}{dW_m}$$

(20) $$sign\left\{\frac{dE_U^{UD}}{dW_m}\right\} = -sign\{\frac{dE_U^{PR}}{dW_m}\}$$

$$\frac{dW_U^{PR}}{dW_m} = [p_{legl} + (1-p_{legl})p_{fn}]g''(E_U^{PR})\frac{dE_U^{PR}}{dW_m}$$

(21) $$sign\left\{\frac{dW_U^{PR}}{dW_m}\right\} = -sign\{\frac{dE_U^{PR}}{dW_m}\}$$

3.3.2 Solutions assuming quadratic production functions

In order to obtain closed-form solutions for the endogenous variables, we need to specify functional forms for the production functions in the covered and uncovered sectors. For tractability, we choose the quadratic functional form which is concave and satisfies the conditions for a typical neo-classical production function. It is also sufficiently simple to allow for closed-form derivation.

Suppose the covered sector production function is

(22) $$f_C(E_C^{PR}) = \alpha_0 + \alpha_1 E_C^{PR} - \frac{\alpha_2}{2}(E_C^{PR})^2 \text{ where } \alpha_1, \alpha_2 > 0 \text{ and } 0 < E_C^{PR} < \frac{\alpha_1}{\alpha_2}$$

Plug into equation (11) and obtain

(23) $$E_C^{PR} = \frac{\alpha_1 - W_m}{\alpha_2}$$

where α_1 can be interpreted as the choke price for labor in the covered sector, which is technically determined. α_2 can be estimated by calibration at the prevailing equilibrium point (W_m^*, E_C^{PR*}).

Suppose the uncovered sector production function is

(24) $$g_U(E_U) = \beta_0 + \beta_1 E_U - \frac{\beta_2}{2}(E_U)^2 \text{ where } \beta_1, \beta_2 > 0 \text{ and } 0 < E_U < \frac{\beta_1}{\beta_2}$$

Plug into equations (6) and (7) and obtain

(25) $$E_U^{PR} = \frac{\beta_1 - W_{U\_legl}^{PR}}{\beta_2}$$

and

(26) $$E_U^{PR} + \beta E_U^{UD} = \frac{\beta_1 - W_{U\_ill}^{PR}}{\beta_2}$$

As shown in equation (13), the unlawful subminimum wage $W_{U\_ill}^{PR}$ is exogenously determined. Also, the lawful subminimum wage is set by the government for special workers so that $W_{U\_legl}^{PR} = W_{sub}$. Thus, we can estimate β_1 and β_2 using equilibrium conditions of $(W_{sub}^*, W_{U\_ill}^{PR*}, E_U^{PR*}, E_U^{UD*})$. Similar to the covered sector production function, β_1 can be interpreted as upper limit on a permanent worker's wage in the uncovered sector.

Plug these two production functions into equation (17) and simplify to obtain a quadratic function in E_U^{PR}:

(27) $$a(E_U^{PR})^2 + bE_U^{PR} + c = 0$$

where $$a = \left[p_{legl} + \left(1 - p_{legl}\right)p_{fn}\right]\beta_2,$$

$$b = W_{ST}^{PR} - \left[p_{legl} + \left(1 - p_{legl}\right)p_{fn}\right]\beta_1 - \left[\left(1 - p_{legl}\right)\left(1 - p_{fn}\right)\right]W_{U\_ill}^{PR} > 0,$$

$$c = \frac{(W_{ST}^{PR} - W_m)(\alpha_1 - W_m)}{\alpha_2}$$

Solve it and get

(28) $$E_U^{PR} = \frac{-b + \sqrt{b^2 - 4\frac{a}{\alpha_2}(W_{ST}^{PR} - W_m)(\alpha_1 - W_m)}}{2a}$$

Take the derivative with respect to W_m to obtain

(29) $$\frac{dE_U^{PR}}{dW_m} = -\frac{2W_m - (\alpha_1 + W_{ST}^{PR})}{\alpha_2\sqrt{b^2 - 4ac}}$$

We can further plug the functional forms into (16) and simplify to get

(30) $$\frac{dP_C^{PR}}{dW_m} < 0$$

It is straightforward to derive the comparative statics with the quadratic production functions.

If $W_{ST}^{PR} < W_m < \frac{\alpha_1 + W_{ST}^{PR}}{2}$,

we have $\frac{dE_C^{PR}}{dW_m} < 0, \frac{dE_U^{PR}}{dW_m} > 0, \frac{dE_U^{UD}}{dW_m} < 0, \frac{dW_U^{PR}}{dW_m} < 0, \frac{dW_U^{UD}}{dW_m} = 0, \frac{dP_C^{PR}}{dW_m} < 0;$

If $\frac{\alpha_1 + W_{ST}^{PR}}{2} < W_m < \alpha_1$,

we have $\frac{dE_C^{PR}}{dW_m} < 0, \frac{dE_U^{PR}}{dW_m} < 0, \frac{dE_U^{UD}}{dW_m} > 0, \frac{dW_U^{PR}}{dW_m} > 0, \frac{dW_U^{UD}}{dW_m} = 0, \frac{dP_C^{PR}}{dW_m} < 0$

3.3.3 Interpretation

When W_m is low, employers are willing to hire permanent workers in the covered sector, instead of undercutting their wages to a subminimum wage level. The uncovered sector demand is filled by unauthorized workers. Thus, the initial level of E_C^{PR} is high, that of E_U^{PR} is low and that of E_U^{UD} is high. The supply of permanent workers in the covered sector is not shadowed by the low W_m, because it is still higher than their reservation wage at W_{ST}^{PR}. The lack of supply of permanent workers in the uncovered sector pushes up W_U^{PR}. P_C^{PR} is close to 1 because almost all permanent workers work in the covered sector.

When W_m increases, demand in the covered sector decreases. Permanent workers first move to the uncovered sector so that $\frac{dE_U^{PR}}{dW_m} > 0$ and $\frac{dW_U^{PR}}{dW_m} < 0$. The total number of permanent workers continues to increase to equalize the expected wages, and $\frac{dP_C^{PR}}{dW_m} < 0$. However, after W_m increases above the midpoint of the choke price for labor in the covered sector and the reservation wage for permanent residents (given by $\frac{\alpha_1 + W_{ST}^{PR}}{2}$), permanent workers begin returning to their originating country because of the increasing proportion of the uncovered sector jobs ($1 - P_C^{PR}$) with decreasing W_U^{PR}, which drives down their expected wage in the destination country. This decreasing trend in total permanent workers is led by a downsizing of permanent covered sector employment (E_C^{PR}) and strengthened by a shrinking of permanent uncovered sector employment (E_U^{PR}). Unauthorized uncovered sector employment (E_U^{UD}) and the wage of permanent workers in the uncovered sector (W_U^{PR}) are affected accordingly. P_C^{PR} continuously drops with a decreasing rate of change due to the increasingly declining denominator.

The wage of unauthorized workers in the uncovered sector (W_U^{UD}) does not change with the minimum wage because the labor supply is assumed to be perfectly elastic.

3.4 Simulation

3.4.1 Calibration

To investigate the effects of minimum wage on the immigrant labor market outcomes, we start by calibrating the values of the parameters to the existing econometric literature and empirics from historical data. We try to find the closest real-world counterparts to the parameters of our model. The parameters are evaluated in the baseline case in around 2016, because firstly more data are available in recent years; and secondly the federal minimum wage has not changed since 2009, which gives a sufficient amount of time for the market to adjust. For some policy parameters, we consider an alternative value, to show the impact of a policy shift. A summary of the definitions and values of the parameters is presented in Table 1.

[Insert Table 1 here]

We set the reservation wage to equal the average wage in Mexico, because Mexico makes up the largest proportion of all immigrants of the U.S. and is the No. 1 originating country for immigrants (Gonzalez-Barrera and Krogstad 2018). Two measures of Mexican wages, a monthly index of average

wages for high skilled and a daily average minimum wage, are converted to hourly USD wages and used to gauge the reservation wage for permanent workers and unauthorized workers, respectively. Note that although we assume that the high-skilled Mexican wage is a relevant wage for prospective permanent residents to the U.S., the reservation wage for these workers is also influenced by U.S. policy. The U.S. government determines the criteria for permanent residency, including factors such as education and occupation that affect the wages workers could earn in the originating country. We will show in the next part how this parameter affects the labor market equilibrium.

The next set of parameters are related to enforcement policies. As we have discussed in this section, two probabilities of deportation are relevant to our model. We calibrate p_{dep} using Mexican unauthorized immigrants, assuming they are a representative sample of the unauthorized population. p_{fn} is calibrated using non-criminal deportation of all unauthorized immigrants, most of whom are deported for unlawful employment. The denominator is the total national employment, assuming there are no other measures to narrow down the target. Another policy parameter is the penalty for employment violation. Immigration-related penalties substantially increase for second and subsequent offenses (DOJ 2017). We assume that most violating employers are first-time offenders (frequent malefactors are less likely to choose between lawful and unlawful behaviors); therefore, we calibrate to the fine for first offenders.

We also calibrate for a set of subminimum wage employment parameters. DOL (2018) sets the youth minimum wage authorized by the FLSA to be $4.25, which we use as the lawful uncovered wage. There is only a small proportion of uncovered employment that is lawful. BLS (2017) estimates that there are about 1.5 million people earning wages below the federal minimum in 2016. Among these subminimum workers, about 130,000 are employed under certificates issued by the Wage and Hour Division (see data of certificate holders in WHD 2018). Thus, we set p_{legl} to be 0.1. Note that p_{legl} depends on the numbers of special need workers (e.g. disabled and student workers) which is beyond the direct control of employers and government, so we take p_{legl} as given.

The last set of parameters are technical parameters of the production functions. We assume that a permanent worker has one efficiency unit of labor and an unauthorized worker has only $\beta < 1$ efficiency units of labor. α_1, defined as the upper limit of the attainable wage in the covered sector, or the largest minimum wage possible, is assumed to be $15. α_1 cannot be set exceedingly large, in order to keep the number of unauthorized workers greater than zero. We further estimate the equilibrium immigrant employment in the covered and uncovered sectors based on Orrenius and Zavodny (2008). Although their study depends on CPS data from 1994 to 2005, this is the closest study we could find to enlighten on immigrant employment in both sectors. Their study shows that the immigrant proportion in the low-wage sector is disproportionately high, where 2.5% immigrants and 1.3% of natives earn exactly minimum wage and 4.8% of immigrants and 3% of natives earn below minimum wage. The minimum wage is defined as the higher of federal and state minimum wage in their study. Given a total number of immigrant workers in 2016 of 27 million (BLS 2017b), we calculate the immigrant workforce in both sectors in equilibrium.

We assume that all immigrants in the covered sector are permanent workers and those in the uncovered sector a sum of permanent and unauthorized workers. This is not to say that no minimum wage workers are unauthorized immigrants. Our argument is that for those with equivalently low skills matching a minimum wage job, employers are likely to pay permanent workers a minimum wage while

to unauthorized workers a subminimum wage. In fact, those unauthorized workers earning at or higher than minimum wage may be well-qualified and have higher skills otherwise. Therefore, we use the equilibrium immigrant covered employment to estimate $E_C^{PR*} = 675{,}000$, and divide immigrant uncovered employment between $E_U^{PR*} = 602{,}000$ and $E_U^{UD*} = 694{,}000$. To obtain the second division, we use another piece of information in Orrenius and Zavodny (2008), that "10% of undocumented immigrants and 3% of documented immigrants are paid less than the minimum wage." These equilibrium employment numbers (with prevailing sectoral wages) are used to solve for production function parameters.

These numbers also show that the immigrant minimum wage sector constitutes a nonnegligible issue for policy makers. While immigrants accounted for about 13% of all workers in the U.S., they made up almost 23% in the covered sector and 19% in the uncovered sector (Orrenius and Zavodny 2008). From a policy-making point of view, low-wage immigrants are a particular concern because of their competition with low wage natives, their possible reliance on social welfare, and their impacts on poverty.

3.4.2 Comparative statics

Table 2 presents combinations of the policy parameters that we examine as comparative statics exercises. p_{dep} and p_{fn} capture both a border enforcement and an interior enforcement. The baseline values are $p_{dep} = 0.045$ and $p_{fn} = 0.0017$. We compare then with a higher deportation rate of $p'_{dep} = 0.06$ and $p'_{fn} = 0.0022$ (row 2). We assume that the probabilities of being captured in a border enforcement and in an interior worksite enforcement increase proportionately (which is a simplifying assumption). Row 3 compares a larger sum of penalty $\mathrm{FN} = 800$ with the baseline $\mathrm{FN}' = 500$. The next parameter is a change in permanent residents' reservation wage from $W_{ST}^{PR} = 5$ to $W_{ST}^{PR\prime} = 4$. This is a case where the government lowers educational or occupational standards for permanent residency. Since permanent residents and unauthorized workers compete in the uncovered sector, this policy could have large effects on the size of unauthorized immigrants.

The last two rows have the same parameters as the baseline case but are evaluated at different minimum wages. This is to show the relationship of response variables Y's along with minimum wage. The Y variables include employment of permanent workers in the covered and uncovered sector, employment of unauthorized workers in the uncovered sector, low wage employment of both immigrants and wage of permanent workers in the uncovered sector.

[Insert Table 2 here]

(1) Effects of deportation increase

Figure 1 shows the shifts in labor market outcomes under an increase in deportation rates. As deportation increases, the direct effect is a reduction in unauthorized labor supply in the uncovered sector. This is likely to drive up the demand for subminimum permanent workers as they substitute for unauthorized workers in the production function. This is confirmed by checking the shift in the wage of permanent workers in the uncovered sector. Since both employment and the wage shift upward, it is a signal that demand for these permanent workers is shifting outward.

Other plots in Figure 1 illustrate the overall effects of stricter deportation. The curve of total permanent workers shifts up, and the share of permanent workers in the covered sector slightly shifts

down. Unauthorized worker employment shifts down. The overall effect of a deportation increase on the total low-wage immigration is downward based on our calibration. Thus, this policy instrument is quite effective.

[Insert Fig 1 here]

(2) Effects of penalty increase

Figure 2 shows the shifts in labor market outcomes under an increase in the penalty for hiring unauthorized workers. The shifting patterns are largely similar to that of Figure 1, only with wider shifting margins. Increasing penalties on unlawful employment is an instrument that raises the expected cost of labor in the uncovered sector. By charging a fine for hiring unauthorized workers, the costs for these workers increase and employers are likely to switch to relatively less expensive lawful permanent workers. That is why we observe higher employment and higher wages for permanent workers in the uncovered sector.

Again, unauthorized worker employment decreases; not because their wage in the uncovered sector increases, but because their expected cost increases in the form of penalties paid to the government. Also, our model only considers unlawful employment of unauthorized aliens but not unlawful payment of subminimum wages to lawful immigrants. One possible reason is that these "semi-legal" transactions can be highly unobservable and reciprocal to both the employer and the employee. Since working in the uncovered sector in the destination country may be more beneficial than working in originating country, these permanent workers may be quite willing to work for less than the minimum wage.

[Insert Fig 2 here]

(3) Effects of relaxation of permanent residency approval

In addition to the two traditional enforcement instruments discussed above, one other policy variable is approval or denial of permanent residency. By easing the requirements for legal status, a larger share of immigrants becomes permanent. This looks similar to the IRCA (Immigration Reform and Control Act) amnesty in 1986, but instead of a universal legalization of unauthorized workers, the policy we examine is based on immigrants' skills and the reservation wage they earn in their originating country. By parameterizing this strategy, we can quantify its effects on labor market outcomes.

Instead of targeting unauthorized immigrants and violating employers, this policy is about lawful immigrants. The idea is that by enlarging the size of permanent residents, the number of unauthorized workers in the uncovered sector may decline because of their competing relationship. More specifically, the U.S. government may recruit from originating countries workers with certain levels of education and skill. Their opportunity cost in their own country may be slightly lower than the current permanent residents' standard, but significantly higher than the level of unauthorized workers. These people could be employed in the uncovered sector with a certified subminimum wage because of their noncitizen status.

Figure 3 shows the story we tell. More immigrants move in and become permanent workers in the uncovered sector. They drive unauthorized workers out of the uncovered sector and keep the wage of permanent workers in the uncovered sector low. The total number of immigrants in the low wage sector

falls and the proportion of permanent workers in the covered sector shifts down considerably. If policy goals are to hold back immigration and minimize its impact on natives, this is a more effective policy than increasing deportation or higher penalties on employers.

[Insert Fig 3 here]

(4) Effects of minimum wage increase

A key value in the theoretical model is the midpoint of the choke price for labor in the covered sector and the reservation wage for permanent residents ($\frac{\alpha_1+W_{ST}^{PR}}{2}$). In the baseline-case simulations, where $\alpha_1 = \$15$ and $W_{ST}^{PR} = \$5$, the midpoint is \$10. In the alternate case where $W_{ST}^{PR\prime} = \$4$, the midpoint is \$9.50. If the minimum wage is less than the midpoint, an increase in the minimum wage causes permanent worker employment in the uncovered sector to increase and unauthorized worker employment to decrease, as illustrated in Figures 1-3. If these are desired policy outcomes, the minimum wage needs to stay less than \$9.50-\$10. When the minimum wage increases beyond the midpoint, the effects on employment and wages are the opposite in sign.

4. Data

4.1 Main data sources

The primary data used in this study are from the 2008 panel of Survey of Income and Program Participation (SIPP). The SIPP provides information on a nationally representative sample of the U.S. population. The 2008 SIPP is a longitudinal survey where sample households are tracked and interviewed every four months for each interview or "wave". Each month about a quarter of the respondent pool are surveyed and asked questions about four months preceding the interview month, i.e. four reference months. The main body of the survey is composed of two parts: the 16 waves of core surveys with exactly the same questions and 13 waves of topical surveys covering different special topics. The core surveys include all dependent variables in this study: the employment status, the wage rates and the working hours. Besides, there are data on individual and household characteristics, taken as control and conditioning variables. The major topical survey used in this analysis is the migration history module contained in the second wave.

The core surveys cover 67 reference months from May 2008 through November 2013 and topical survey wave 2 takes place at the beginning of 2009. Migration questions are asked only about the fourth reference month, maybe because migration behaviors are less frequent and likely to be the same for the four reference months. Thus, we have most of the migration information for the period of December 2008 to March 2009. Regarding the sample size, it is varying for each reference month. Since we merged topical wave 2 to the main dataset to include the migration information and dropped all respondents with IDs not matched, the monthly sample size does not exceed the size of the last reference month of wave 2, which is 98,504. All person-month observations sum up to roughly 4.7 million, with a range of 1 to 64 months of observations per person. We are interested in those with an adult status (age>=15) for all months.

The SIPP fits the data needs because it is the only nationally representative household survey that includes questions about the permanent residency status of noncitizen respondents (Capps et al. 2013). The SIPP migration module includes a couple of questions about the immigration status of noncitizens.

For status upon entry, they ask whether immigrants entered the U.S. with permanent residency (variable *timstat*); for status at time of survey, they ask whether non-permanent residents have adjusted to permanent status (variable *eadjust*), their citizenship status (variable *ecitiznt*), and whether they have adjusted to citizenship through naturalization (variable *enatcitt*). Thus, we have two points of observations in the noncitizens' immigration history, and we can distinguish them into different groups based on their status change.

Most economists believe that for the noncitizen group, it is impossible to precisely distinguish between authorized and unauthorized immigrants because it is difficult to obtain their documentation types from the data (East et al. 2018). Therefore, they use the group of noncitizens with lower education to proxy the unauthorized population, because this group is supposed to capture a large portion of them. However, our theoretical model shows that, within the group of noncitizens, whether having permanent residency matters in the immigrants' labor market outcomes, thus SIPP brings us one step closer. Sociologists, on the other hand, use cross-survey multiple imputation between SIPP (with immigration status information but having smaller sample size) and ACS (lacking immigration status but with large sample size) to estimate the state level estimates of unauthorized population, which validates the use of SIPP in approximating the unauthorized immigrants (Batalova, Hooker, and Capps 2014, Capps et al. 2013).

Supplemented to this data source are monthly state minimum wage rates from Tax Policy Center (TPC 2010) and monthly state labor force participation rates and unemployment rates data from Local Area Unemployment Statistics of Bureau of Labor Statistics (LAUS 2018). The measure of minimum wage we use is the effective minimum wage which is the higher of federal and state minimum wage. The federal minimum wage increased for two times during the early sample period, from $5.85 to $6.55 in July 2008 and to $7.25 in July 2009 and stayed there till the end of 2013. There were more adjustments in the state minimum wage rates and abundant variation within the choice variable. Since Tax Policy Center provides the date on which the state minimum wage level increases yearly, we can derive the monthly minimum wage for each state. For most states, the minimum wage only changes once every year. We further control for state labor market conditions using the not seasonally adjusted data, in accord with the original data in the SIPP.

4.2 Variable description

4.2.1 Outcome variables

We obtain the labor market outcome variables from the 16 waves of core surveys of the SIPP data. The main variables we are interested in are the person-month level employment variable, wage rate variable and working hours variable which are the main concerns of the theoretical model. Although we do not have a model for working hours, its minimum wage effects provide additional information on how market responds to minimum wage increase intensively.

We construct a dummy for employment which equals 1 if the person has a job for an employer. Having self-employment or owning a business is excluded and set to missing, because those who own a business themselves are likely to have different labor market outcomes than employees. Including them into employment may positively bias the effects of minimum wage on employment. The wage rates are those of the employees paid by the hour. We did not include hourly wage calculated by dividing the monthly income, because wages provided by the hour are supposed to be more accurate. For the cases

where they work for more than one job, the weighted average wage with weights in proportionate hours of the two jobs is used. The working hours are the sum of hours for multiple jobs if the employee has more than one job. Varying hours of a job are set to 15, which is a point estimate of mean hours worked per week at the part-time jobs (BLS 2018c).

Figure 4 shows the time trend of rate of low wage sector jobs, defined as less than or equal to 1.5 times minimum wage, over total hourly paid jobs. The low wage sector can further break down into three subsectors: below-, at-, and slightly above minimum wage. It seems that the low wage sector rate increased and then leveled off, and the subsector of below and exactly at minimum wage level stayed stable after the federal minimum wage increase in 2009.

[Insert Fig 4 here]

4.2.2 Choice variable

The policy choice variable minimum wage rates we use in this study are from Tax Policy Center (TPC). There are a few data sources that provide effective minimum wages at yearly intervals, as most states have minimum wage change no more than once a year (see historical minimum wage at WHD 2017). However, since the SIPP data is a person-month panel dataset, it is better if we could match SIPP with monthly data knowing the exact months the state minimum wages update. Thus, TPC data become quite unique in this regard. By observing the minimum wage for the whole survey period and 51 states (including Washington D.C.), we find that except for rare cases (Maine in October and New Hampshire in September), other states modify their state minimum wages in either January or July of a year. This timing pattern leads us to reorganize the monthly minimum wage dataset for descriptive purpose.

It is a challenge to clearly visualize the time-series and cross-sectional dimensions of the state minimum wage panel in one figure (see Political Calculations 2014). The sheer number of states and time periods intimidates the attempt to graphically present them together. We propose a way to divide states according to the number of "minimum wage periods" during which the minimum wage stays flat (see Figure 5). We conduct this graphic exercise by first reducing the time dimension. Instead of having monthly time points, we break the 6-year time series into 12 half-year periods which start in January or July annually, assuming they are the only time points with a step upward in the minimum wage. We then divide the states into four groups, each having different frequency of minimum wage change (or number of "minimum wage periods"). We further combine states with exactly overlapping trajectories. These manipulations make the time trend in each state more discernible.

[Insert Fig 5 here]

4.2.3 Control variables

The main variable of interest in our empirical model is minimum wage rate. In addition to that, we also include a number of control variables. The personal and household demographic variables are mainly taken from the core questionnaire of SIPP, for example, age, race and ethnicity origin (which are fixed), education level, family status (including marriage status and the number of children), language skills (available for those who do not speak English at home), disability, geographic location (metro or nonmetro), citizenship (including naturalization status, from a core survey question available each month) to control for the change of status in months other than that in migration module, and union

membership at work. Note that we treat members of a household as individuals and have not explored their intrahousehold interaction (such as work status of spouse) in this study.

A variable that is also interesting is the time since entry to the U.S., which is generated by taking the difference of survey year and arrival year. Similarly, the time since adjustment to permanent residency is also relevant for some groups. Both time variables are selected from the migration module of SIPP. As we have mentioned, also included are state level monthly variables of labor force participation rate and unemployment rate.

4.2.4 Conditioning/grouping variables

(1) Working age condition

Besides the control variables, there are also important dichotomous or categorical variables which serve as subsetting conditions or grouping categories of the regression. One of such variables is the working age dummy variable. We define working age as between 20 and 59 for all months. We do not consider workers that are young and enter work force after the starting month, or old and leave work force before the last period. They may be of interest if our research question is about youth employment and retirement.

(2) No interstate migration condition

Another conditioning variable is a dummy for migration out of state. We dropped all observations of a person if they have migrated out of their origin state of residence during the survey. This is because we want to minimize the causal effect in the reversal direction, possibly the (un)employment leads to change of state of residence in search of better terms, maybe including lower minimum wage in another state, and thus the relationship between minimum wage and labor market outcomes. It is also possible that migrating immigrants have some unobservable personal traits which help them find jobs in a new state. This may not be an issue in our fixed effects panel data models but may cause the cross-sectional analysis unreliable.

(3) Paid-by-the-hour job condition

By adding the condition of having a paid-by-the-hour job in the reference month, we effectively set the workers to be employed with an hourly wage and working hours greater than zero. By categorizing themselves as hourly-paid workers, respondents need to report a positive hourly wage. Excluded by this condition are those having no jobs, having self-employment, having jobs with annually set salaries, and family workers without pay. Although the omitted job categories are also interesting, their hourly pay rates are set to zero in SIPP, which would bring the issue of dealing with zero wage observations. The distinction between hourly-paid workers and other wage and salary workers is also practiced by Bureau of Labor Statistics in their summary of the statistics of minimum wage workers (see latest version of annual report, BLS 2018). Our calculated percentage of workers with wages at or below the minimum is about 8 percent, which is slightly above the BLS statistics of 5 percent over 2008-2013, because the BLS percentage is compared to the federal minimum wage while our percentage is compared to the higher of federal and state minimum.

(4) Low wage sector condition

In this set of baseline models, we set low wage sector as a condition, which is defined as monthly average wage lower than 1.5 times the monthly minimum wage and greater than zero. This is the wage sector that is most likely to be susceptible to the minimum wage increase. We do not further distinguish between covered and uncovered sectors for the baseline models, different from the theoretical part. For empirical reason, this is to keep the sample size not so small; for conceptual reason, by slightly extending the range, we give minimum wage earners a margin of change in wage when still considered as affected by minimum wage. In most past literature, this zone of effects is as small as the difference between effective minimum wages of two consecutive periods. In our empirical analysis, we attempt to capture the minimum wage effects on the low wage sector, which could be regarded as a sum of the covered sector (with wage exactly at or slightly above the minimum) and the uncovered sector (with wage below minimum). It is reasonable to test for a low wage sector effect in general before treating the two subsectors separately.

(5) Immigrant status grouping

As we mentioned earlier, there are several variables about the immigration history of the workers that can be used to generate different immigrant groups. Although we do not have documentation status of immigrants directly, this segmentation of immigrants could help us narrow down to those with comparable characteristics as unauthorized immigrants. We run regressions separately for each immigrant group, assuming that different groups behave differently and may have effects from explanatory variables of different signs.

The immigrants have two statuses when arrived: permanent residents and nonpermanent residents; the data do not further distinguish between unauthorized immigrants and temporary nonimmigrants. They have three possible statuses several years later when taking the survey: permanent residents, nonpermanent residents, and naturalized citizens. For those transferring into citizenship, they could be obtaining the status through military service instead of naturalization, but we disregard this subgroup for their small sample size.

These two time points for each immigrant allow us to divide all immigrants into five groups: Group 1 (arrived as nonpermanent residents and stayed as-is, or “NPR to NPR”), Group 2 (arrived as nonpermanent residents and adjusted to permanent, or “NPR to PR”), Group 3 (arrived as nonpermanent residents and naturalized, or “NPR to naturalized”), Group 4 (arrived as permanent residents and stayed as-is, or “PR to PR”), and Group 5 (arrived as permanent residents and naturalized, or “PR to naturalized”). The rest of the sample are U.S. citizens (either U.S. born or foreign born and attaining citizenship through parents or born in an U.S. island territory). We do not specifically analyze citizens, because of the large sum of studies already focusing on them and because they are likely to have different characteristics from immigrants.

Table 3 shows the sample size of the five immigrant groups and one citizen group under five incremental conditions. Our empirical work is performed with all five conditions imposed and estimation size does not exceed the size in the last column for each group. We also calculated the proportion of immigrants over total and naturalization rate over immigrants under each condition. The immigrant proportion is largest and the naturalization rate is lowest in the low wage hourly paid group. The sizes of these proportions are supported by previous literature (immigrants proportion: see López, Bialik, and

Radford 2018; BLS 2010; and Capps et al. 2003; naturalization rate see Batalova and Nielsen 2011). This comparison confirms that SIPP data is nationally representative and our counts of each group of the immigrants is quite accurate.

[Insert Table 3 here]

Figure 6 further shows the employment in four wage sectors of the five immigrant groups at person-month level. As one would expect, the largest proportion of higher wages within a group (>1.5*MW) locate in the naturalized groups and largest proportion of lower wages (<=1.5*MW) distribute in the stay-as-is groups. This could be explained by either labor supply or demand for more qualified workers in the naturalized groups, compared with the less qualified workers in the stay-as-is groups. The group of "making-some-progress" or NPR to PR group performs in between the other two categories.

[Insert Fig 6 here]

(6) The dimension of education

It is an unsettled issue whether we should further divide immigrant groups based on their educational attainment. Education, as the source of human capital, is arguably a determining factor of the status of immigrants. Some important literature (e.g. Orrenius and Zavodny 2008) assumes that low-educated immigrants are more likely to be unauthorized and they explicitly estimate minimum wage effects on low-educated immigrants as a group. Before following their path, we conduct some graphic analysis.

Figure 7 shows a wage distribution of immigrants with different statuses and education levels at person-month level. It seems that for groups not yet naturalized, there are disproportionally lower educated immigrants; for naturalized groups, differently educated immigrants have much of overlapping around the minimum wage; and for citizen group, higher educated workers represent larger size within the whole wage distribution. We agree that for group 1 (NPR to NPR), group 2 (NPR to PR) and group 4 (PR to PR), a further subdivision of lower educated immigrants is sensible, which might be the reason why they stayed as-is; but for other immigrant groups, it may be sufficient to regress with the two education levels combined. Note that we have education level (a dummy for higher education) in our fixed-effects models, but it captures within-person instead cross-sectional variation in education. We will conduct exercises with different specifications in the robustness checks.

[Insert Fig 7 here]

4.3 Summary statistics

Table 4 presents the summary statistics for the variables in our empirical analysis, including that for outcome variables (Panel A), control variables (Panel B) and conditioning variables (Panel C). Since the statistics of mean and sample size are based on grouping of immigrant status, the total population is for those in the universe of the migration module, who are greater than 15 years of age in the last reference month of wave 2. The mean for dependent variables shows that, comparing cross-sectionally, those adjusted to permanent residency have highest employment; and those with naturalized status have highest hourly wage, as well as highest working hours.

The control variables also suggest interesting information. For example, the Years in U.S. is shortest for groups stayed-as-is and longest for groups naturalized, indicating that the status change is a process and that immigrants may be on the path towards lawful citizenship although their status has not changed yet. However, other demographic variables indicate that the composition of different immigrant groups may indeed be different, e.g. the variables of whether attaining higher education, of whether speaking English at home, and of racial and ethnic groups. It is shown that the NPR to NPR group has the lowest education level and language integration, they are least represented in non-Hispanic White and most in Hispanics. These characteristics are evidence that there are at least some unauthorized immigrants included in this group.

[Insert Table 4 here]

5. Econometric Models and Preliminary Results (incomplete)

5.1 Baseline models

To identify the effects of minimum wages on labor market outcomes, we utilize the panel data structure of SIPP and start with the following baseline specifications:

For hourly wage and working hours, which are continuous dependent variables, we estimate fixed effects linear models

where

(31) $$Y_{ism} = \beta_0 + \beta_1 lnMW_{sm} + X_{im}\delta + \lambda_i + \mu_m + \varepsilon_{ism}$$

For employment, which is a dummy dependent variable, we estimate fixed effects logit model

where

(32) $$\Pr(Y_{ism} = 1|x) = \frac{\exp(\beta_0+\beta_1 lnMW_{sm}+X_{im}\delta+\lambda_i+\mu_m+\varepsilon_{ism})}{1+\exp(\beta_0+\beta_1 lnMW_{sm}+X_{im}\delta+\lambda_i+\mu_m+\varepsilon_{ism})}$$

Y_{ism} represents the outcome variable of interest for individual i, in state s, in month m; $lnMW_{sm}$ is the natural log of minimum wages at the state level in month m; X_{im} is a vector of control variables at person-month level, λ_i is a set of individual fixed effects and μ_m is a set of monthly fixed effects to capture time-varying macro shocks. ε_{ism} are the standard errors clustered at the state and month level. The coefficient β_1 is the coefficient of interest, which estimates the effects of minimum wages on labor market outcomes.

5.2 Preliminary results

The preliminary results in Table 5 indicate possible analyses to be performed in the next step. Panel A shows that for most immigrant groups (except for NPR to PR), the minimum wage effects on low wage sector employment is positive. The effect is most significant for NPR to NPR and PR to naturalized groups and marginally significant for NPR to naturalized group. The overall positive effect is most consistent with the theoretical effect on total permanent workers' employment in both covered and uncovered sector when minimum wage is not very large, indicating that we are capturing effects on permanent workers mainly. It is interesting to further divide the NPR to NPR group by minimum wage sector, education, race/ethnicity, etc., in order to isolate the effects on unauthorized immigrants.

Panel B shows that the hourly wage for all immigrant groups, as well as the all workers group, increases with the minimum wage. This could be an indicator that the data are mostly capturing the covered sector wage change, which might extend to the uncovered sector. This hypothesis leads us to further segment low wage workers into below minimum and at or slightly above minimum wage sectors, in order to split the sectoral effects and reveal the underlying mechanisms.

Panel C shows that the working hours effects are almost nonexistent except for the NPR to naturalized group. This is to be expected since we are focusing on hourly-paid workers. Compared with salaried workers who are paid a certain sum for whatever hours they work, hourly-paid workers receive more payment when they work more hours. Thus, increasing working hours and having additional employment are likely to be substitutes. Since almost all groups experience higher employment, a lack of change in working hours is reasonable.

[Insert Table 5 here]

6. Conclusion

Immigrants have become an important component of the U.S. labor force, accounting for more than 10% of the U.S. population for more than a decade. Among the U.S. foreign-born population, about a quarter were unauthorized immigrants in 2016 (López, Bialik, and Radford 2018). Immigrant workers are inevitably exposed to U.S. labor policies such as the minimum wage laws. However, despite the large volume of studies on effects of the minimum wage, very few have examined effects on immigrants, especially unauthorized ones.

This study develops a theoretical framework and provides empirical evidence on the effects of the minimum wage on labor market outcomes for immigrant workers. In the theoretical model, one sector in the destination country for immigrants is covered by the minimum wage, while the other (illegal) sector is uncovered by the minimum wage. The model shows that as long as the minimum wage is not too high (below the midpoint of the choke price for labor in the covered sector and the reservation wage for permanent residents), an increase in the minimum wage will increase employment of permanent workers and decrease employment of unauthorized workers. However, when the minimum wage increases beyond this midpoint, the effects on employment are the opposite in sign. Simulation analyses using the theoretical model suggest that this midpoint is in the range of $9.50-$10/hour.

In our preliminary empirical exploration, we find evidence mainly for increased employment for permanent workers and an increased wage rate in the covered sector in response to a rise in the minimum wage. In order to find effects of the minimum wage based on immigrant status, we divided immigrants into five different groups based on their immigration history. Four of the five immigrant groups are associated with permanent residents (either adjusting from or into or via permanent residency). In future work, we will focus on the non-permanent resident group (NPR to NPR) and try to identify unauthorized workers by lack of permanent residency combined with other demographic characteristics. This direction will hopefully help us to more robustly test the hypotheses coming out of the theoretical model.

There are important implications for both minimum wage and immigration policies from this study. Changes in the minimum wage can have unintended consequences for immigration. A moderate increase in the federal minimum wage to, say, $9.50/hour, could actually reduce employment of

unauthorized workers. However, a higher minimum wage of $12/hour or $15/hour could significantly increase employment of unauthorized workers in the uncovered sector. Similarly, changes in immigration policy can have unforeseen impacts on the effectiveness of the minimum wage. An increase in the deportation rate or in the fine for employing unauthorized workers, while reducing employment of unauthorized workers, could also increase employment of permanent residents in the uncovered sector. Therefore, our study shows that policy makers should consider interactive effects when designing and implementing minimum wage and immigration policies.

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Table 1. Calibration of exogenous variables

Exogenous variable	Definition	Baseline case (2016 estimate)	Alternative value	Data source
Reservation wage for PR (W_{ST}^{PR})	Mexico nominal hourly USD wage in manufacturing or for high skilled	5	4	Trading Economics (2018b)
Reservation wage for UD (W_{ST}^{UD})	Mexico minimum hourly USD wage	0.5		Trading Economics (2018a)
Border deportation rate (p_{dep})	Deported UD Mexican immigrants/estimated total UD Mexican immigrants	0.045	0.06	Gonzalez-Barrera and Krogstad (2018)
Unauthorized employment capture rate (p_{fn})	Deported non-criminal immigrants/total employment (nonfarm and farming) in 2014	0.0017	0.0022	Gonzalez-Barrera and Krogstad (2016), BLS (2018)
Violation penalty (FN)	Penalty in USD for unlawful employment of aliens, first order (per unauthorized alien)	500	800	DOJ (2017)
Lawful subminimum wage (W_{sub})	Lawful wage for special workers in the uncovered sector	4.25		DOL (2018)
Lawful uncovered rate (p_{legl})	Lawful uncovered employment as fraction of total uncovered employment	0.1		WHD (2018), BLS (2017)
Efficiency coefficient (β)	An immigrant is endowed with β efficiency units of labor	0.8		Assumption
Max wage in the covered sector (α_1)	Upper limit of U.S. minimum wage in the covered sector	15		Assumption
Production function parameter (α_2)	Parameter for quadratic production function $f_C(\cdot)$	1.15E-05		Authors' calculation
Max PR wage in the uncovered sector (β_1)	Upper limit of PR wage in the uncovered sector	7		Authors' calculation
Production function parameter (β_2)	Parameter for quadratic production function $g_U(\cdot)$	4.56E-06		Authors' calculation

Table 2. Response variables shift with policy variables and move along with explanatory variable

	Policy Parameters				X	Y(X; parameters)				
	p_{dep}	p_{fn}	FN	W_{ST}^{PR}	W_m	E_C^{PR}	E_U^{PR}	E_U^{UD}	E_{CU}^{IMM}	W_U^{PR}
(1)	0.045	0.0017	500	5	7.25	6.74E+05	5.09E+05	8.12E+05	1.99E+06	2.02
(2)	0.06	0.0022	500	5	7.25	6.74E+05	5.59E+05	6.60E+05	1.89E+06	2.29
(3)	0.045	0.0017	800	5	7.25	6.74E+05	6.17E+05	5.01E+05	1.79E+06	2.54
(4)	0.045	0.0017	500	4	7.25	6.74E+05	9.93E+05	2.06E+05	1.87E+06	1.80
(5)	0.045	0.0017	500	5	8	6.09E+05	6.04E+05	6.93E+05	1.91E+06	1.98
(6)	0.045	0.0017	500	5	13	1.74E+05	4.70E+05	8.61E+05	1.50E+06	2.04

Table 3. Sample size of person-months and immigrant distribution under different conditions

Immigrant Group	Adding Conditions				
	Age>=15	+ Working Age	+No Migration	+Hourly Paid	+Low Wage
NPR to NPR	76,143	69,235	66,162	29,429	19,909
NPR to PR	41,980	36,009	34,072	13,859	7,311
NPR to Naturalized	76,591	52,659	51,612	17,591	6,714
PR to PR	130,885	105,338	100,880	42,252	24,907
PR to Naturalized	157,381	101,110	97,180	36,039	13,437
Citizen	3,227,527	2,084,192	1,965,385	751,919	280,041
Total	3,710,507	2,448,543	2,315,291	891,089	352,319
Immigrants%	13%	15%	15%	16%	21%
Naturalized%	48%	42%	43%	39%	28%

Table 4. Summary statistics for different immigrant groups

	NPR to NPR	NPR to PR	NPR to Naturalized	PR to PR	PR to Naturalized	Citizens	Total
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Outcome Variables							
Employment							
Mean	0.63	0.67	0.61	0.60	0.59	0.58	0.58
N	71,343	38,233	70,523	122,610	144,187	3,021,881	3,468,777
Average Wage							
Mean	10.86	12.55	14.94	11.80	14.96	14.46	14.24
N	31,762	15,541	20,781	48,628	43,857	966,398	1,126,967
Working Hours							
Mean	35.87	37.26	37.35	35.88	37.29	36.75	36.74
N	44,805	25,528	43,161	73,358	84,420	1,744,266	2,015,538
Panel B: Control Variables							
Age							
Mean	35.66	43.21	51.07	42.24	52.57	48.04	47.78
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Higher Education							
Mean	0.30	0.47	0.62	0.39	0.58	0.61	0.59
N	76,143	41,980	76,591	130,885	157,381	3,227,527	3,710,507
Speak English at Home							
Mean	0.16	0.19	0.31	0.22	0.37	0.93	0.84
N	76,417	41,984	76,667	130,949	157,425	3,229,826	3,713,268
Married							
Mean	0.58	0.66	0.65	0.62	0.65	0.53	0.55
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Divorced							
Mean	0.04	0.06	0.10	0.06	0.09	0.11	0.11
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Single							
Mean	0.34	0.21	0.15	0.25	0.15	0.26	0.26
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Number of Kids							
Mean	1.11	0.98	0.70	1.01	0.60	0.58	0.61
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Disabled							
Mean	0.05	0.08	0.09	0.08	0.10	0.15	0.14
N	75,208	40,094	64,752	122,546	130,472	2,762,956	3,196,028
Metro Area							
Mean	0.91	0.95	0.94	0.89	0.94	0.78	0.80
N	73,590	39,315	73,508	124,438	150,008	3,092,705	3,553,564
Naturalized							
Mean	0.01	0.03	1.00	0.03	1.00	0.59	0.50
N	76,149	41,840	76,711	130,513	157,350	261	482,824

Union Membership							
Mean	0.03	0.06	0.08	0.04	0.08	0.07	0.07
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Years in U.S.							
Mean	11.05	16.26	20.22	13.93	22.67	19.89	17.67
N	76,453	41,984	76,711	130,953	157,429	32,679	516,209
Male (Fixed Effect)							
Mean	0.51	0.47	0.48	0.46	0.44	0.47	0.47
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Non-Hispanic White (Fixed Effect)							
Mean	0.15	0.24	0.33	0.23	0.33	0.77	0.70
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Hispanic (Fixed Effect)							
Mean	0.64	0.46	0.30	0.45	0.24	0.07	0.11
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Panel C: Conditioning Variables							
Working Age							
Mean	0.91	0.86	0.69	0.80	0.64	0.65	0.66
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Interstate Migration							
Mean	0.14	0.13	0.05	0.15	0.10	0.15	0.14
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Paid-by-Hour							
Mean	0.42	0.37	0.27	0.37	0.28	0.30	0.30
N	76,453	41,984	76,711	130,953	157,429	3,230,006	3,713,536
Low Wage Sector							
Mean	0.68	0.56	0.40	0.60	0.38	0.41	0.43
N	31,762	15,541	20,781	48,628	43,857	966,398	1,126,967

Table 5. Preliminary results from baseline individual fixed effects models

Panel A: Employment						
Explanatory Variables	All Immigrants and Citizens	NPR to NPR	NPR to PR	NPR to Naturalized	PR to PR	PR to Naturalized
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log MW	4.1767***	6.5281***	-1.5304	3.4831†	2.1052*	6.7100***
	(8.3119)	(6.8313)	(-0.8308)	(1.9577)	(2.5106)	(5.3128)
Individual FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Control Vars	Y	Y	Y	Y	Y	Y
No. of person-months	51,889	14,077	4,982	4,978	18,541	9,283
No. of persons	1,460	389	134	147	520	268

Panel B: Hourly Wages						
Explanatory Variables	All Immigrants and Citizens	NPR to NPR	NPR to PR	NPR to Naturalized	PR to PR	PR to Naturalized
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log MW	0.3368***	0.2884**	0.6823***	0.4397**	0.2322*	0.3136*
	(5.6201)	(2.5977)	(4.5206)	(2.7566)	(2.0475)	(2.3732)
Individual FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Control Vars	Y	Y	Y	Y	Y	Y
No. of person-months	68,810	19,206	7,034	6,406	23,463	12,685
No. of persons	3,056	822	291	314	1,040	585

Panel C: Working Hours						
Explanatory Variables	All Immigrants and Citizens	NPR to NPR	NPR to PR	NPR to Naturalized	PR to PR	PR to Naturalized
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log MW	0.1612	0.1776	-0.5194	1.4954**	0.2563	-0.3886
	(0.9770)	(0.5381)	(-1.2455)	(3.3167)	(0.9055)	(-1.0225)
Individual FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Control Vars	Y	Y	Y	Y	Y	Y
No. of person-months	68,810	19,206	7,034	6,406	23,463	12,685
No. of persons	3,056	822	291	314	1,040	585

Note: † p≤0.10, * p≤0.05, ** p≤0.01, *** p≤0.001; t statistics are in parentheses.

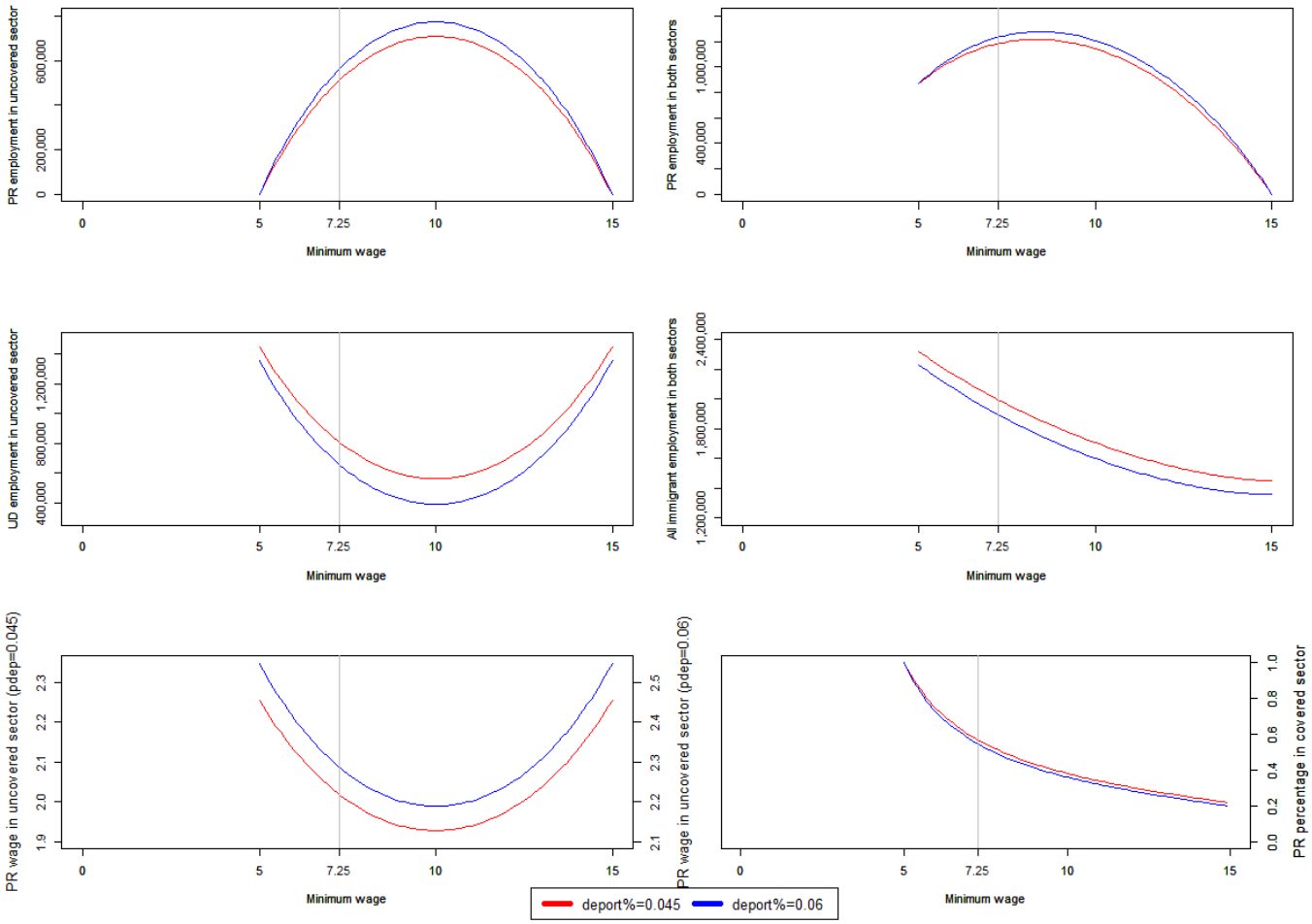

Fig 1. Immigrant labor market outcomes with deportation rates shifters

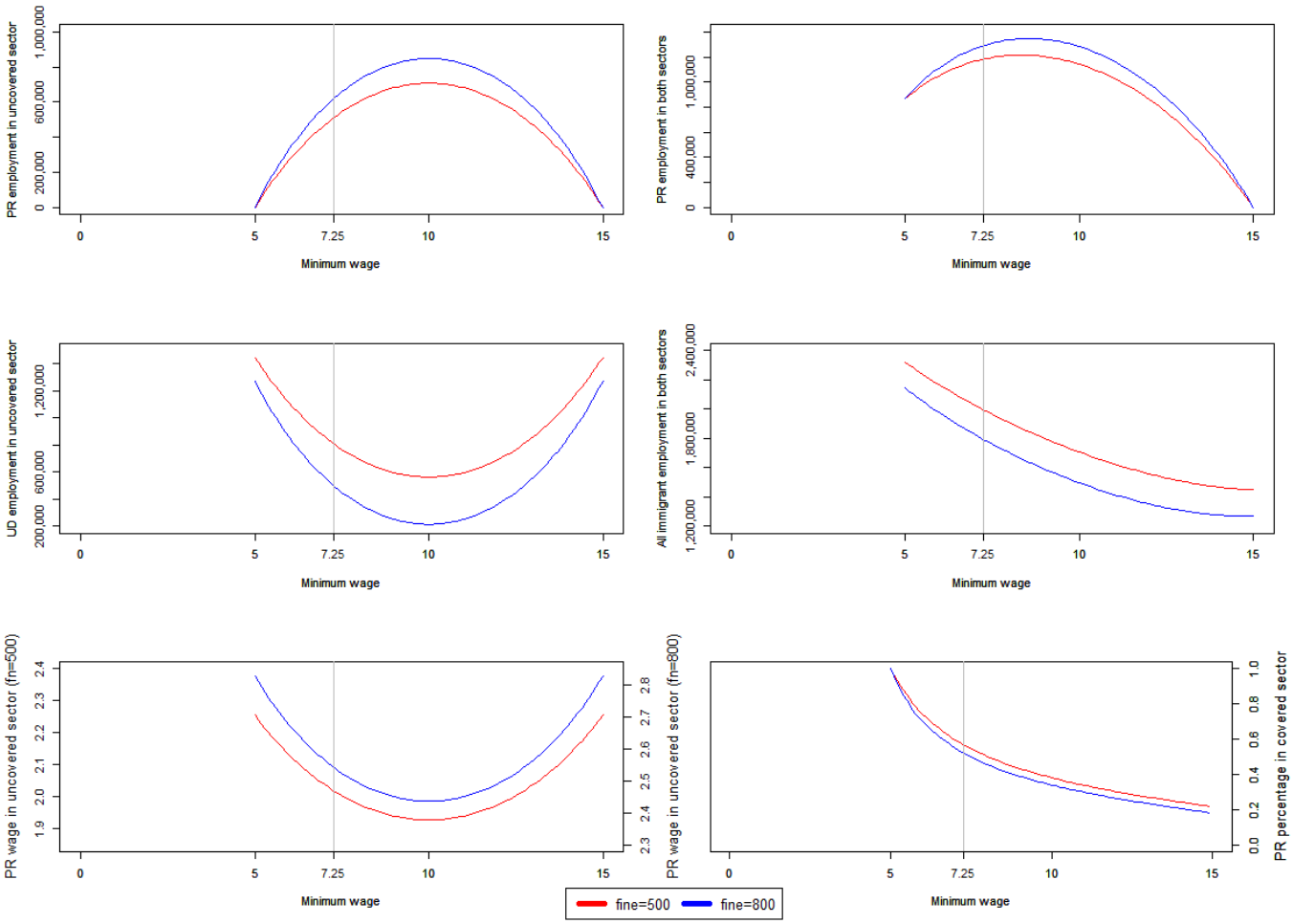

Fig 2. Immigrant labor market outcomes with penalty shifters

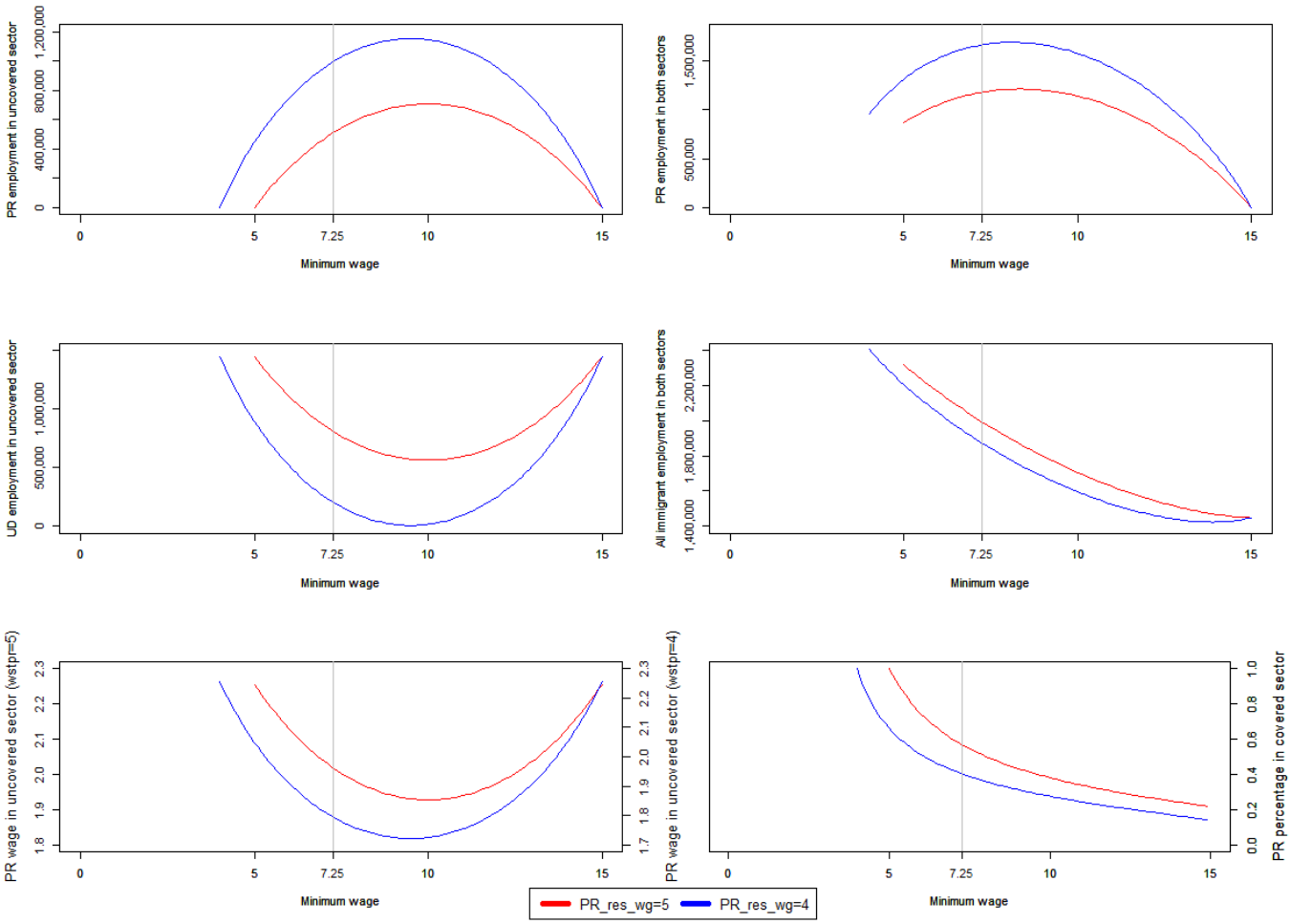

Fig 3. Immigrant labor market outcomes with permanent worker reservation wage shifters

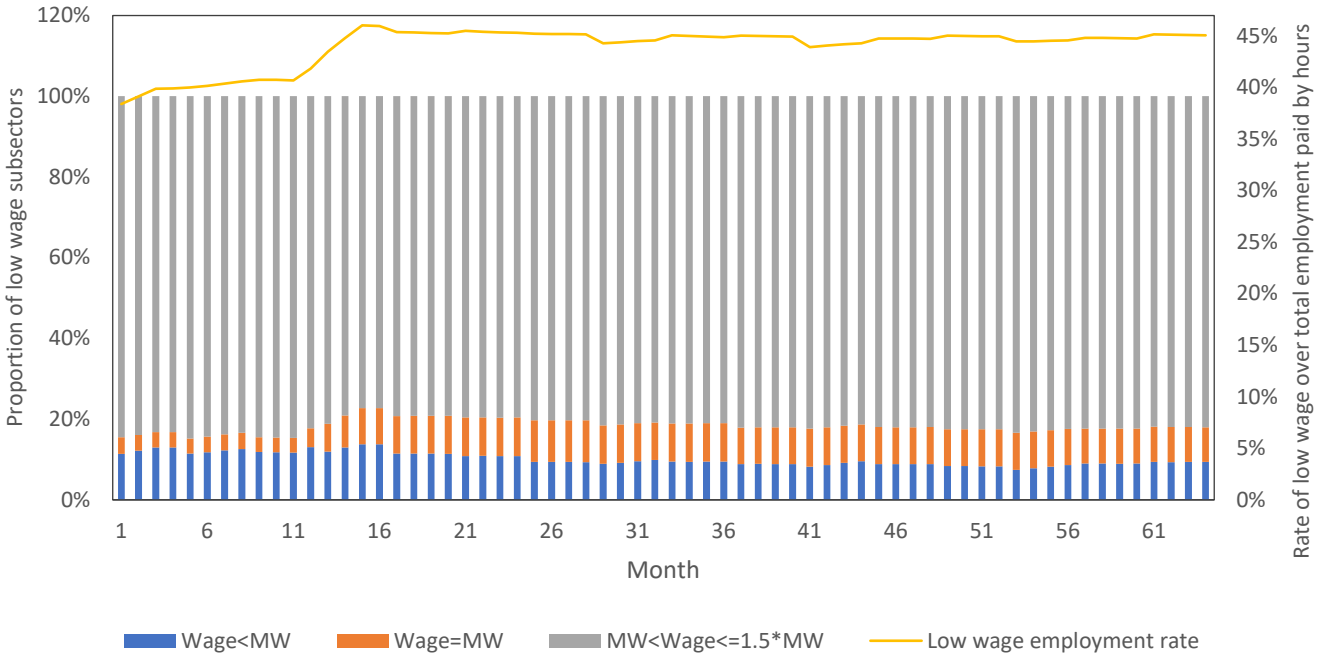

Fig 4. Monthly proportion of low wage subsectors and rate of low wage sector employment in hourly paid jobs

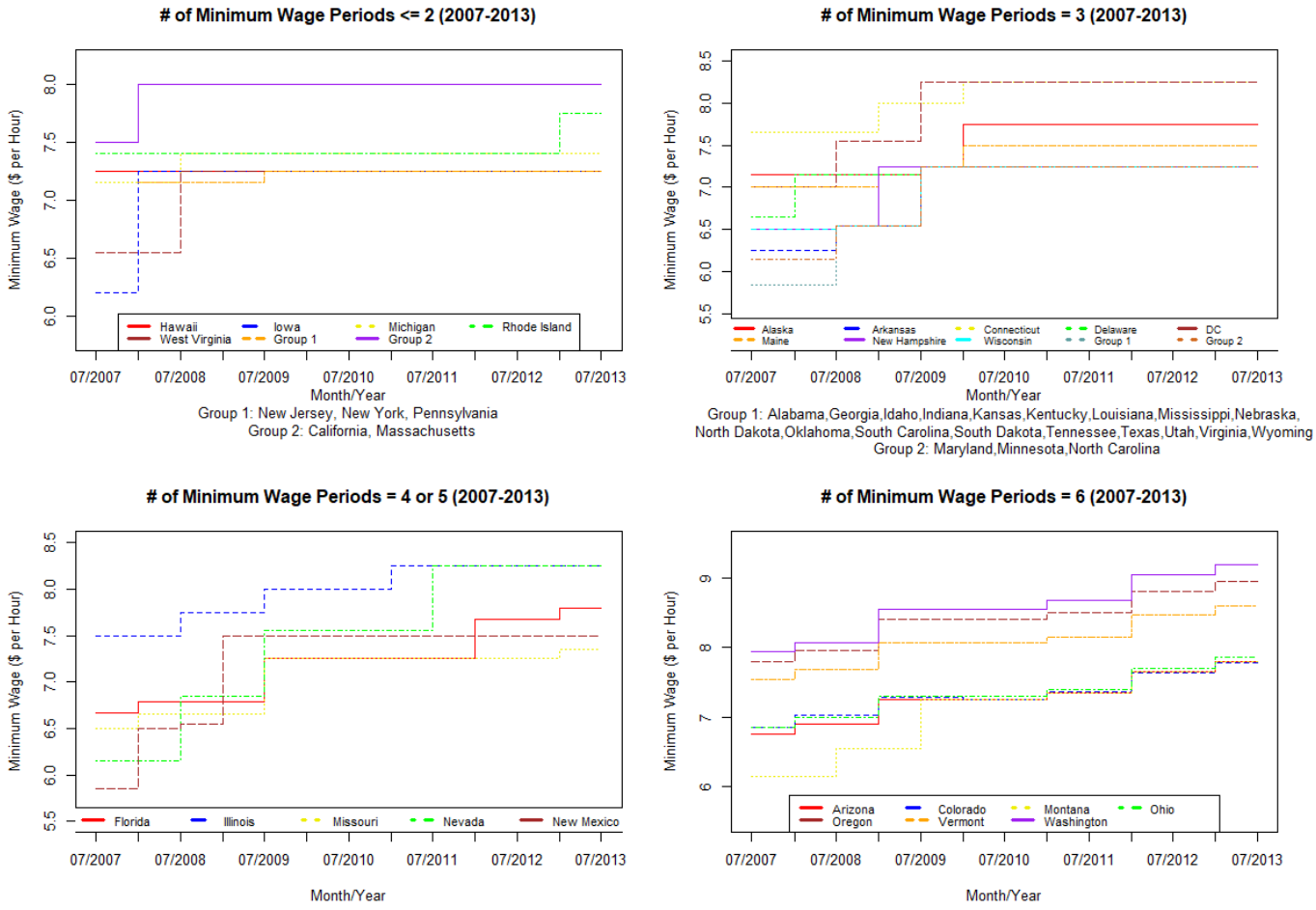

Fig 5. Minimum wage change periods for U.S. states

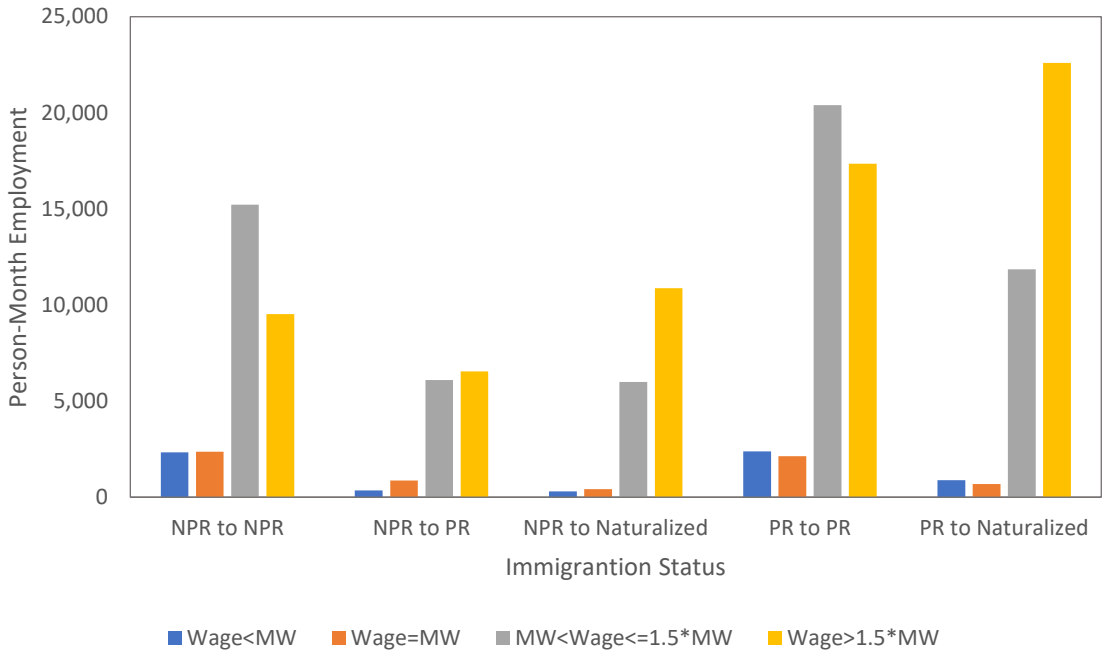

Fig 6. Person-month employment of immigrants of different statuses and wage sectors in hourly paid jobs

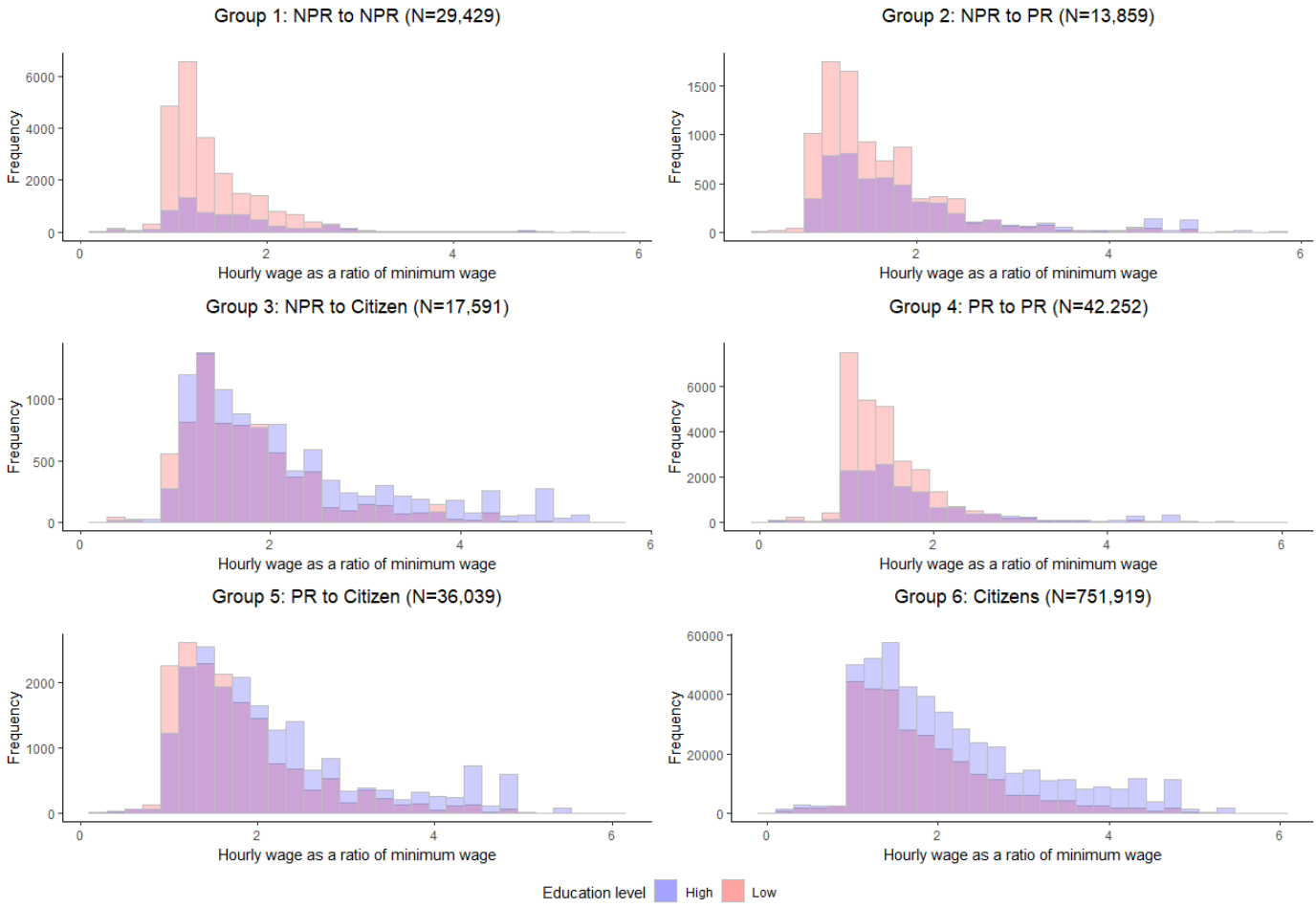

Fig 7. Wage ratio distribution for immigrants of different immigrant groups and education levels in hourly paid jobs