Minimum Wage, Informality, and Non-Compliance

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Abstract: *This paper develops an equilibrium wage-posting model that provides a coherent theoretical prediction of the effect of minimum wage on the labor market structure. The model incorporates labor market features commonly found in developing countries such as (i) monopsonistic competition among firms, (ii) firms that decide whether or not to comply with the minimum wage law, and (iii) heterogeneity of firm and worker productivity in the formal and informal sectors. Using historical minimum wage changes in Indonesia during 2000~2014, this paper empirically confirms the predictions of the equilibrium wage-posting model. An increase in the minimum wage induces (i) no reduction in formal sector employment, (ii) an increase in formal sector wages, (iii) reduced economic rents for monopsonistic employers, and (iv) an increase in the number of formal sector firms that do not comply with the minimum wage regulation.*

Key Words: Minimum Wage, Informality, Non-compliance, Monopsony
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I. Introduction

How does minimum wage affect the labor market in developing countries? Many policymakers are interested in this question as the minimum wage policy has been the single most widely implemented labor protection measure in developing countries. Though development and labor economists have examined this topic extensively, the literature has yet to reach an agreement, because the effect of the law is dependent on the institutional structure of the countries. In particular, certain features common to developing countries, such as a high proportion of informal sector economic activity [3], the imperfection in the formal sector labor market such as non-compliant behavior of firms to labor protection regulations or monopsony behavior, add complications for analysis. The existing literature on the minimum wage focuses on its effect on one or another aspect of labor market outcomes but often fails to show its overall impact on the structure of the labor market. Both theoretical and empirical study is much needed to provide a more comprehensive understanding of minimum wage regulation and to evaluate its impact on the overall labor market accurately.

In this paper, we use the historical minimum wage hike in Indonesia between 2000 and 2014 to theoretically and empirically investigate the effect of the law on labor market structure. Indonesia is an ideal case study for this research question as there has been a considerable variation in minimum wage levels across provinces and/or districts and also overtime. Besides, exceptionally high-quality panel data, Indonesian Family Life Survey (IFLS henceforth) and Industry Survey (IS henceforth), allows us to examine the characteristics of existing formal and informal sector labor markets, which determine the effect of minimum wage regulation.

To this end, we start our analysis by detailing and explaining the informal and formal sector labor market characteristics in Indonesia. Our examination of the informal sector labor market shows significant income heterogeneity among informal sector workers, of whom a sizable propor-

[3] Informal economic activity refers to a business that is not legally registered with the government. These are primarily small, household-run businesses that often lag in productivity behind formal firms, which are legally registered.

tion earn more than formal sector wage earners. This feature of the informal sector labor market implies that some informal sector workers may choose to work there voluntarily, while others are rationed out of the formal sector. Regarding the formal sector labor market, our analysis documents that formal sector labor market is mostly imperfect in that (i) majority workers found jobs through their connections such as family and friends, (ii) payment to workers are often less than minimum wage, and (iii) a significant gap is found between the average values of labor productivity and wages. These facts on informal and formal sectors of the economy imply that an properly set minimum wage may increase formal sector employment as a result of informal sector workers transitioning to the formal sector as wage earners (Card and Krueger, 1994).

Other developing countries generally share similar underlying features of the Indonesian labor market, which motivates us to construct a coherent structural model that reflects features of labor market structure in a unified way. Though there have been critical theoretical works that attempt to unify various aspects of labor markets in developing countries, our model is unique in that it allows for heterogeneity in firms' productivity, workers' reservation wages, and firms' choice on non-compliance within the Burdett and Mortensen framework (1998; henceforth the BM model). By accounting for these heterogeneities, our model captures employees' and companies' sorting behaviour in response to minimum wage increases as the mechanism of the formalization. Our structural model suggests plausible mechanisms under which a minimum wage hike can (i) positively affect the whole wage distribution, (ii) increase (or decrease) formal sector employment, (iii) decrease economic rents for monopsonistic firms, and (iv) increase non-compliant behavior of firms with minimum wage laws.

In the third step of the investigation, we conduct a regression analysis to test the validity of the proposed model. Using local minimum wages in Indonesia that changed annually during 2000 - 2014 and a sample of working individuals and manufacturing plants, we implement an econometric method that exploits variation in the minimum wage between geographically proximate districts. By focusing on geographically proximate districts that have similar local market conditions but are subject to different minimum wage levels, we circumvent the potential endogeneity concern that minimum wage changes correlate with changes in local economic conditions. Our findings indicate that a minimum wage hike leads to (i) no reduction in formal sector employment, (ii) increases in the wages earned by formal sector workers (increase in the average wage payment by manufacturing plants), (iii) the reduction of economic rents for manufacturing firms, and (iv) increases in the non-compliance of minimum wage law.

Our work contributes to two strands of the literature. First, it contributes to the body of research devoted to modelling the characteristics of emerging economies' labor markets. Our model extends the framework of Burdett and Mortensen (1998, henceforth the BM model) by incorporating informal sector economic activity and firm's non-compliance behavior into existing labor market regulation. While numerous authors have adapted the Burdett and Mortensen model to examine labor markets in developed economies (see Cahuc et al., 2006; van den Berg et al., 1998; Postel-Vinay and Robin, 2002; Jolivet et al., 2006; Engbom and Moser, 2018), few have included non-compliance and the informal sector economy in the model. Informality and non-compliance are prevalent phenomena in developing countries, and incorporating them is particularly relevant to our understanding of the effect of various labor market regulations.[4]

There are a few exception that extended BM model to include both informal economy and non-compliance. Among them, Meghir et al. (2015) introduce a firm's endogenous choice between the formal sector and informal sector economic activity. Though the model encompasses different views of informal sector economy by allowing heterogeneity in firm productivity, their model is conceived with the economies of Latin America in mind where informal sector firms are either (i) productive enough to survive in the formal sector but choose to remain informal to avoid tax and other labor marker regulations or (ii) not competitive enough to operate in the formal sector, since regulatory costs are too high for them. With this viewpoint of informality, their model portrays that formalization occurs as a result of firms' registration decisions. Our model differs

[4]For the model that models firms' non-compliance with minimum wage regulation in the U.S. economy, look Eckstein et al (2011).

from Meghir et al. (2015) in that it emphasizes employment status transfers between informal sector self-employment and wage-earning occupations as a formalization mechanism. To put it another way, our model does not allow informal sector entrepreneurs to formally register and operate in the formal sector; instead, it merely permits them to shut their businesses and work as wage earners in the formal sector. Our modelling assumption comes from our household level data analysis, which is also consistent with empirical findings of Rothenberg et al. (2016). They find the persistence of informal sector businesses that do not formally register despite the availability of a business registration program. This perspective on the informal sector economy is in line with La Porta and Shleifer (2014), and portrays the informal economies of Asian countries.

Other works, following the literature on industrial organization, model the non-compliance behavior of formally registered businesses. For example, Ulyssea (2018) models firms' decisions on formal sector registration and their response to existing labor market legislation. Basu et al. (2010) also incorporate into their model the imperfect compliance of a firm with labor regulations. However, models based on the industrial organization literature generally do not contain a mechanism that explains the movement of the entire wage distribution (both compliant and non-compliant wage) along with minimum wage, which is widely documented in developing countries (Cunningham, 2007). Including non-compliant mechanism behavior of the firms in the framework of BM is especially rewarding as it allows for the movement of wage distribution along with the minimum wage setting.

Another approach has extended Mortensen and Pissarides' (1994, henceforth the MP model) model from a macroeconomic standpoint. For instance, Zenou (2008) describes a model in which formal and informal labor markets coexist and the formal sector faces search friction. The model emphasizes the influence of search friction and other legal enforcement on the establishment of the informal sector economy. Another example is Albrecht et al. (2009). They assume formal sector search friction and continuous worker heterogeneity in the MP framework, which enables them to conduct a full distributional analysis of labor market policy effects. They calibrate their model to reflect crucial facts in several major Latin American economies and then simulate the influence of payroll taxes and severance compensation on informality. Compare to models that extend MP model, the advantage of the extending BM model is that it explicitly assumes firms with market power in the employment of workers. The idea that employers have significant market power over workers, called monopsony power, has gotten increasing academic interest in recent years where the analysis mostly focuses on the developed economy. However, worker exploitation is a considerably more serious issue in emerging economies, where fewer firms compete for workers and search frictions are high. When competent informal sector workers prefer to stay in the informal sector as a result of their cost-benefit analysis (Radchenko 2014), enterprises' monopsonistic activity influences workers' sorting behaviour between the formal and informal sectors. By extending the BM model to include workers with heterogenous remuneration in the informal sector, our model demonstrates how informal sector workers respond to increased minimum wages by sorting into the formal sector, while productive firms continue to profit (albeit at a reduced rate) from hiring an increased number of workers at a higher wage.

Second, our study on the effect of the minimum wage complements a long-standing debate on how minimum wages affect labor market outcomes. There are voluminous studies analyzing the impact of the minimum wage on employment in developing countries (Gindling and Terrell (2007) for Costa Rica; Alaniz et al. (2011) for the case of Nicaragua; Lemos (2007) for Brazil; Dinkelman and Ranchhod (2012) for South Africa). This literature generally agrees that minimum wage policies increase wages while decreasing or having no effect on formal sector employment. For the case of Indonesia, previous empirical evidence gives a consistent answer about wages but no general agreement on employment (see Rama, 2001; Del Carpio et al., 2015; Harrison and Scorse, 2010; Alatas and Cameron, 2008; Comola and de Mello, 2011; Magruder, 2013). We contributes to the existing empirical literature in that we further provide evidence for the effect of minimum wage on employment, on wages for different groups of workers, on non-compliance, and also on profit margin by hiring workers, measured by various monopsony indices. To date, the empirical literature that studies the effect of minimum wage on economic rents for employers is rare, and our empirical results provide evidence that further research in this direction is valuable.

Outline. The paper proceeds as follows. Section 2 introduces the Indonesian labor market—both formal and informal sector, and minimum wage regulation. In Sector 3, we construct an equilibrium search model that contains features of formal and informal labor markets documented in Section 2. Section 4 is devoted to confirming the prediction of the model empirically: we introduce our identification strategy and regression results. Section 5 concludes.

2. Facts about Indonesian Labor Market

The effect of minimum wage law on the labor market critically hinges on the size and characteristics of the informal and formal sector labor market. Depending on the features of the existing labor market, the effect of minimum wage regulation varies in different directions. For instance, if the informal sector labor market serves as the last resort to unemployment (Fields, 2005; Harris and Todaro, 1970), an increase in the minimum wage would not have any effect on labor supply in the formal sector labor market. On the other hand, if the majority of workers in the informal sector remain there as a result of their cost-benefit analysis, a raise in the minimum wage may provide an additional incentive to work in the formal sector, resulting in an increase in formal-sector labor supply. The structure of the formal-sector labor market also plays a crucial role in the effect of a minimum wage. If the labor market in the formal sector is mostly characterized as monopsonistic, then an increase in the minimum wage may decrease the share of economic rents for an employer without decreasing labor demand. On the other hand, if the labor market is competitive, the increase in minimum wage only reduces labor demand. As such, understanding the effect of minimum wage requires us to expound underlying labor market features, through which minimum wage increase influences the structure of the labor market. This section is devoted to explaining the characteristics of the Indonesian labor market. We first document the informal and formal sector labor markets using IFLS and IS data, respectively, and then detail Indonesia's minimum wage policy, which is critical for our regression analysis.

2.1. Data and definitions

We use two data sets for the analysis of the Indonesian labor market during 2000 - 2014. The first data set consists of three separate surveys conducted by the Indonesian Family Life Survey (IFLS) in 2000, 2007, and 2014 ("Wave 3," "Wave 4," and "Wave 5"). The IFLS covers 83 percent of the total population living in 13 out of the 27 provinces, primarily on the west side of the country. IFLS contains rich individual-level information, which allows us to construct individual-level panel data, and also has various individual-level information that can be used as controls in the regression analyses. The sample we use for the analysis is comprised of the working population, ages between 15 and 64 years, during the period from 2000 to 2014. This leaves us with 58,717 valid observations. As income related variables, household asset values, and working hours are cleared measured with error, we winsorize 1 percent in both sides of the tails for each year.

Indonesia's National Statistics Agency (Badan Pusat Statistik, BPS) identifies enterprises as legal entities if they are registered with the Ministry of Manpower. Unfortunately, the IFLS data do not include identifiers for the legal classification of labor, and we thus designate wage earners in the private or public sectors as formal sector workers, in accordance with previous literature. We regard self-employment, casual workers and unpaid family workers as informal sector workers. Though the definition of formal sector employment is incomplete in that we do not know whether wage earners work for foramlly registered firms, it is reasonable to assume that self-employed workers, casual workers, and unpaid family workers are all informal sector workers, as identified directly by the IFLS survey.[5]

We supplement the IFLS data with the annual Indonesian manufacturing survey (IS), which

[5] ADB Report (2010) documents 95 percent of self-employed workers as informal sector workers and 98 percent of casual workers and unpaid family workers as informally hired, which we can directly identify from the IFLS survey.

has been collected and compiled by BPS. The completion of this survey is required by law for companies with more than 20 employees. The IS data contains detailed information on a wide range of plant-level characteristics, allowing us to investigate formal sector economic activity in greater depth. Specifically, IS data includes an information on the number of workers and wages paid for production and non-production employments, total capital stock, investment, total materials and fuels purchased, and total revenues. These information will subsequently be used to calculate monopsony indices, which are discussed in Section 2.3. The shortcoming of IS data is that it only displays employment in manufacturing, which is not reflective of overall formal sector employment. The IS data ranges from 2000 to 2009 with 218,632 observations where we winsorize outcome and control variables at 1 percent of each table. Our variable construction is outlined in full in Appendix A.

2.2. Heterogeneity in the informal sector labor market

The literature on informality is vast and diverse, with many controversies over the mechanism driving informal sector economic activities in developing countries. For instance, Harris and Todaro (1970) and Fields (2005) regard informal sector employment as a predominantly involuntary engagement of workers who are not capable of finding jobs in the formal sector. With the same view on informality, La Porta and Shleifer (2014) argue that the informal business sector in developing countries is too small to ever register and operate in the formal sector. In contrast to these views, Maloney (1999, 2004) observes that informal sector workers rationally opted into the informal sector labor market for higher income. De Soto (1989) argues that potentially productive informal firms can formalize and survive once the government removes the high cost of formal registration. Our IFLS data suggests that Indonesia's informal sector does not fit neatly into a single category. For example, IFLS data shows that there is a rare movement between employers with permanent employees and employers with family workers, which is consistent with Rothenberg et al. (2016), who show the persistence of informal sector businesses that do not formally register despite the existence of a business registration programme. In this regard, the informal sector in Indonesia appears to support La Porta and Shleifer's argument (2014). However, according to IFLS data, a large number of informal sector firm owners earn higher income than formal sector employees. This leads us to infer that some informal sector business owners prefer to run their own businesses rather than work as wage earners in the formal sector.

Table 1 provides information on individuals who work in the formal and informal sectors from IFLS data. We observe that the majority of workers (60 percent) are involved in informal sector employment, and are typically employed in businesses with less than five employees. Their education attainment is lower than that of formal sector employees, implying that informal sector workers are generally less productive than formal sector wage earners. However, we also see substantial overlap between the informal and formal sectors, although within coarsely defined occupation data, which suggests that some individuals may opt to change their employment status in response to market conditions.

Figure 1 further indicates heterogeneity within the informal labor sector. The graph illustrates the ratio of formal versus informal workers by income decile. Whereas informal sector workers constitute 78 percent of the lowest income decile, we still observe 30 percent of the individuals in the top income decile working in the informal sector. This feature suggests that even though overall characteristics of informal sector economy in Indonesia aligns with the viewpoint of La Porta and Shleifer (2014), there is still sufficient heterogeneity among informal sector laborers to support the argument that a sizable portion of informal sector workers choose to remain in the informal sector economy out of their cost-benefit analysis.

2.3. Labor market imperfection in the formal sector

The empirical literature on labor markets in the developing countries finds that the formal sector labor market is often imperfect due to information friction, monopsony, and incomplete governmental monitoring (Bhaskar et al. (2002), Manning (2003)). Indonesia's labor market shares many of the characteristics addressed in the literature. We use IFLS and IS data to highlight several characteristics of labor market imperfection below.

Two recent sets of IFLS data (IFLS 4 and 5) include useful survey information regarding respondents' methods of job search. According to Table A.1 in the Appendix A, 48-49 percent of all respondents obtained employment through friends or relatives, whereas 48-50 percent of formal sector employees obtained employment through friends or relatives. Given that just 10% of employees obtained positions through job fairs, a mechanism that we unambiguously regard as an open market platform, the table shows that job seekers rely on personal contact rather than open market operation for a job search.

Another form of labor market imperfection that has received much attention in the literature is labor market monopsony that features worker underpayment. To demonstrate this, we use IS data and construct several indices of monopsony. The first index is the standard measure of Pigou's E, which is the normalized gap between the value of a worker's productivity and the wage: $E = \frac{pF'(L) - w(L)}{w(L)}$, where $pF'(L)$ is firm's marginal revenue of labor product and $w(L)$ is wage. With no imperfections in the labor market, profit-maximizing employers should hire workers until the marginal product of labor equals the payment. Thus, a higher value of Pigou's E suggests that labor market distortions are more severe. However, this traditional method for diagnosing labor market monopoly is limited by the possibility that wage payment divergence from the value of the worker's marginal product might be caused by a firm's output market power. In other words, when companies mark up their output, markups cause the wage payment to diverge from the worker's marginal product. (Brooks et al. 2021).

To circumvent this problem, we also use an index proposed by Brooks et al. (2021) which distinguishes between a company's factor market power on the labor market (called markdown) and its market power on the goods market (called markup). The main intuition of the method is that as long as there is one input for which firms have no monopsony power, one can construct an index that distinguish between an output markup and an input markdown by comparing the ratios of the value of marginal product and the input price across inputs. For instance, if firms are price-takers in the material market whereas they have a wage-setting power in the labor market, the markdown index for firm i (μ_i) can be constructed as follows: $\mu_i = \frac{\mu_i^L}{\mu_i^M}$ where $\mu_i^j = \frac{\theta_i^j}{\alpha_i^j}$, $j = L, M$. Here, θ_i^j denotes factor j's contribution on producing output for firm i, and α_i^j is firm i's specific payment share on factor j. The ratio of labor's contribution to production and payment, μ_i^L, indicates firms' price-setting power on both the good market and the labor market, whereas the ratio of material's contribution to production and payment, μ_i^M, reflects firms' price-setting power only on the good market. By dividing the ratio and netting out firm's output market power, the constructed index identifies firms' monopsony power on labor market. Within this approach, we follow Brooks et al. (2021) to construct two different monopsony indexes called CRS markdown and CD markdown. The disadvantage of using an index based on Brooks et al. (2021) is that they assume the specific functional form for the production function and that firms have at least one input for which they do not have monopsony power. As an index based on Pigou's E measure has fewer assumptions, we employ both indexes to examine labor market monopoly and complement each other. In Appendix B, we detail the construction of different monopsony indexes.

The variables included in our regression study with IS data, including the market distortion indices, are summarised in Table 2. Almost every firm employs laborers for production-related tasks, while around 11 percent of firms do not use employees for non-production-related tasks. The number of firms reporting wage payments for non-production workers is even less than that of firms reporting non-production worker hiring. We cannot distinguish whether this discrepancy came from non-payment hiring or simple omission. Thus, when estimating monopsony indices, we do not impute values for omitted values in wage payment for non-production employees; instead, we use the available sample to estimate monopsony indices separately for production and non-production workers. We observe significant anomalies on our estimates of monopsony indices, even after winsorizing the 3 percent on both sides. Thus, we normalize the distribution by taking a log. Despite a substantial disparity in markdown indices, both indices suggest a significant gap between the labor's elasticity and wages, which varies across plants. Though this reflects a varying degrees of wage setting power across plants, the role of labor protection regulations such as minimum wage on this disparity is still not yet unknown. Increases in the minimum wage may deter employers from employing new workers while enhancing labor productivity, resulting in no change in monopsony indices, or they may correct an existing distorted labor market, bringing the equilibrium wage closer to competitive market wages. In Section 4, we formally test the role of minimum wage and show that the minimum wage increase reduces market distortions and thus worked as a market correction mechanism.

2.4 Minimum wage and non-compliance

In Indonesia, a minimum wage regulation has been enacted since 1970, though it was rarely implemented until Western customers put pressure on the Indonesian government in the 1990s (See Harrison and Scores (2010) for a more detailed discussion). During the first half of the 1990s, alongside rapid economic expansion, the real minimum wage grew quickly, but this growth slowed in the second half of the 1990s. Especially due to depreciation in the currency during the Asian financial crisis in 1997, real minimum wages declined by 30 percent in 1998. The Asian crisis also provided the political and economic impetus that led to the demise of Suharto, the dictator of Indonesia from 1967 to 1998, and the subsequent political transformation that led to the enactment of the decentralization laws of 1999. These laws allowed each provincial government to make independent policies in consideration of the local economy, including the determination of minimum wage rates. Since then, the level of the minimum wage has been set and annually updated in discussions among provincial tripartite wage councils—representative of the Ministry of Manpower, local employers, and unions.

The process of setting minimum wages is mostly based on negotiation and is weakly linked to technical assessments of the cost of living increases. Though the technical basis for calculating the cost of a decent living for workers (Kebutuhan Hidup Minimal, KHL) exists as an input for determining minimum wages, the influence of the KHL on minimum wage was relatively small in practice. The negotiation based procedure brought large variations in the minimum wage across provinces (Figure 2A-D). Especially during 2013, relative to the years between 2006 and 2012, during when the minimum wage grew by 7.6 percent per year on average, unions were more successful in their negotiations to raise local minimum wages, and there has been a 43.7 percent increase in Jakarta and 49.7 percent in East Kalimantan.

It is a well-known fact that the level of a minimum wage is quite close to the median wage in developing countries, and Indonesian data also demonstrates this feature. Table A.2 in Appendix A records the ratio of the minimum wage to the median of full-time wage, part-time wage, and profit by province and year. The table indicates that the range of ratio spans from 80 percent to 85 percent for full-time workers across the years. It also shows that the income gap between full-time wage earners and the rest of workers has been widening across years, which may be attributed to the increase in the minimum wage that only applies to formal sector full-time workers. Figure 3A illustrates this point from another angle. The graph is the kernel density for the wage income distribution and the profit income distribution, respectively, where the distributions are normalized by the minimum wage. It is striking to observe that the normalized wage density curve is relatively stable across the years, even though there has been a rapid increase in the real minimum wage (Fig. 1). The stability of the normalized kernel density shows that the wage distribution has been moving alongside minimum wage, and the minimum wage in Indonesia does not function as a safety net to protect vulnerable workers. As documented by the World Bank Report (2010), the Indonesian minimum wage appears to be rather a wage-setting mechanism for negotiation.

Another significant feature regarding the minimum wage is the non-compliance ratio. The Manpower Law requires all employers to pay minimum wage to full-time employees. If employers fail to pay minimum wage, the Manpower Law stipulates that employers face imprisonment between 1 and 4 years, and required to pay monetary compensation between Rp 10,000,000 and 400,000,000. Despite the high penalties, we observe from IFLS data (Fig. 3A) that the ratio of full-time formal sector workers who earn a sub-minimum wage is about 43 - 47 percent. Figure 3B also illustrates the seriousness of non-compliance from IS data. The graph shows the distribution of the mean wage for manufacturing firms, and we observe 40 percent of manufacturing firms' average wage payment is below the minimum wage. This non-compliance ratio is rather severe, which shows that enforcement of the minimum wage regulations is far less than complete. The problem of non-compliance is particularly common in developing countries, and Basu et al. (2010) develop a theoretical model that expounds the rational choice of government to turn a blind eye to non-compliant behaviors. Table A.3 in Appendix A shows the non-compliance rate with minimum wage regulations by (i) firm size and (ii) worker education level using a sample of full-time formal sector workers. Consistent with the literature, large firms tend to comply more with minimum wage regulation as large firms are more likely to be monitored by the government. Likewise, people with high education tend to receive more than the minimum wage. Despite widespread underpayment of workers, it is clear that highly educated workers have greater bargaining leverage than less educated ones.

Overall, our baseline study for the labor market in Indonesia shows the following aspects: (i) a sizable informal economy with significant heterogeneity in profit income among informal sector workers, (ii) monopsonistic behavior of employers, (iii) the minimum wage close to the median wage, and (iv) imperfect government monitoring and non-compliance of minimum wage regulations. These features of labor markets are prevalent in other developing countries (Cunningham, 2007) and merits the development of a structural model that features the mechanism through which minimum wage affects the overall labor market. In the next section, we build up a structural model that incorporates these labor market characteristics.

3. Equilibrium Model

The descriptive statistics in the previous section portrays the essential features of the labor market and the minimum wage in Indonesia that are also commonly found in other developing countries. We now develop a stationary equilibrium model that incorporates the key features of the labor market we showed in the previous section. To capture the monopsonistic behavior of the firms, our model extends Burdett and Mortensen (1998) by allowing for differences in firm productivity and also for heterogeneity in the workers' outside option. The Burdett-Mortensen model provides a theoretical foundation for a monopsonistic behavior of firms even when there is no dominant monopsonist in the labor market. We combine this model with Basu et al. (2010) by introducing a punishment mechanism against non-compliant behavior against minimum wage law in order to capture the empirical observation of the sub-minimum wage payment from formally registered firms. Finally, we follow Engbom and Moser (2018) by introducing a segmented labor market such that workers with individual innate abilities are bound to find jobs within their labor market. Combining these components generates the empirically relevant wage distribution and employment effect in response to a minimum wage hike.

3.1. Environment

We study a stationary economy cast in continuous time. The measure of workers in the labor market z is indicated by m_z, whereas the measure of employers is normalized to 1. For the following discussion and problem of the firm, we define expected earned wage, $\widetilde{\omega} = \omega + \kappa max\{0, \omega_{min} - \omega\}$, where ω is the firm's offered wage. We use expected wage concept $\widetilde{\omega}$ which is distinguished from wage offer as it is the expected wage that determines a worker's occupational choice between the formal and informal sectors of employment. This assumption essentially means that we allow for the wage transfer; in the case that firms who pay below minimum wage get monitored by the authorities, they should transfer the gap, $\omega_{min} - \omega$, to the workers. This wage transfer ensures that the the equilibrium expected wage distribution moves along with the minimum wage as our data illustrates. When firms pay more than minimum wage, the expected wage becomes the wage offer, ω ($\widetilde{\omega} = \omega$). When firms pay less than the minimum wage, the expected wage payment is the combination of the offered wage and the minimum wage weighted by the punishment ratio, κ ($\widetilde{\omega} = (1-\kappa)\omega + \kappa\omega_{min}$; where κ is the punishment ratio). We see that expected punishment $\kappa(\omega_{min} - \omega)n_z(\widetilde{\omega})$, increases with the enforcement intensity, κ, the gap between the minimum wage and the offered wage, $\omega_{min} - \omega$, and the employment level at labor market z, n_z.

Note that the minimum wage increase may not affect the equilibrium expected wage distribution in some labor market z if the minimum wage and its enforcement rate are significantly low. As one can see, worker's expected wage $\widetilde{\omega} = \omega + \kappa max\{0, \omega_{min} - \omega\}$ can be targeted by the firm's wage offer, ω; firms can respond to the minimum wage change by adjusting wage offer, ω, to target the same expected wage payment, $\widetilde{\omega}$, and thus the equilibrium expected wage distribution may not be affected by increase in minimum wage at all. Minimum wage will have a real effect in market z, when the increased minimum wage and the penalty are high enough that the least productive firm (lowest paying firm) participating in the labor market is forced to pay $\kappa\omega_{min}$, even though it can pay wages less than $\kappa\omega_{min}$ to attract workers. When the least productive firm pays $\kappa\omega_{min}$, all the offered wages are affected at equilibrium as firms in the labor market are engaged with monopsonistic competition (Burdett and Mortensen (1998)).

3.2. Workers

The problem for workers is a straightforward adaptation of Burdett and Mortensen (1998). We assume that workers joining the labor market are composed of (i) current employees in the formal sector (ii) workers in the informal sector. [6]

[6] Unlike the original paper, we do not make the assumption for the unemployed workers in our model. In the IFLS sample, people who can be treated as unemployed are those whose primary activities during the past week involved searching for a job. In our sample, these people are less than 1 percent among the respondents.

Workers differ in their permanent ability level, z,and their opportunity cost of employment, x. Worker's ability, z, is distributed as $T(\cdot)$ over support $[\underline{z}, \overline{z}]$, and $H_z(x)$ denotes the proportion of workers in the labor market, z, whose opportunity cost of employment, i.e. earnings in the informal sector, is no greater than x. As worker's outside option, x, differs from his reservation wage, $R_z(x)$, we also define $D_z(R_z(x))$ as the proportion of workers in the labor market, z, whose reservation wage is no greater than $R_z(x)$. We assume that worker's outside options, x, is positively related with his ability as an employee; if $z_1 < z_2$, then $H_{z_1}(x) \preceq_{FOSD} H_{z_2}(x)$. We show$H_z(x) = D_z(R_z(x))$ in the Appendix C.1, and thus, $D_{z_1}(R_{z_1}(x)) \preceq_{FOSD} D_{z_2}(R_{z_2}(x))$, if $z_1 < z_2$. The labor market is segmented in that workers with z abilities are allowed to search wage earning jobs only in that labor market z while firms can decide which labor market to join and what wages to offer in each market. Search is a random process as workers do not direct their search towards specific firms. Workers maximize their lifetime income discounted at a rate ρ.

Individuals receive job offers according to a Poisson process with arrival rate λ_z^s where $s = i, e$. Let λ_z^i denote the arrival rate for the informal sector laborer, and λ_z^e be the arrival rate for those currently working in the formal sector. We assume that the instantaneous job arrival rate for hired workers in the formal sector (λ_z^e) are the same–either they are hired with the legal wage or not. This means that within the specific z labor markets, those hired with legal wage and those hired "off the book" are not segmented and they compete directly against each other. The assumption is clearly a limitation and we employ it for reasons of tractability. Considering that our model allows for arrival rates that vary with worker's ability, z, we do not see the assumption as too restrictive.

Firms strategically post wage offer ω in each labor market z with consideration of their expected wage payment, $\widetilde{\omega}$, other firms' wage post, and distribution of reservation wage, $D_z(R_z(x))$. We define the distribution of the firm's expected wage payment as $F_z(\widetilde{\omega})$. [7] Formal sector jobs

[7]The wage package for legally hired workers and illegally hired ones can differ in different dimensions other than financial remuneration. For example, it is often the case that formal sector workers receive benefits such as insurance subsidies. We address this

will be terminated exogenously with δ_z ratio, or endogenously by laborers moving ahead to the better paying formal sector jobs. Let $S_z(x)$ be the value function of an agent with ability z who works in the informal sector whose outside option is x, and $W_z(\widetilde{\omega}, x)$ be the value function of that agent when working in the formal sector with an expected earned wage, $\widetilde{\omega}$. The worker receives x in case he chooses to work in the informal sector. Then the following Bellman equations can be formulated.

$$(1)\ \rho S_z(x) = x + \lambda_z^i \int_{\underline{\omega}_z}^{\overline{\omega}_z} max\{W_z(y,x) - S_z(x), 0\} dF_z(y)$$

$$(2)\ \rho W_z(\widetilde{\omega}, x) = \widetilde{\omega} + \lambda_z^e \int_{\widetilde{\omega}}^{\overline{\omega}_z} (W_z(y,x) - W_z(\widetilde{\omega}, x)) dF_z(y) + \delta_z[S_z(x) - W_z(\widetilde{\omega}, x)]$$

where $\overline{\widetilde{\omega}}_z$ and $\underline{\widetilde{\omega}}_z$ denote highest and lowest wage payment in the labor market z accordingly. From these equations the reservation wage can be derived as follows:

$$(3)\ R_z(x) = x + (\lambda_z^i - \lambda_z^e) \int_{R_z(x)}^{\overline{\widetilde{\omega}}_z} \frac{1 - F_z(y)}{\rho + \delta_z + \lambda_z^e(1 - F_z(y))} dy$$

As $W_z(\widetilde{\omega}, x)$ is increasing in $\widetilde{\omega}$ whereas $S_z(x)$ is independent of it, there is a unique reservation wage, $R_z(x)$, such that $W_z(\widetilde{\omega}, x) \gtrless S_z(x)$ as $\widetilde{\omega} \gtrless R_z(x)$. The decision rule of agents is to become a wage-earner in the formal sector if $\widetilde{\omega} > R_z(x)$, and remain self-employed if $\widetilde{\omega} < R_z(x)$.

Now, we define the steady-state measure of the informal sector and the labor supply. Let $I_z(R_z(x)|F_z)$ denote the steady-state number for informal sector workers in labor market z whose reservation wage is less than or equal to $R_z(x)$, conditional on the wage offer distribution F_z. As $\frac{\delta_z}{\delta_z + \lambda_z^i[1 - F_z(R_z(x))]}$ denotes the rate of inflow to the informal sector at the steady state for workers whose reservation wage is $R_z(x)$, we can write $I_z(R_z(x)|F_z)$ as

$$(4)\ I_z(R_z(x)|F_z) = \int_{\underline{R}_z}^{R_z(x)} \left(\frac{\delta_z m_z}{\delta_z + \lambda_z^i[1 - F_z(y)]} \right) dD_z(y)$$

difference in benefits by defining wage as the entire monetary compensation for the worker. The wage is after tax (if it is levied) but before social security deduction. Social security is considered part of their compensation as it entitles them to a pension and health benefits.

where $\underline{R}_z$ denote the lowest reservation wage for workers with ability z, $\underline{R}_z = R_z(\underline{x})$. For the further discussion, we also denote highest reservation wage for workers with ability z as $\overline{R}_z = R_z(\overline{x})$. Let the steady-state number of workers employed with a wage no greater than $\widetilde{\omega}$ be given by $G_z(\widetilde{\omega})(m_z - I_z)$, where $I_z = I_z(\overline{R}_z|F_z)$ is the total ratio of informal sector workers, and $G_z(\widetilde{\omega})$ is the distribution of earning among formal sector workers whose ability is z. At the steady-state, the flow of workers leaving employers offering a wage no greater than $\widetilde{\omega}$ equals to the flow of workers returning to such employers,

$$(5)\ (\delta_z + \lambda_z^e(1 - F_z(\widetilde{\omega}))G_z(\widetilde{\omega})(m_z - I_z) = \lambda_z^i \int_{\underline{R}_z}^{\widetilde{\omega}} (F_z(\widetilde{\omega}) - F_z(R_z(x)))dI_z(R_z(x)|F_z)$$

where $F_z(\widetilde{\omega}) - F_z(R_z(x))$ represents the share of workers whose reservation wage is $R_z(x)$ who will accept an offer less than or equal to $\widetilde{\omega}$, and $dI_z(R_z(x)|F_z)$ measure of informal sector workers with reservation wage $R_z(x)$. From (4), we have $[1 + k_z^i(1 - F_z(R_z(x)))]dI_z(R_z(x)|F_z) = m_z dD_z(R_z(x))$. We can now express (5) as follows:

$$G_z(\widetilde{\omega})(m_z - I_z) = \frac{k_z^i \int_{\underline{R}_z}^{\widetilde{\omega}} (F_z(\widetilde{\omega}) - F_z(y))dI_z(y|F)}{(1 + k_z^e(1 - F_z(\widetilde{\omega}))} = \frac{k_z^i m_z}{(1 + k_z^e(1 - F_z(\widetilde{\omega}))} \int_{\underline{R}_z}^{\widetilde{\omega}} \frac{(F_z(\widetilde{\omega}) - F_z(y)}{(1 + k_z^i(1 - F_z(y))} dD_z(y)$$

From this expression, we use integration by parts to derive

$$\int_{\underline{R}_z}^{\widetilde{\omega}} \frac{(F_z(\widetilde{\omega}) - F_z(y))}{(1 + k_z^i(1 - F_z(y)))} dD_z(y) = \int_{\underline{R}_z}^{\widetilde{\omega}} D_z(y) \left(\frac{1}{(1 + k_z^i(1 - F_z(y))} + \frac{k_z^i(F_z(\widetilde{\omega}) - F_z(y))}{(1 + k_z^i(1 - F_z(y))^2} \right) dF_z(y).$$

The steady-state number of workers earning a wage in the interval $[\widetilde{\omega} - \epsilon, \widetilde{\omega}]$ is represented by $dG_z(\widetilde{\omega})(m_z - I_z)$, while $dF_z(\widetilde{\omega})$ is the measure of firms offering an expected wage payment, $\widetilde{\omega}$, in the same interval. Thus, the measure of workers per firm offering a wage, $\widetilde{\omega}$, at the steady state can be expressed as

$$(6)\ n_z(\widetilde{\omega}|F_z, D_z) = \frac{(m_z - I_z)dG_z(\widetilde{\omega})}{dF_z(\widetilde{\omega})} = \frac{k_z^i m_z D_z(\widetilde{\omega})}{(1 + k_z^i(1 - F_z(\widetilde{\omega})))(1 + k_z^e(1 - F_z(\widetilde{\omega})))}$$

3.3. Firms

There is a continuum of heterogeneous firms whose idiosyncratic productivity, p, is drawn from the distribution Γ. Let Z be the set of labor markets where firms operate. Firms join multiple labor markets, $z \in Z$, with different wage posting strategies, considering the level of minimum wage, the enforcement rate and the distribution of worker's reservation wage. Firms commit to paying a wage ω for the remainder of the match. They operate a linear production technology combining n_z workers from each labor market z to produce flow output. Then the total production is

$$y(p, \{n_z\}_{z\in Z}) = p \int_{z\in Z} z n_z dz$$

As the model assumes perfect segmentation of labor markets and production technology is a linear combination of production from different labor segments, entrepreneurs can maximize their aggregate profit by maximizing profit in each labor market separately.

$$(7)\ \pi_z(\widetilde{\omega}_z) = max_{\widetilde{\omega}\geq\kappa\omega_{min},\underline{R}_z} \left\{ \left(pz - \widetilde{\omega}\right) n_z(\widetilde{\omega}|F_z, D_z) \right\}$$

where $n_z(\widetilde{\omega}|F_z, D_z)$ is the labor hired at wage $\widetilde{\omega}$, given F_z and D_z. In other words, employers decide wages in each segmented labor market to maximize (7), considering the expected wage payment distribution, $F_z(\widetilde{\omega})$, the distribution of reservation wage for the workers, $D_z(R_z(x))$, and the measure of workers available with expected wage $\widetilde{\omega}$ in labor market z, $n_z(\widetilde{\omega}|F_z, D_z)$, which is derived in equation (6). As discussed earlier, imperfect monitoring of the minimum wage law will create profitable opportunities for firms to ignore the regulations and hire unofficially. For instance, if the lowest reservation wage $\underline{R}_z$ is less than minimum wage ω_{min}, some employers may hire workers with a sub-minimum wage, as illegal wage is still greater than worker's reservation wage. However, imperfect monitoring still works to enforce an effective expected minimum wage

$\kappa\omega_{min}$ so that all employers are expected to pay more than $\kappa\omega_{min}$.

3.4. Equilibrium

The stationary search equilibrium is a set of reservation policies functions $\{R_z(x)\}_{z\in Z,x\in H}$; wage offer distributions $\{F_z(\widetilde{\omega})\}_{z\in Z}$; firm sizes $\{n_z(\widetilde{\omega})\}_{z\in Z}$; self-employment rates $\{I_z(R_z(x))\}_{z\in Z,x\in H}$ such that given ω_{min} and κ,

1. Worker optimality: Given x,z,ω, κ,$F_z(\widetilde{\omega})$,and $R_z(x)$, workers set reservation policies, $\{D_z(R_z(x))\}_{z\in Z,x\in H}$, that solve their occupational choice.

2. Entrepreneur optimality: Taking $F_z(\widetilde{\omega})$ as given and knowing $D_z(R_z(x)), k_z^i, k_z^e$, and m_z, the wage policies in each market solves the entrepreneurs' problem.

3. Labor market consistency: The self employment rates in labor market z are consistent with $I_z(\overline{R}_z|F_z) = \int_{\underline{R}_z}^{\overline{R}_z} \left(\frac{\delta_z m_z}{\delta_z+\lambda_z^i[1-F_z(y)]}\right) dD_z(y)$.

4. Aggregation: The wage distribution in each segment of the labor market will be determined.

3.5. Equilibrium characterization

The critical characteristics of the equilibrium wage and the employment in our model closely follows Burdett and Mortensen (1998) and Engbom and Moser (2018). We feature some of the characteristics below.

Proposition 1: In the given labor market z, workers in the more productive firms earn higher wages than workers in the less productive firms.

Proof: Let $\widetilde{\omega}^1$ and $\widetilde{\omega}^2$ be the equilibrium wage of the firms whose productivity is p_1 and p_2 accordingly. Assume that $p_2 > p_1$. Then,

$$
\begin{aligned}
&(p_2 z - \widetilde{\omega}^2)\, \tfrac{k_z^i m_z D_z(\widetilde{\omega}^2)}{(1+k_z^i[1-F_z(\widetilde{\omega})])(1+k_z^e[1-F_z(\widetilde{\omega})])} \geq ((p_2 z - \widetilde{\omega}^1)\, \tfrac{k_z^i m_z D_z(\widetilde{\omega}^1)}{(1+k_z^i[1-F_z(\widetilde{\omega}^1)])(1+k_z^e[1-F_z(\widetilde{\omega}^1)])} \\
&> (p_1 z - \widetilde{\omega}^1)\, \tfrac{k_z^i m_z D_z(\widetilde{\omega}^1)}{(1+k_z^i[1-F_z(\widetilde{\omega})])(1+k_z^e[1-F_z(\widetilde{\omega})])} \geq (p_1 z - \widetilde{\omega}^2)\, \tfrac{k_z^i m_z D_z(\widetilde{\omega}^2)}{(1+k_z^i[1-F_z(\widetilde{\omega})])(1+k_z^e[1-F_z(\widetilde{\omega})])} \\
&\Leftrightarrow (p_2 - p_1) z \tfrac{k_z^i m_z D_z(\widetilde{\omega}^2)}{(1+k_z^i[1-F_z(\widetilde{\omega})])(1+k_z^e[1-F_z(\widetilde{\omega})])} > (p_2 - p_1) z \tfrac{k_z^i m_z D_z(\widetilde{\omega}^1)}{(1+k_z^i[1-F_z(\widetilde{\omega})])(1+k_z^e[1-F_z(\widetilde{\omega})])} \\
&\Leftrightarrow \widetilde{\omega}^2 > \widetilde{\omega}^1
\end{aligned}
$$

Q.E.D. □

As Bontemps et al. (2000) proved, this property is also satisfied for the case of continuous productivity of employers, and there is a unique equilibrium wage associated with each productivity type. This implies that the market distribution of wage offers is a transformation of the underlying distribution of employer productivity. Let us define $J_z(p)$ that corresponds to the equilibrium wage distribution; $F_z(\widetilde{\omega}^*(p)) = J_z(p)$, where $\widetilde{\omega}^*(p)$ is equilibrium wage that corresponds with firm with productivity p. Then $J_z(p)$ is interpreted as the proportion of employers with productivity no greater than p.

Given that there is a one-on-one matching between firm's productivity and the equilibrium wage distribution, the proportion of workers whose reservation wage is no greater than $\widetilde{\omega}^*$, $D_z(\widetilde{\omega}^*(p))$, can be also expressed in terms of the firm's productivity. Assume $J_z(p)$ is continuous and differentiable with support $[\underline{p}, \overline{p}]$. From $F_z(\widetilde{\omega}^*(p)) = J_z(p)$, we can derive $\widetilde{\omega}_z^*(p) = F_z^{-1}(J_z(p))$. We substitute this into $D_z(\widetilde{\omega}_z^*(p))$, so that $D_z(\widetilde{\omega}_z^*(p)) = D_z(F_z^{-1}(J_z(p))) = (D_z \circ F_z^{-1} \circ J_z)(p) = Q_z(p)$. Thus, $Q_z(p)$ refers to the proportion of workers that a firm with productivity p can attract. Thus from $F_z(\widetilde{\omega}_z^*(p)) = J_z(p)$ and $D_z(\widetilde{\omega}_z^*(p)) = Q_z(p)$, we can derive the following: $F_z'(\widetilde{\omega}_z^*(p))\widetilde{\omega}_z^{*\prime}(p) = J_z'(p)$ and $D_z'(\widetilde{\omega}_z^*(p))\widetilde{\omega}_z^{*\prime}(p) = Q_z'(p)$. As all wage offers must be at least as great as the lowest reservation wage, $\underline{R}_z$, only employers with productivity $pz \geq \underline{R}_z$ can make a profit and participate in the labor market z. Hence without loss of generality, we infer $\underline{p} = \frac{\underline{R}_z}{z}$ and $p \in (\frac{\underline{R}_z}{z}, \overline{p}]$. Now we can derive the equilibrium wage associated with the employer's productivity (Equation (9)) from the producers' profit maximization problem (Equation (8)). The details of derivation are discussed in Appendix C.2.

$$(8)\ \pi(p,z,\widetilde{\omega}|D_z,F_z)=Max_{\widetilde{\omega}}\left\{(pz-\widetilde{\omega})\,n_z(\widetilde{\omega})\right\}=\left\{(pz-\widetilde{\omega})\frac{k_z^i m_z D_z(\widetilde{\omega})}{(1+k_z^i(1-F_z(\widetilde{\omega})))(1+k_z^e(1-F_z(\widetilde{\omega})))}\right\}$$

Proposition 2: Suppose there is an unique equilibrium solution, $F_z^*(\widetilde{\omega})$, to the wage posting game for all $p\in[b,\overline{p}]$. Then there exist an equilibrium earned wage correspondence, $\widetilde{\omega}_z^*(p)$, that maps underlying firm productivity to the wage offer, which can be derived as (9):

$$(9)\ \widetilde{\omega}_z^*(p)=z\left[p-\int_{\frac{\underline{R}_z}{z}}^{p}\frac{\left(1+k_z^i(1-J_z(p))\right)(1+k_z^e(1-J_z(p)))Q_z(y)}{(1+k_z^i(1-J_z(y)))(1+k_z^e(1-J_z(y)))Q_z(p)}dy\right]$$

Proof: See Appendix C.2.

We can see equilibrium wage is determined by worker productivity, firm productivity, firms' relative competitiveness in labor market z, and wage posting strategies by other participating firms in labor market z. To understand this clearly, let us redefine equation (9) as $\widetilde{\omega}_z^*(p)=z\left[p-\int_{\frac{\underline{R}_z}{z}}^{p}\frac{A_z(p)/Q_z(p)}{A_z(y)/Q_z(y)}dy\right]$ where $A_z(p)$ is defined as $\left(\delta_z+\lambda_z^i(1-J_z(p))\right)\left(\delta_z+\lambda_z^e(1-J_z(p))\right)$. Note that $A_z(p)$ captures the job loss due to firms' relative incompetance in the labor market z, and $\frac{\partial A_z(p)}{\partial p}<0$ shows that the amount of job loss decreases for high productivity firms. As $Q_z(p)$ is the proportion of workers attracted to work for employer whose productivity is p, $\frac{A_z(p)}{Q_z(p)}$ captures the ratio of lost workers to attracted workers for firms with productivity p.

Now from $\widetilde{\omega}_z^*(p)=z\left[p-\int_{\frac{\underline{R}_z}{z}}^{p}\frac{A_z(p)/Q_z(p)}{A_z(y)/Q_z(y)}dy\right]$, we can first study for the change in equilibrium wage in response with change in $\underline{R}_z$. It is straightforward to derive $\frac{\partial\widetilde{\omega}_z^*(p)}{\partial(\underline{R}_z)}=\frac{A_z(p)/Q_z(p)}{A_z((\underline{R}_z/z))/Q_z((\underline{R}_z/z))}>0$. The result shows that as least productive firms in this labor market become more productive, wage posting strategies for all the remaining firms get affected positively in equilibrium (Burdett and Mortensen (1998)). Note that equilibrium wage growth in response to reservation wage change $\left(\frac{\partial\widetilde{\omega}_z^*(p)}{\partial(\underline{R}_z/z)}=\frac{A_z(p)/Q_z(p)}{A_z((\underline{R}_z/z))/Q_z((\underline{R}_z/z))}\right)$ can be interpreted as the ratio of firms' retaining probability. Firms with high p can attract and retain workers so that $A_z(p)/Q_z(p)$ will be low.

The least productive firm with productivity $p = \underline{R}_z/z$ cannot initially attract many workers and cannot retain them so that $A_z(\underline{R}_z/z)/Q_z(\underline{R}_z/z)$ will be high. As such, the relative productivity of firms in this equilibrium affects to the equilibrium wage. If the gap between p and $\underline{R}_z/z$ is high, then small increase in $\underline{R}_z/z$ would not change eqilibrium wage posting. However, if the gap between p and $\underline{R}_z/z$ is small, then the productivity of the least productive firms becomes a real threat, and firms with p will increase equilibrium wage posting even higher. This point can be made clear by deducing the second derivative with respect to reservation wage, $\left(\frac{\partial \frac{\partial \widetilde{\omega}_z^*(p)}{\partial(\underline{R}_z/z)}}{\partial(\underline{R}_z/z)} = \frac{A_z(p)}{Q_z(p)} \frac{Q_z'(\underline{R}_z/z)A_z(\underline{R}_z/z) - Q_z(\underline{R}_z/z)A_z'(\underline{R}_z/z)}{[A_z(\underline{R}_z/z)]^2} > 0\right)$, and $\widetilde{\omega}_z^*(p)$ is the convex function of $\underline{R}_z$.

Proposition 3: A minimum wage hike increases wages in any labor market z where $\underline{R}_z \leq \kappa\omega_{min}$.

Proof:

$$\frac{\partial \widetilde{\omega}_z^*(p)}{\partial \omega_m} = \left[\kappa \frac{\left(1+k_z^i(1-J_z(p))\right)(1+k_z^e(1-J_z(p)))}{\left(1+k_z^i(1-J_z(\frac{\kappa\omega_m}{z}))\right)\left(1+k_z^e(1-J_z(\frac{\kappa\omega_m}{z}))\right)}\right]\left[\frac{Q_z\left(\frac{\kappa\omega_m}{z}\right)}{Q_z(p)}\right] > 0$$

$Q.E.D.\ \square$

Thus, for the labor market z that minimum wage binds ($\underline{R}_z \leq \kappa\omega_{min}$), the equilibrium wage earning distribution F_z is stochastically increasing in $\kappa\omega_{min}$.

Proposition 4: A minimum wage hike increases employment by the firms whose productivity is greater than $\frac{\kappa_z\omega_{min}}{z}$ in the labor market z $\left(p > \frac{\kappa_z\omega_{min}}{z}\right)$, while it pushes out firms from the market whose productivity less than $\frac{\kappa_z\omega_{min}}{z}$, $\left(\frac{\kappa_z\omega_{min}}{z} > p\right)$. [8]

Proof: Let us denote $\widetilde{\omega}_z^*(p)$ in equation (9) as $\widetilde{\omega}_z^*$. From equation (6) and Proposition 3, we can deduce the following equation for the firms who still remain in the market (whose productivity p is greater than $\frac{\kappa_z\omega_{min}}{z}$):

[8] One can look at this from the firm's viewpoint: a firm with productivity p will post wages in all labor market z that satisfy $z > \frac{\kappa_z\omega_{min}}{p}$, while firms would not consider of joining labor market whose productivity less than $\frac{\kappa_z\omega_{min}}{p}$, $\left(\frac{\kappa_z\omega_{min}}{p} > z\right)$.

$$\frac{\partial n_z(\widetilde{\omega}_z^*)}{\partial \omega_{min}} = \frac{k_z^i m_z D_z'(\widetilde{\omega}_z^*)\left(1+k_z^i(1-F_z(\widetilde{\omega}_z^*))\right)\left(1+k_z^e(1-F_z(\widetilde{\omega}_z^*))\right)+k_z^i m_z D_z(\widetilde{\omega}_z^*)\left[k_z^i F_z'(\widetilde{\omega}_z^*)\left(1+k_z^e(1-F_z(\widetilde{\omega}_z^*))\right)+k_z^e F_z'(\widetilde{\omega}_z^*)\left(1+k_z^i(1-F_z(\widetilde{\omega}_z^*))\right)\right]}{\left(1+k_z^i(1-F_z(\widetilde{\omega}_z^*))\right)^2\left(1+k_z^e(1-F_z(\widetilde{\omega}_z^*))\right)^2} \frac{\partial \widetilde{\omega}_z^*}{\partial \omega_{min}}$$

From proposition 3, we know that the minimum wage increase affects the whole wage distribution in a first-order stochastically dominant way, thus $\frac{\partial n_z(\widetilde{\omega}^*)}{\partial \omega_{min}} > 0$ for firms whose productivity is greater than $\frac{\kappa_z \omega_{min}}{z}\left(p > \frac{\kappa_z \omega_{min}}{z}\right)$. This portion of increased employment is due to the decrease in the inefficient informal sector workers whose wages were less than the reservation wage even though their contributions to the employers' revenue exceed the opportunity cost of employment. Note that total employment effect of minimum wage is ambiguous as there is a disemployment effect due to pushed-out firms. We can compare the aggregated amount of employment due to minimum wage increase. Equation (10) and (11) are aggregated amount of formal sector workers without/with minimum wage. If we define $\widetilde{\omega}_z^{sup_1} = sup\{\widetilde{\omega}_z^*(p)|p \in \Gamma\}$ and $\widetilde{\omega}_z^{sup_2} = sup\{\widetilde{\omega}_z^*(p)|\omega_{min}, p \in \Gamma\}$.

$$(10)\ \int_{\underline{z}}^{\overline{z}} \int_{\underline{R}_z}^{\widetilde{\omega}_z^{sup_1}} n_z dF_z(y) dT(z) = \int_{\underline{z}}^{\overline{z}} \int_{\underline{R}_z}^{\widetilde{\omega}_z^{sup_1}} \frac{k_z^i m_z D_z(y)}{(1+k_z^i(1-F_z(y)))(1+k_z^e(1-F_z(y)))} dF_z(y) dT(z)$$

$$(11)\ \int_{\underline{z}}^{\overline{z}} \int_{\kappa\omega_{min}}^{\widetilde{\omega}_z^{sup_2}} n_z dF_z(y) dT(z) = \int_{\underline{z}}^{\overline{z}} \int_{\kappa\omega_{min}}^{\widetilde{\omega}_z^{sup_2}} \frac{k_z^i m_z D_z(y)}{(1+k_z^i(1-F_z(y)))(1+k_z^e(1-F_z(y)))} dF_z(y) dT(z)$$

Minimum wage increase has a positive (negative) employment effect if

$$\int_{\underline{z}}^{\overline{z}} \int_{\kappa\omega_{min}}^{\widetilde{\omega}_z^{sup_2}} n_z dF_z(\widetilde{\omega}_z) dT(z) \gtrless \int_{\underline{z}}^{\overline{z}} \int_{\underline{R}_z}^{\widetilde{\omega}_z^{sup_1}} n_z dF_z(\widetilde{\omega}_z) dT(z).$$

$Q.E.D.$ □

Proposition 5: A minimum wage hike increases the non-compliance ratio among the formal sector firms.

Proof: From Proposition 2, we also know that the minimum wage hike does not increase the wage distribution by the same magnitude of the minimum wage increase.

$$\frac{\partial \widetilde{\omega}_z(p)}{\partial \omega_m} = \left[z \frac{\left(1+k_z^i(1-J_z(p))\right)(1+k_z^e(1-J_z(p)))}{\left(1+k_z^i(1-J_z(\frac{\kappa\omega_m}{z}))\right)\left(1+k_z^e(1-J_z(\frac{\kappa\omega_m}{z}))\right)} \right] \left[\frac{Q_z\left(\frac{\kappa\omega_m}{z}\right)}{Q_z(p)} \right] < 1$$

Combining with proposition 4, we can deduce that the minimum wage increase generates a higher non-compliance ratio to the minimum wage law in the formal sector.

Q.E.D. □

Proposition 6: For labor market z where the minimum wage has an effect, an increase in the minimum wage boosts the remuneration of lower paid workers more than that of higher paid worker.

Proof: As equation (10) establishes that $\widetilde{\omega}_z^*(p)$ monotonically increases in p, we only need to show that an increase in wage due to a minimum wage hike decreases in p.

$$\frac{\frac{\partial \widetilde{\omega}_z(p)}{\partial \omega_{min}}}{\partial p} = -z \frac{\left(k_z^i J_z'(p)(1+k_z^e(1-J_z(p)))+k_z^e J_z'(p)\left(1+k_z^i(1-J_z(p))\right)\right)Q_z(p)+\left(1+k_z^i(1-J_z(p))\right)(1+k_z^e(1-J_z(p)))Q_z'(p)}{[Q_z(p)]^2} *$$
$$\frac{Q_z\left(\frac{\kappa\omega_m}{z}\right)}{\left(1+k_z^i(1-J_z(\frac{\kappa\omega_m}{z}))\right)\left(1+k_z^e(1-J_z(\frac{\kappa\omega_m}{z}))\right)} < 0$$

Q.E.D. □

This establishes the empirical fact that a minimum wage increase affects initially sub-minimum wage earners more than those earning the legal wage.

4. Empirical Analysis

The theoretical model we developed in the previous section predicts that the effect of minimum wage law critically hinges on the characteristics of informal and formal sector labor markets, the relative stance of the minimum wage on wage distribution, and the enforcement rate of the law.

For instance, if the minimum wage is considerably higher than wage levels firms can pay and also the regulatory enforcement is effective, labor demand and formal sector employment declines in response to minimum wage increase. However, if firms underpay workers, a properly set minimum wage may boost labor supply without decreasing labor demand, hence increasing formal sector employment (Card and Kruger, 1994; Burdett and Mortensen, 1998). Also, if enforcement of the minimum wage law is imperfect, then monopsonistic firms who have considerable bargaining power can still optimize their job-offering behavior by offering a sub-minimum wage. Notably, small and medium-sized firms who are often not under strict governmental monitoring may offer sub-minimum wage jobs that are still profitable to the firms and sufficiently attractive for informal sector workers. Also, our model predicts that an increase in the minimum wage affect the whole wage distribution, as the firms in the labor market are engaged in wage posting game. Lastly, our model predicts that, with a minimum wage increase, monopsonistic gains from hiring workers are reduced.

Guided by our theoretical model, we study the effect of minimum wage on various labor-market outcomes in Indonesia between 2000 and 2014. In Sections 4.1 and 4.2, we offer our estimation equations that examine the impact of the minimum wage on labour market adjustment, including employment, wage payment, and company exploitation. Our proposed identification strategies include regression discontinuity-type methods that take advantage of adjacent districts and conventional two-way fixed effects. These two methodologies have been the subject of intense controversy in the academic literature (Dube et al.,2010; Allegretto, 2017; Neumark et al., 2014, 2017): examining the advantages and disadvantages of these two estimation methods will help in the interpretation of Section 4.4's regression results. In Section 4.3, we explain the estimation strategy for non-compliance for which we follow Ham (2018)'s approach. Our estimation results are discussed in Section 4.4.

4.1. Difference-in-Spatial Difference

As previously mentioned, in Indonesia, minimum wages are carefully targeted by the local government in consideration of the overall provincial economy. As such, the provincial minimum wage tends to be set higher when the provincial GDP per capita is high. The nonrandom distribution of province or district-level minimum wage policies thus poses a severe challenge for causal inference to canonical two-way fixed effect (fixed effect for each period and a fixed effect for each province) panel data approach, which assumes parallel trends across provinces. To account for potential heterogeneous pre-trends, we use the minimum wage variation among contiguous cross-border districts in adjacent provinces to construct the proper control group (Spatial Difference; SD henceforth; Dube et al., 2010; Allegretto et al., 2017). That is, the method assumes that contiguous cross-border districts share economic similarities due to geographic proximity and economic trade, and the minimum wage level does not reflect the economic condition of these cross-border districts if the minimum wage is set to account for the province's overall economy. Thus, any change in the minimum wage in these contiguous districts can have a causal implication on labor market outcomes.

This regression discontinuity type approach also has its limitation: if provincial boundaries affect other legal differences other than minimum wage in the way that influence local labor market, SD estimator attributes all changes in labor market outcomes across districts to minimum wage variation. Magruder (2013) presents the Difference-in-Spatial Difference (DSD) approach, which adds district dummies to the SD specification to relax the SD approach's assumption. By controlling nonparametrically for differences among borderline districts which persists over the length of the panel, the DSD approach can isolate the effect of minimum wage and yield causal inference. Magruder applies this strategy to the entire set of contiguous districts in Indonesia's bordering provinces.

Our primary identification strategy extends Magruder's approach by using individual-level data.[9] Using aggregated data in regression analysis may cause misleading results as it assumes a homogeneous relationship among control variables in the regression model. Instead, we employ individual-level data to allow individual-specific relationship among control variables and thus improve the precision of estimation. We use the whole sample of individuals who live nearby the contiguous districts in the bordering provinces for DSD estimation.

A first-order analysis to motivate our primary identification strategy would ask what happens to employment locally at the border. Fig. 4 plots the mean employment status against distance to the border of a minimum wage regime, where a positive distance indicates that the district is located at the side of the border with the higher minimum wage. Let $y^*_{ist} = y_{ist} - \frac{1}{n_{st}(\epsilon)} \sum_{i',s':d(s,s')<\epsilon} y_{i's't'}$ denote the difference between an outcome for individual i in district s in year t and the average outcome among all other individuals living in a district that is located within units of district s in year t. Likewise, we define $MW^*_{st} = MW_{st} - \frac{1}{n_{st}(\epsilon)} \sum_{s':d(s,s')<\epsilon} MW_{i's't'}$ which can be termed as spatially-differenced minimum wage. Figure 4 plots the spatial difference in employment status as a function of the spatially-differenced minimum wage. We can observe that in the districts with higher minimum wage compare to nearby districts, there is a higher ratio of formal sector or full-time formal sector workers. Also, we observe the opposite relationship for self-employed and family business: the regions with relatively lower minimum wage compare to the nearby area have a higher ratio of workers whose employment status is self-employed or family-business. This borderline analysis suggests that the minimum wage drives the positive correlation between minimum wage and formal sector jobs if we assume that local authorities decided minimum wage level in consideration of the overall province-level economy. However, as it is also possible that persistent district characteristics may affect the level of minimum wage setting, we need a further regression analysis that controls for this possibility. Our main identification strategy, DSD, is written in equation (12):

$$(12)\ y_{ist} = \beta MW_{st} + \eta GDP_{st} + \gamma X_{ist} + \alpha_s + \delta_{st} + u_{ist}$$

[9] Magruder used districts (Kabupaten) as the unit of observation for regression analysis.

where i indicates an individual or a plant, s is the district of the respondent, and t represents time. MW_{st} is the log of the minimum wage that varies by time and province/districts. GDP_{st} denotes province-specific log of gross domestic product, and X_{ist} represents individual controls. With the IFLS data, X_{ist} contains log values of household assets, dummy variables for (i) urban/rural residence, (ii) gender status, and (iii) labor force participation status [10], age and age squared, education level and education squared. With the IS data, X_{ist} represents firm-specific controls such as percentage of government ownership and foreigner ownership respectively, log values of used material, and export status. δ_{st} controls for district-time specific heterogeneity, and α_s represents the district fixed effect that controls nonparametrically for differences between nearby districts, which persists throughout the investigation period. Under the assumption of a shared economic environment nearby the contiguous districts within radius ϵ, the DSD method spatially differences out, δ_{st}, the time-varying local market characteristics, which is the main concern for endogeneity. As every district-year has a different radius that shares a similar labor market environment, it is not possible to measure each different radius to spatially difference out δ_{st} for each pair of borderline districts. Thus, we follow Magruder to assume that within randomly chosen radius, ϵ, unobserved labor market circumstances or economic shock will be shared for all the borderline districts (that is, $\delta_{st} - \delta_{s't} = 0$ if $d(s, s') < \epsilon$ where $d(s, s')$ is a measure of geographic distance). As this assumption is rather strong, we choose several different radii for robustness checks. Consequently, identification of β is based on minimum wage variation between neighboring districts on the border between two different provinces/districts, conditional on the individual-level characteristics and province-specific log of gross domestic product. Then the estimation of the model is based on the following differenced regression equation.

[10] The labor force participation status is defined according to whether the respondent spent the majority of their time working or seeking employment.

$$
\begin{aligned}
y_{ist} - \tfrac{1}{n_{ist}(\epsilon)} \textstyle\sum_{i',s':d(s,s')<\epsilon} y_{i's't} \quad &= \beta \left(MW_{st} - \tfrac{1}{n_{ist}(\epsilon)} \textstyle\sum_{i',s':d(s,s')<\epsilon} MW_{i's't} \right) \\
&+ \gamma' \left(X_{ist} - \tfrac{1}{n_{ist}(\epsilon)} \textstyle\sum_{i',s':d(s,s')<\epsilon} X_{i's't} \right) \\
&+ \left(\alpha_s - \tfrac{1}{n_{ist}(\epsilon)} \textstyle\sum_{i',s':d(s,s')<\epsilon} \alpha_s \right) \\
&+ \left(\delta_{st} - \tfrac{1}{n_{ist}(\epsilon)} \textstyle\sum_{i',s':d(s,s')<\epsilon} \delta_{s't} \right) \\
&+ \left(u_{ist} - \tfrac{1}{n_{ist}(\epsilon)} \textstyle\sum_{i',s':d(s,s')<\epsilon} u_{i's't} \right)
\end{aligned}
$$

where $n_{ist}(\epsilon)$ denotes the number of individuals in districts within a distance ϵ of district s in year t. If ϵ is chosen so that the local time trends, δ_{st}, are the same for districts within the radius ϵ, then the fifth term on the right-hand side is negligible and a valid estimator is obtained by estimating a regression in spatial differences. This approach weakens assumptions of regression discontinuity or the assumptions in difference-in-difference estimation in that (1) district fixed effect, α_s, controls innate difference of nearby districts and therefore address issues with spatial discontinuity in regression discontinuity approach and (2) it loosens the assumption of parallel trends in difference-in-difference estimation approach (Magruder, 2013). For computing standard errors, we follow the lead of Conley (1999) and Magruder (2013) by clustering at the policy group (province/minimum wage regime) level and allowing for spatial autocorrelation.

4.2. Two-Way Fixed Effect Approach

Our DSD method addresses endogeneity concern, which comes from the correlation between minimum wage and time-varying unobserved economic circumstances. Despite the appeal of the DSD approach, we still want to consider criticism of the DSD method brought by Neumark et al. (2014) and Neumark and Wascher (2017). Neumark et al. (2014) argue that the borderline approach discards too much valid identifying variation in pursuit of ideal counterfactuals as the approach substantially reduces samples to individuals residing in the districts where minimum wages of contiguous districts differ. The potential alternative approach that addresses lack of identifying information from DSD approach is to use traditional two-way fixed effect (TWFE henchforth) approach with the inclusion of regional time trend or regional macro variables. If districts or provinces with greater employment growth are more likely to raise their minimum wage, then inclusion of regional time-trend can effectively account for this confounding variance. Majority of studies of the minimum wage followed this strategy. Nevertheless, Meer and West (2016) demonstrate that if the minimum wage has dynamic impacts on the evolution of outcome variables, the estimation technique that includes regional-specific time trends is likely to attenuate estimates of the treatment effect. Taking these reasons into consideration, we proceed with estimate using the traditional two-way fixed effect with and without trend. Including province-specific log of GDP further attenuate concern for omitted variable bias. The following equation is the two-way fixed effect regression model used for the robustness check:

$$(13)\ y_{ist} = \beta MW_{st} + \gamma X_{ist} + \eta GDP_{st} + \theta_j + \delta_t + (\eta_s * t) + u_{ist}$$

where $j = i$ (individual) or s (district), and $\eta_s * t$ are district-specific linear time trends. With IFLS data, we take advantage of individual-level panel data by controlling the individual fixed effect, θ_i. With IS data, we only offer results with a district fixed effect, θ_s, due to its lack of information on plant ID for 2002 and 2003. Whenever our sample spans across years without omitting years in between, we also report our results with the inclusion of district time-trend. For instance, when using IFLS data, we do not control for the district-specific time trend because we only have three rounds of data with a seven-year gap between surveys: we cannot restrict the identifying information based on the deviation of three data points from district-specific linear time trends. When we use the IS data, we include district-specific time trends as interval of survey is only one year. Then the identifying assumption is that, after controlling for individual characteristics and the provincial macroeconomy, the outcome of interest would have followed a similar trend across provinces, if not for the differential changes in the minimum wage level.

4.3. Non-compliance to the minimum wage

There are several econometric issues to deal with when examining the employer's incentive to comply with the minimum wage (Ham, 2018). First, the firm's willingness to observe the minimum wage regulation depends on the intensity of government surveillance; however, data to quantify it is not always available. Second, it is challenging to identify the control and treatment groups clearly. For instance, let us suppose that we want to test how a firm's size affects the observance of the law against uncertain minimum wage hike. During the period of study, certain individuals may sort into larger firms if they are more likely to earn minimum wage in larger firms, contaminating the control and treatment groups. Third, firm-level data has a potential for misreporting: firms may not accurately report wage payments if they violate the minimum wage law.

Though we are not able to address the intensity of government surveillance, it is possible to address the misreporting and group identification issues by using individual-level panel data (IFLS). Specifically, using individual-level data alleviates the systematic misreporting issue, and panel data allows us to clearly identify the treatment and control groups. Here, we use workers in medium-sized firms (with between 5 and 199 employees) as a treatment group and workers in large-sized firms (with more than 200 employees) as a control group to compare the non-compliance rate in reaction to the 2013 extraordinary minimum wage raise. Several empirical studies find the importance of firm size in determining minimum wage compliance, as large businesses are subject to more stringent government monitoring and fines and hence are more likely to adhere to minimum wage regulation. For example, Harrison (2010) studies the effect of the anti-sweatshop movement on wage growth in Indonesia. The result shows that targeted foreign-owned, large-sized firms under the high intensity of surveillance increased their wage payment compare to small firms.

Panel A of Figure 5 illustrates the time trend of the relative ratio of the minimum wage over the median wage. Panels B and C show compliance with the minimum wage regulation by firm size across three periods. As mentioned in Section 2, successful labor union negotiations caused a surge of the minimum wage in 2013. The Jakarta Report described this unusual surge as an unexpected shock to most firms, and there is a steep increase in the minimum wage-median wage ratio in 2014. When we look at the Panel C, we observe that non-compliance ratio for firms in the medium-sized firms (5-199 employees) and large-sized firms decrease slightly between 2000 and 2007, though it decreases faster for large firms (>200 employees). Between 2007 and 2014, however, we can observe that the non-compliance ratio for medium-sized firms increases, whereas the large-sized firm does not change. It seems that minimum wage hike especially increases non-compliance ratio for medium-sized firms as government monitoring activities were relatively not as intense as they were for large-sized firms. We test this hypothesis formally with the following regression specification:

$$(14)\ BMW_{ijt} = \alpha + \beta D_{ijt} + \gamma X_{ijt} + \lambda_i + \delta_t + u_{ijt}$$

Here j is the firm-size category, and BMW_{ijt} is a binary indicator that identifies a worker i in the province firm-size category j at time t paid below the minimum wage. D_{ijt} is the interaction term between the treatment group indicator and the year 2014 indicator. We regard the 2013 event as an exogenous policy shock to firms. The treatment and control groups were constructed using a subsample of full-time formal sector wage earners who remained at the same firm for more than two consecutive rounds. The control group consists of full-time workers who remained in firms with more than 200 employees. The treatment group consists of full-time workers who remained in firms with 5-199 employees. This regression tests how firms whose expected fine payment is small compared to the control group respond to the unanticipated minimum wage hike. The method assumes that in the absence of the unexpected minimum wage change in 2013, the compliance ratio in medium-sized firms would follow a similar trend to that of large-sized firms.

The coefficient on the interaction term, β, captures the average difference in non-compliance to the minimum wage law across the treatment and control groups before and after 2013. We also estimate an expanded version of this equation, where the treatment identifier interacts with dummy variables for each year. This regression specification tests the parallel trend assumption of difference-in-difference, and thus examine the validity of difference-in-difference strategy to test for non-compliance with the minimum wage law. In the next session, we report estimates of the minimum wage impact on employment, wages, monopsony indices, and non-compliance.

4.4. Empirical Results on Labor Market Outcomes

In this subsection, we present our empirical findings about the impact of the minimum wage on employment, wages, and economic rents, as assessed by a variety of monopsony indicators. We also report the non-compliance ratio of medium-sized firms to compare to that of the large-sized firms.

Table 3 presents the regression results for various categories of employment in response to real minimum wages using SD, DSD, TWFE methods. To demonstrate the validity of the findings, the table presents SD and DSD estimates with varying bandwidths used to define contiguous districts. Binary indicators for each category of employment are constructed and used as dependent variables. Individuals who work in the government or the private sector fall under the formal sector group. Respondents who work in the formal sector more than 40 hours per week are classified as full-time formal. Respondents who work in the formal sector for fewer than 40 hours are classified as part-time formal. The Self-Employed group comprises respondents who are either self-employed or self-employed with family members. To define Family Business, we add unpaid family workers to the preceding group. The regression results report the probability of being in each employment category compared to being in another category of employment.

The DSD regression results for employment status show that a rise in the minimum wage is not statistically significantly related to employment status. If we increase our control sample to increase statistical power at the expense of allowing potential endogeneity, DSD estimator starts to show statistically significant results: at the bandwidth of 60 miles, we find a 10 percent increase in the minimum wage is positively related with an increase in formal sector employment of 1.1 percent and a decrease in family businesses of 1.2 percent. These estimation results, though not statistically significant across different bandwidth, suggest rather unconventional outcomes such as informal sector workers' sorting into the formal sector in response to minimum wage increase. Also, DSD estimator suggests that part-time workers are negatively related with minimum wage increase, and it shows statistically significant effect at the bandwidth of 40 miles. If we consider part-time workers marginal workers, our estimates indicate that formal sector marginal workers are more likely to lose their jobs due to the minimum wage increase.

Our results with SD and TWFE regressions show statistically significant results. The results with the SD specification is more pronounced in magnitude compre to DSD estimates, which can be attributed to the absence of district dummy variables. TWFE estimates are somewhat similar to those of DSD, and we find statistically significant and positive effect on formal sector employment and negative impact on family business. The only noticeable difference compare to SD and DSD estimator is on Part-Time formal sector workers: TWFE results show positive relation betwen minimum wage and part-time workers, whereas SD and DSD results show negative coefficients. In overall, our regression results suggest that we have do not have a convincing evidence on the positive (negative) effect of minimum wage on formal (informal) sector employment, whereas the evidence against the minimum wage's disemployment effect on formal sector is strong.

Plant-level data further support the results with the IFLS sample. In Table 4, we present our estimation results for the number of plant-level employees. We present three sets of results by regressing on total workers, production workers, and non-production workers with SD, DSD, and TWFE respectively. Except SD method, we do not find statistically significant association between minimum wage and number of workers, with the exception of the 25-mile bandwidth for DSD estimation. Given that the estimation results from TWFE with and without the inclusion district time trend are qualitatively similar to our results from the DSD specification, it appears that SD results are skewed upward, highlighting the importance of controlling for fixed effects. Overall, the results suggest that the minimum wage has no negative effect on employment in the formal sector. The fact that none of our results suggest a negative effect of the minimum wage on employment is consistent with the monopsonistic competition theory.

These findings are consistent with Magruder (2013) and Hohberg and Lay (2015), who also used IFLS data, but are not consistent with Harrison and Score (2010) or Del Carpio et al. (2015), who used IS data. Harrison and Score (2010) and Del Carpio et al. (2015) used IS data to discover a statistically significant negative impact of the minimum wage. The results with IS data in this paper differ from their results due to several reasons. First, our paper uses different sample periods compare to the other two works. Harrison and Score used date from period 1988 - 1996 when the central government still determined the minimum wage in Jakarta. In contrast, our sample comes from the periods when each province had its jurisdiction to set the minimum wage considering the status of the local economy. The analysis of Del Carpio et al. (2015) uses the same years between 1993 and 2006. During the periods, the Indonesian economy experienced a financial crisis, the demise of Suharto, and the decentralization of the bureaucratic regime. It is well known in the literature that during an economic recession, labor protection regulations such as minimum wage amplify the negative employment effect as market wages are often lower than minimum wage. In contrast to their analysis, we restrict our samples to the periods when the economy stays on a steady growth phase, as our paper aims to understand the impact of the minimum wage on steady-state employment: the Indonesian economy, from 2000 to 2014, did not experience a significant downturn but shows a steady increase in gross domestic product per capita. Second, our paper uses district-level minimum wage. While there were only five provinces that exhibited within-province variance in minimum wage during 2000, by 2014, at least 14 out of Indonesia's 34 provinces had within-province variation in the minimum wage. To the best of our knowledge, our paper is the very first attempt to use all the district-level minimum wage variation across the time span between 2000 and 2014. Third, our DSD estimator lessens the common trend assumption of fixed effect approach used by both papers.

Tables 5 and 6 report the effect of the minimum wage on the average wage using IFLS and IS sample respectively. We find a statistically significant and positive wage effect for individuals and plants directly affected by the minimum wage across different estimation methodologies. From the IFLS sample, the DSD estimator suggests that a 10 percent increase in the minimum wage is associated with 8-10.5 percent wage increase for formal sector workers. The reason that we observe more than 10 percent of the wage increase in response to a 10 percent increase in the minimum wage with IFLS data is that the estimation also contains individuals who sort into a wage-earning job. The SD estimator finds larger coefficient compare to the DSD estimator, as was the case for employment regression results. TWFE estimator shows smaller effects compare to DSD method. Compared to the DSD estimation, where the district fixed effect is controlled for, controlling for individual fixed effects appears to absorb more considerable impacts previously attributed to minimum wage.

In addition to the overall effect, it is also interesting to study the heterogeneous effect of minimum wage on workers who are initially paid less than the minimum wage and those who are initially paid more than the minimum wage. Basu et al. (2010) predict that if there is incomplete monitoring for the minimum wage law and the fine increases in proportion to the amount of gap between minimum wage and equilibrium sub-minimum wage, initially non-complying firms will further reduce wage in response to minimum wage. However, empirical work often finds increases in sub-minimum wage in response to the hike of the legal minimum wage (Cunningham, 2007). Our regression results support the results of Cunningham (2007) and validate the prediction of our theoretical model. Notably, the DSD estimator finds that wage increase for the initial sub-minimum wage-paid group is greater than for the other group whose initial wage is higher than the minimum wage at the bandwidth of 35, 40, 60 miles. The similar pattern is observed with the TWFE estimator and SD estimator across all bandwidths: the initial sub-minimum wage-paid group's wage increase is greater than that of the initial over-minimum wage-paid group's, supporting proposition 6. We consider that the findings of DSD estimation with a bandwidth of 25 and 30 differ from those with larger bandwidths due to smaller sample sizes and dummy variables. When the regression model has a limited sample size and extensive controls, a small number of outliers can significantly impact the estimation results.

Regression results with IS data are also consistent with the analysis with IFLS data, except that the coefficient is much smaller now. Our DSD estimate indicates that with a 10 percent increase in the minimum wage, average wage increases by 2.9 - 4.9 percent for all workers, 2.7 - 4.8 percent among production workers, and 4.7 - 5.4 among non-production workers, respectively. Again, the relevance of controlling for district fixed effect is demonstrated by the fact that our TWFE results are comparable to those of DSD, while SD estimates are substantially higher. Overall, these empirical findings support the validity of our model, which predicts that minimum wage affects earnings in various labour market segments and the entire wage distribution (Proposition 3).

Table 7 presents regression results on the minimum wage's relationship to market distortion indices. As explained in Section 2, if the gap between the marginal revenue of labor and wage comes from the monopsonistic behavior of employers, minimum wage regulations could work as a market correcting tool and reduce market distortions. We study this hypothesis by studying the relationship between minimum wage and various market imperfection indices. Market imperfection indices, as measured by Pigou's E, CRS Markdown, CD Markup, and Markup, are regressed on the minimum wage using SD, DSD, and TWFE, respectively.

Our most persuasive regression results are (i) DSD and (ii) TWFE with district-specific time trend if its coefficients do not significantly differ from TWFE without district-specific time trend. As explained in Sections 4.1 and 4.2, the SD estimator may be prone to omitted variable bias, and the TWFE without controlling for district-specific time trend may be vulnerable to differing pre-trends. However, if the inclusion of time trend on TWFE significantly differs from TWFE without time trend, we should be suspicious of the dynamic effect of the minimum wage on outcome variables (Meer and West, 2016). From this perspective, our findings indicate that an increase in the minimum wage reduces firms' monopsony behaviour, particularly for non-production workers, although not all of our estimation results reveal a statistically significant effect across various estimation methods and bandwidth selections. While our DSD estimator finds only statistically significant and negative impacts of minimum wage on Pigou's E at the 60 mile bandwidth, TWFE estimators with and without the inclusion of district time-trend reveal the same negative and statistically significant effects: 10 percent increase in the minimum wage is associated with 1.1 percent decrease in Pigou's E using a DSD estimator with a 60-mile bandwidth and a TWFE estimator with district-specific time trend.

Estimation results on Markdowns suggest that the reduction in overall monopsony behaviours as assessed by Pigou's E is driven by firms' monopsony behaviour toward non-production workers. The DSD estimate indicates that the minimum wage has a statistically significant negative effect on CRS markdowns for non-production workers at 25, 30, and 40 miles. When CD markdowns are the dependent variable, the DSD estimator reveals statistically significant negative effects of the minimum wage only at a bandwidth of 25 miles. Although our DSD regression results on markdown indices for non-production workers are not robust across different bandwidths, estimation results from the TWFE estimator with district-specific time trends comparable to TWFE estimation without the trends imply that minimum wage has a statistically significant negative effect on markdowns. According to the DSD estimate, a 10 percent rise in the minimum wage is related with a 2.7-3.4 percent reduction in CRS Markdown and a 2.9 percent decrease in CD Markdown for non-production workers. Using TWFE with district-specific time trend, we find 10 percent increase in minimum wage is related with 1.3 percent drop in CRS Markdown for non-production workers and 1.7 percent decrease in CD Markdown for non-production workers.

Interestingly, our estimation results suggest that CD Markdowns and CRS Markdowns for production workers are not statistically significantly related with the minimum wage. Only findings from TWFE without trends, which are vulnerable to the potential endogeneity, provide negative coefficients with statistical significance. Our DSD estimates for CD Markup show a statistically significant and positive effect. The results infer that the rise in the minimum wage forces some firms to exit the market, while the surviving firms improve their output market share which reflects in Markup index.

Table 8 presents estimation findings for equation (13), which compares the noncompliance practises of medium-sized enterprises (treatment group) and large firms (control group) in reaction to the unexpected increase in the minimum wage in 2013. In reaction to a 10 percent increase in the minimum wage, the non-compliance ratio rises by 0.7 to 0.8 percent, as shown in the table. This result is robust to the inclusion of dummy interaction terms. This finding indicates that medium-sized firms tend to break minimum wage regulation in the presence of the unexpected minimum wage shock.

Overall, our empirical results support the predictions of our structural model. Historical increase in minimum wage during 2000~2014 in Indonesia has increased overall wage distribution across different segments of labor market without decreasing employment in the formal sector. Our regression results also support the model's mechanism on firms' monopsonistic competition which reduces economic rents of remaining firms. Lastly, the growth in non-compliant wage payments in response to the 2013 minimum wage increase among small and medium-sized firms validates our theoretical model, which theorises the optimal decision of smaller firms, which are less susceptible to government surveillance activity. These estimation results are robust when we only only sample of individuals without migration history, which is reported in Appedix D.

5. Conclusion

In this paper, we analyze the role of the minimum wage on the labor market in Indonesia.

Similar to other developing countries, Indonesia has a substantial proportion of its labor force involved in informal sector economic activities, and the formal sector labor market is imperfect as reflected by informational frictions and the sizable positive gap between the marginal revenue of labor and the wage payment. Interestingly, the informal sector in Indonesia may differ from that of other developing countries in that it exhibits significant income heterogeneity; there is a sizeable proportion of workers whose income is substantially higher than that of formal sector wage earners, while the majority of their income is lower.. Predicting the impact of minimum wage on this labor market environment is far from clear as both labor demand and supply are affected by the minimum wage increase.

To help in understanding the underlying mechanism of the labor market coherently, we construct a structural search model in the spirit of Burdett and Mortensen (1998). The key feature of the model is to incorporate the employers' non-compliant behavior into the framework of Burdett and Mortensen. Introducing heterogeneous firm productivity and worker's reservation payment enables allows for a rich mechanism that can explain both labor supply and demand. A binding minimum wage generates spillover effects on the whole wage distribution, generated by monopsonistic firms engaged in a wage-posting competition. The increase in wage posting distribution generates an incentive for some informal sector workers to find jobs in the formal sector, whereas some marginal workers in the formal sector can be rationed out. While the model leaves open the possibility of a positive or negative effect of minimum wage on employment, it does provide an unambiguous conjecture for an increase in wage payment, a reduced gap between marginal labor productivity and wage, and an increase in the ratio of non-compliance with minimum wage regulations amongst smaller sized firms. Our structural model is grounded in the documented facts of the existing labor market in developing countries, and policymakers can use the model for policy implementation.

We use unique historical Indonesian minimum wage data from 2000 to 2014 to conduct a regression analysis, and confirm the prediction of the model. Using the sample of workers who live in the nearby the province/district border, we conduct a difference-in-spatial-difference (DSD), approaches that weakens the assumption of both regression discontinuity and difference-in-difference. When the data structure justifies the inclusion of trends, we also do traditional two-way fixed effect (TWFE) analyses that include district-specific trends. Our regression results indicate that a rise in the minimum wage has no detrimental effect on employment, contrary to what a competitive labor market would predict. In addition, our empirical findings demonstrate a positive effect of the minimum wage on the average salary (for both the initially sub-minimum wage paid and the over-minimum wage paid workers) and a negative effect on the economic rents of monopsonists. Our difference-in-difference results support the model's prediction that the minimum wage hike in 2013 increased the non-compliance rate for medium-sized enterprises relative to large firms.

This paper points to interesting future work. First, our model can easily be expanded to study the occupational choice between a formal sector entrepreneurial job and a formal sector wage-earning job, from which we have abstracted. A significant and robust increase in the minimum wage gives more incentives to individuals to earn a formal sector wage-earning job, and less incentive to become an entrepreneur in the formal sector. Until now, this potential channel of occupational choice has not been modeled as literature on minimum wage is primarily focused on developed nations. Considering that minimum wage does affect the whole wage distribution in developing countries, including on more layer of occupational choice into the existing model can shed additional light on the study of labor protection policy. Second, our study leads us to investigate further how firms respond to the other existing labor market regulations. Our current analysis abstracts from the interaction of different labor protection institutions. A minimum wage increase may incentivize firms to violate other regulations, such as mandatory health insurance or severance costs. Including these factors into the existing model can further our understanding of the effect of minimum wage on the firms' compliance behavior of other labor protection regulations. Third, our analysis directs us to study the welfare implication of the minimum wage regulation. While our empirical results seem to suggest increased welfare of the overall workers, imperfect monitoring of the regulation still induce firms to hire workers with illegal wages. These two conflicting effects prevent us from providing a definitive answer about the effect of the regulation on social welfare, and the analysis belongs to future work.

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Figures

Figure 1. Ratio of Formal/Informal Sector Workers by Income Decile

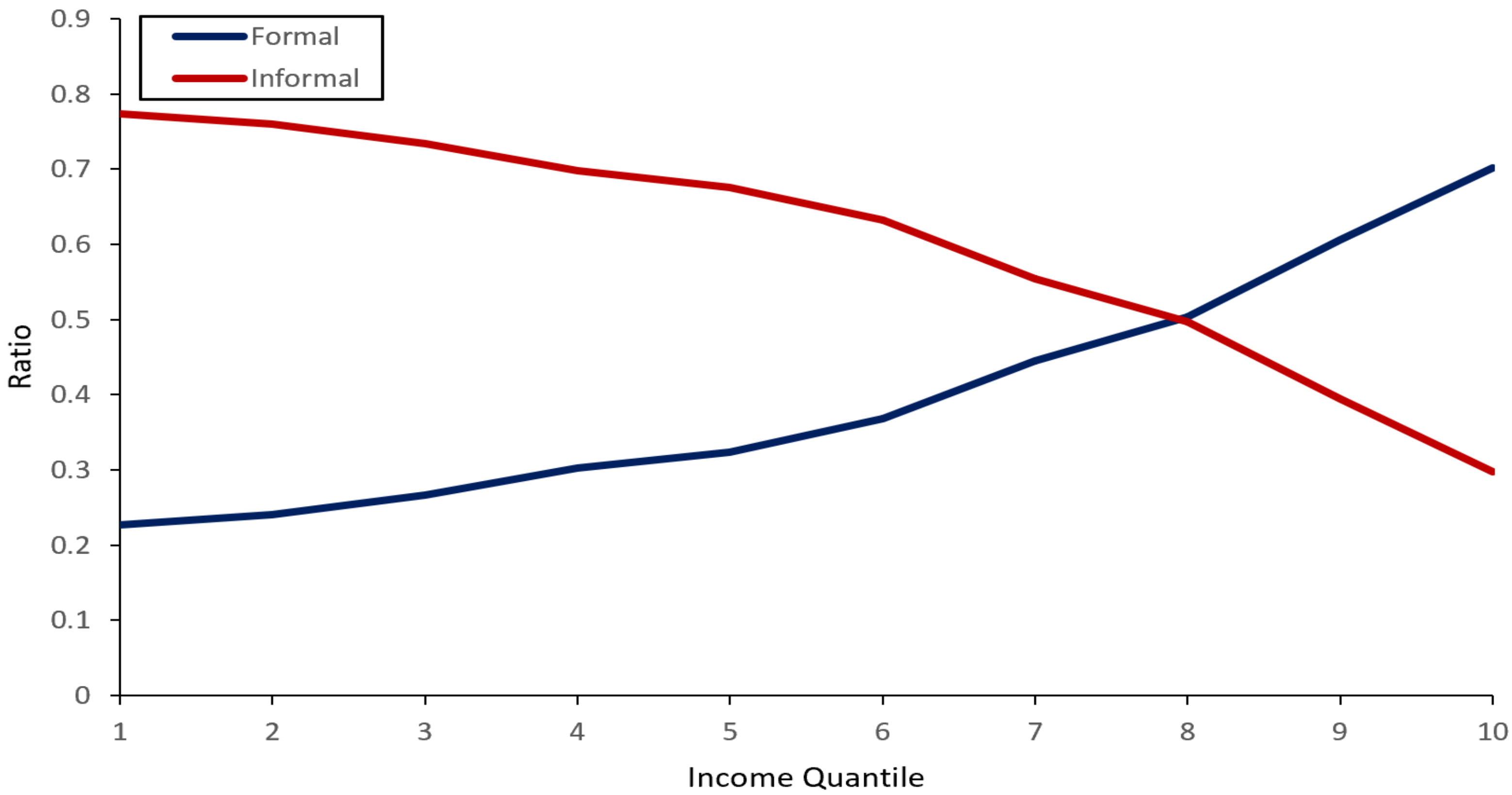
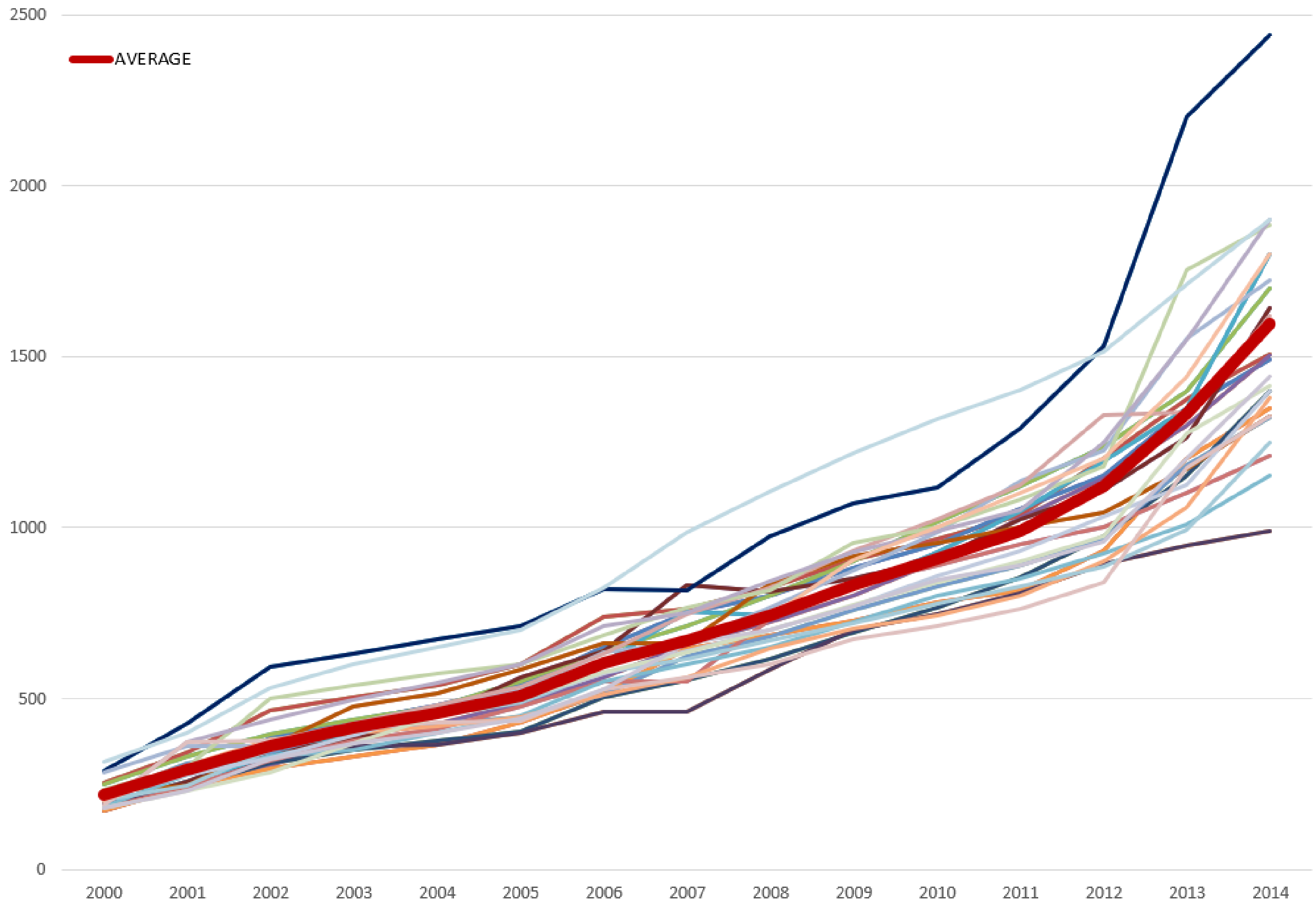


Figure 2A: Real Minimum Wage by Province



Notes: We use a province-specific CPI to deflate minimum wages. Both the CPI and the province level minimum wages are from the Indonesia's Central Bureau of Statistics (BPS). The BPS provides a CPI for different cities across the country. We match the CPIs of the capital city with each province to create a CPI measure for each province in each year. Each line represents a different province and the thick line is the simple average across all provinces for each year. The base year for deflating with the CPI is 2007.

Figure 2B: Nominal Minimum wage by District in 2000

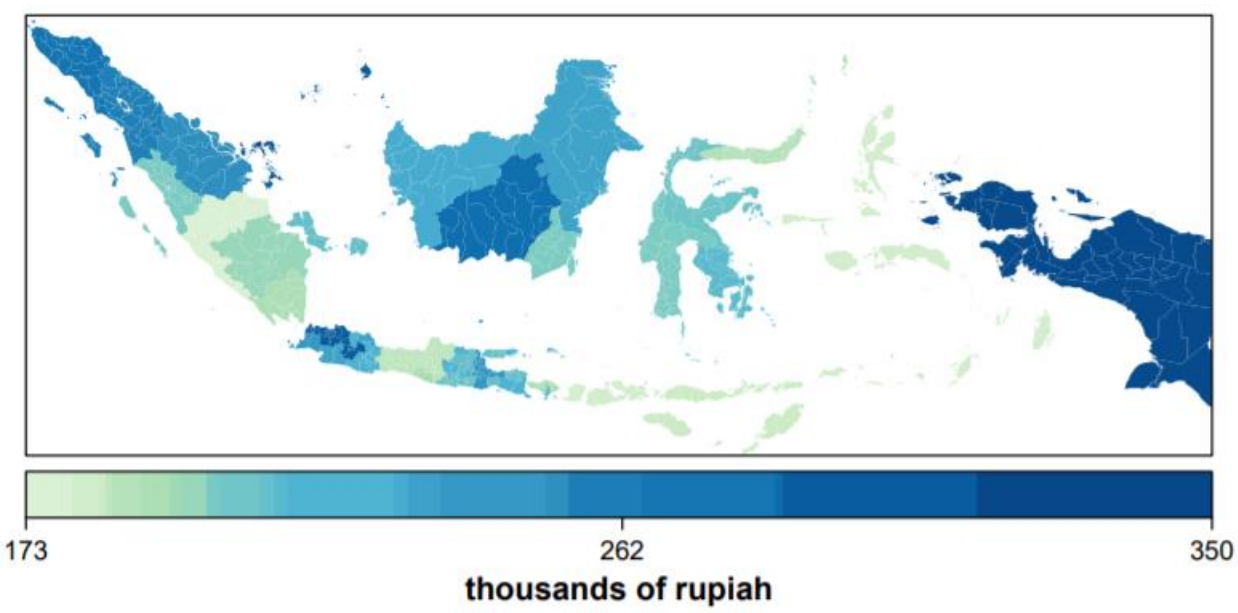


Figure 2C: Nominal Minimum wage by District in 2007

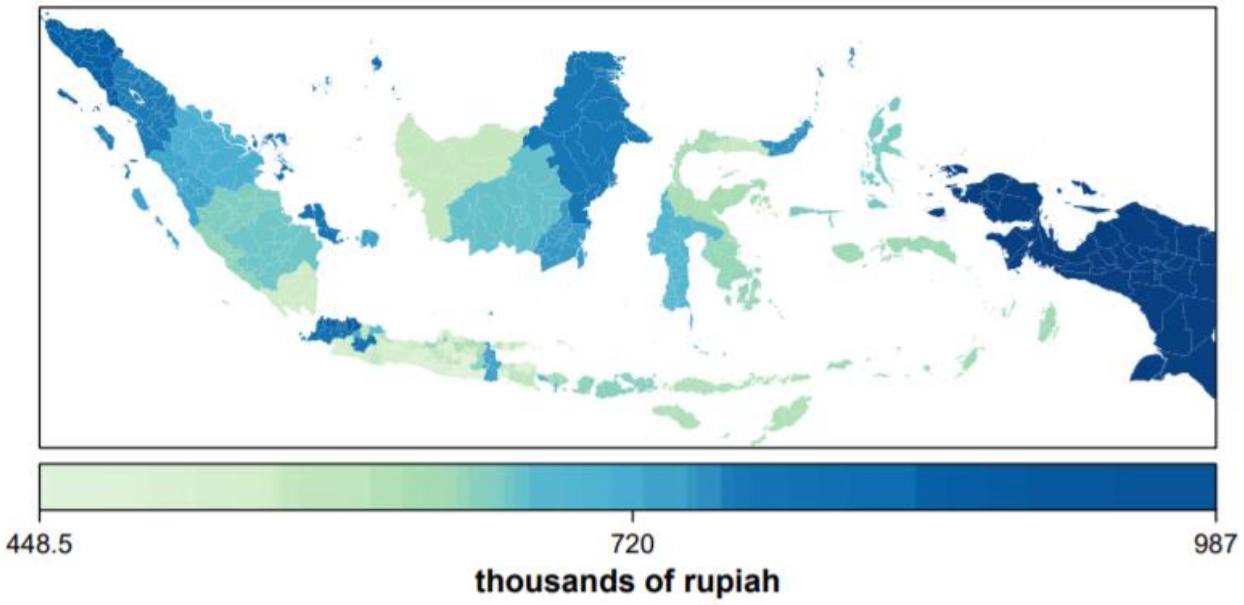


Figure 2D: Nominal Minimum wage by District in 2014

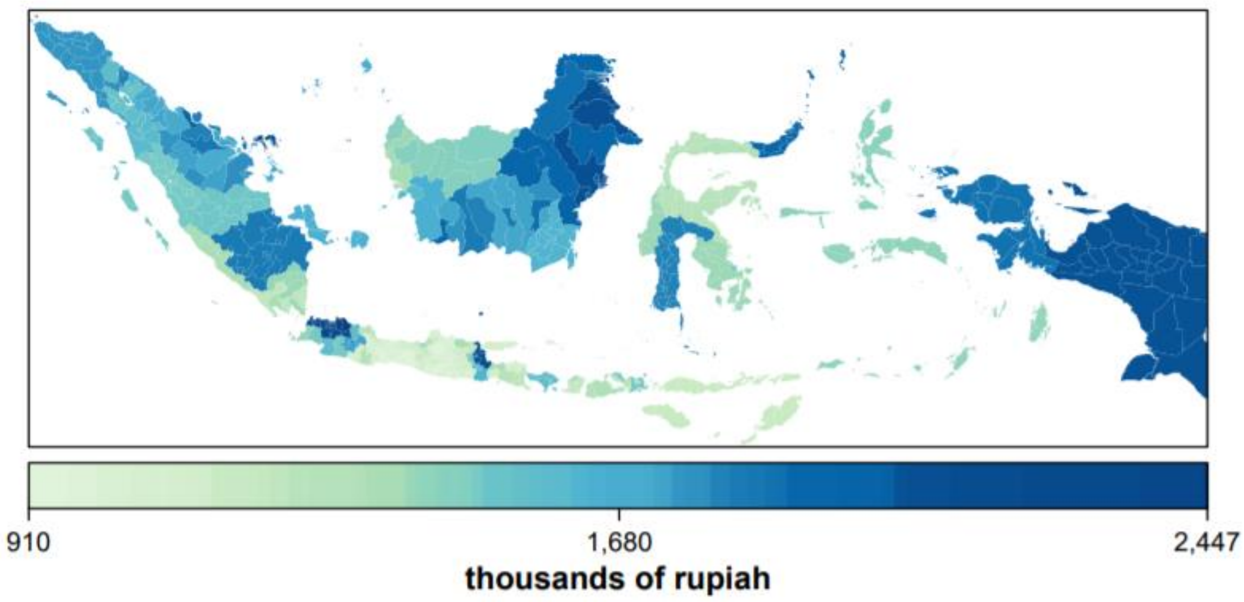
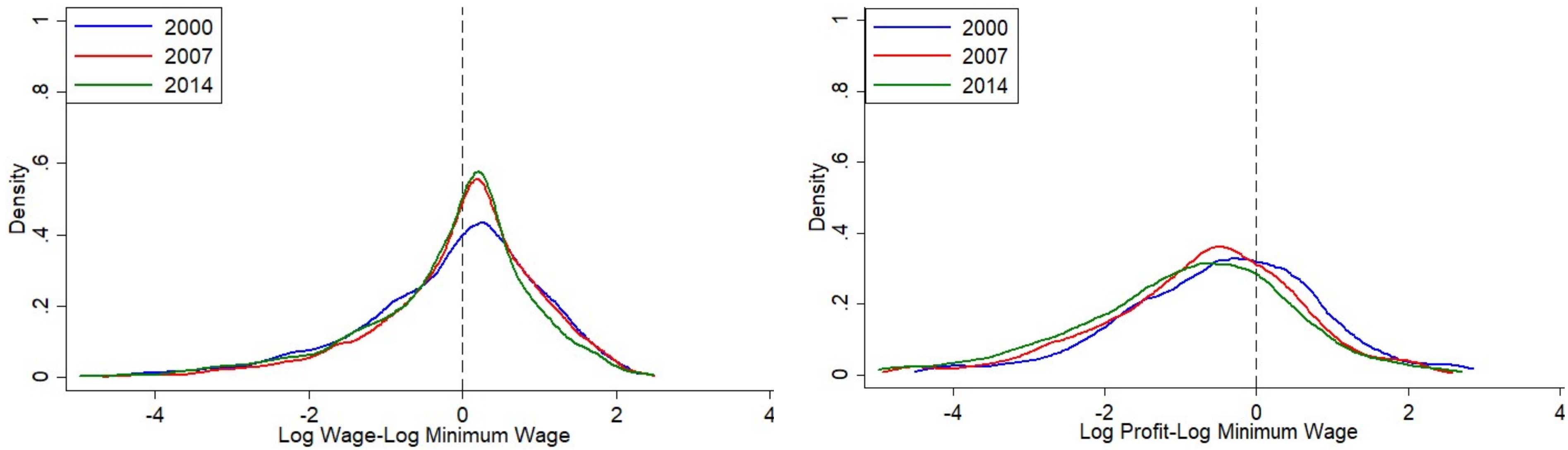


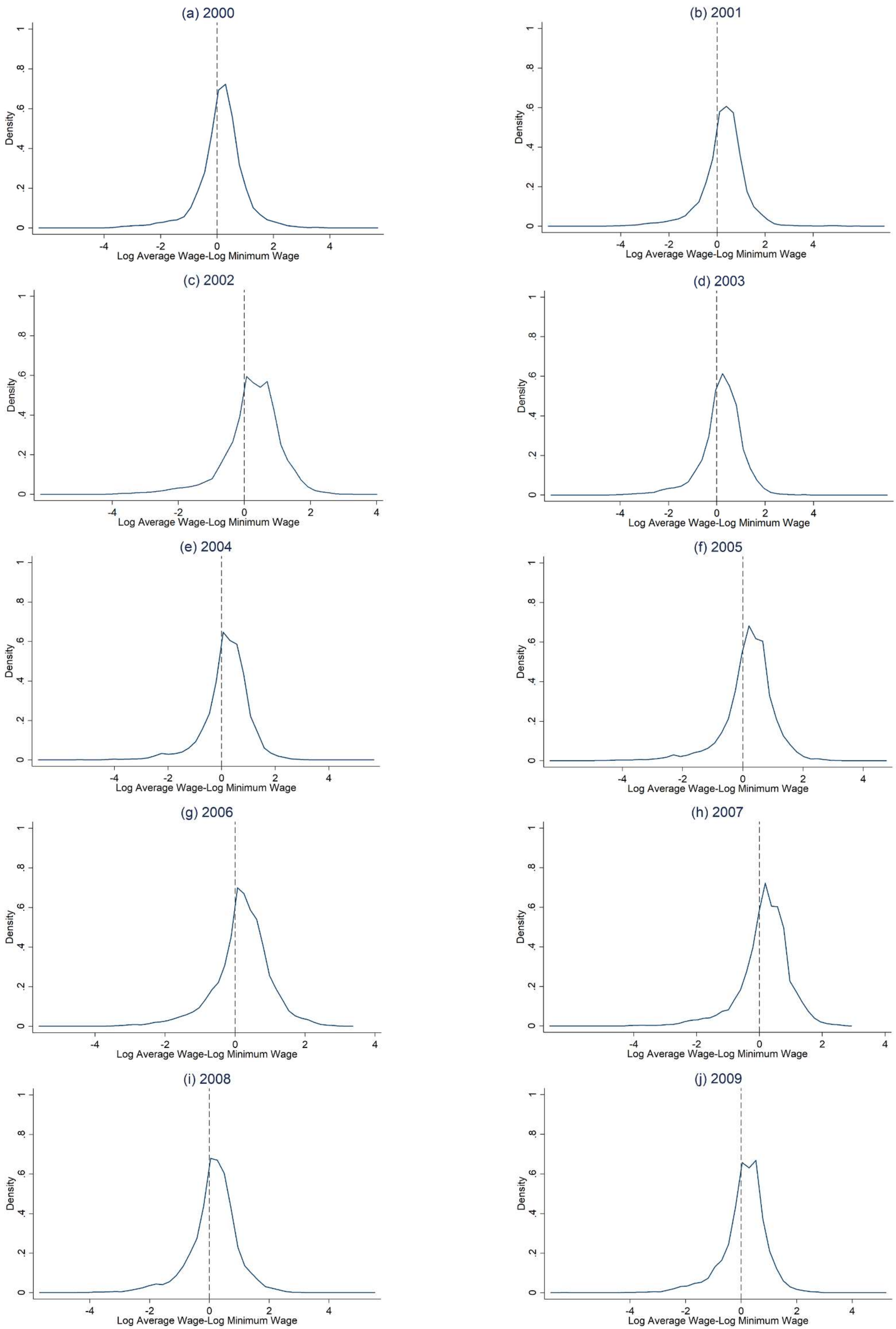
Figure 3A. Kernel Densities of Log Earnings Normalized to Minimum Wage

Panel A: Wage distribution **Panel B: Profit distribution**



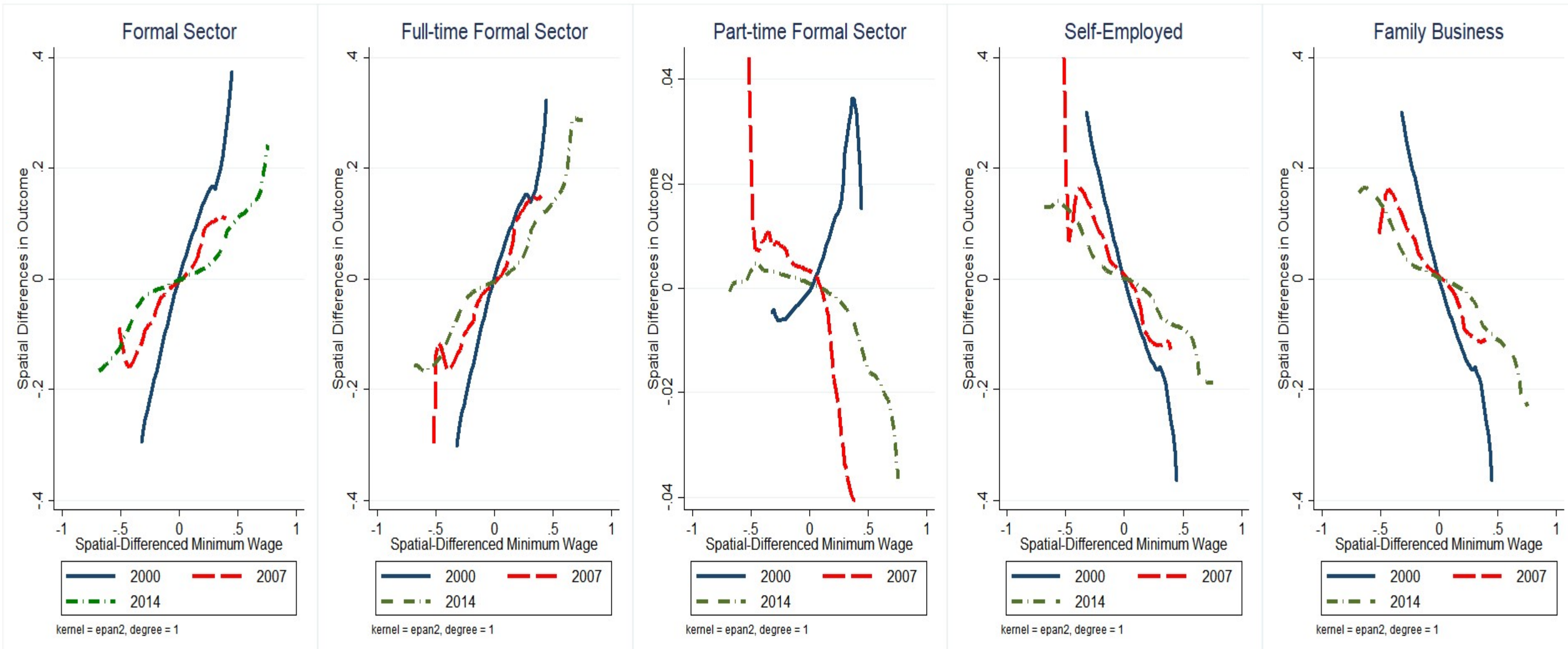
Source: Indonesian Family Life Survey (2000,2007,2014)

Figure 3B. Kernel Densities of Log Average Wage per Firm Normalized to Minimum Wage



Source: Industry Survey (2000~2009)

Figure 4. Spatial Variation in Outcomes and Minimum Wage

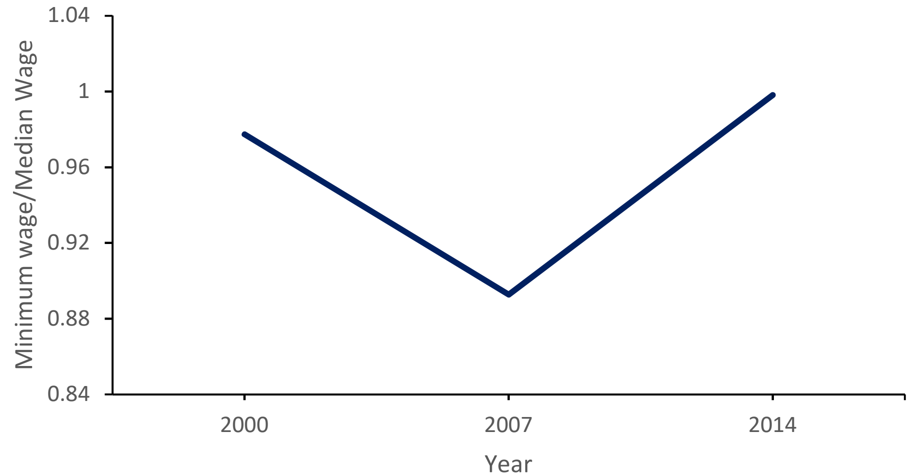


Source: Indonesian Family Life Survey (2000,2007,2014)

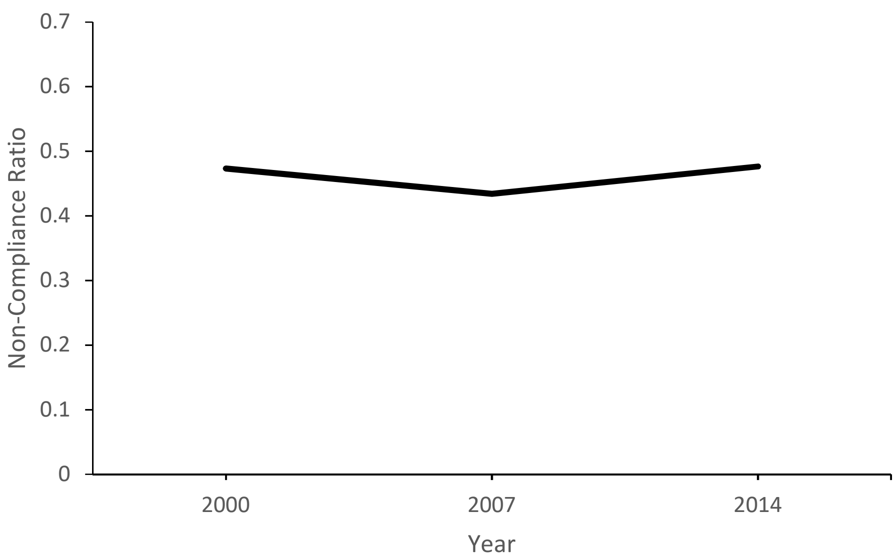
Notes: The graph plots the spatial difference in employment status as a function of the spatially-differenced minimum wage. We define respondents who work either in the government or private sector as formal sector workers (Formal Sector). Among them, respondents working more than 40 hours are defined as full-time workers (Full-Time Formal Sector). Respondents working less than 40 hours are defined as part-time workers (Part-Time Formal Sector). Respondents whose working status are either self-employed or self-employed with family members are categorized as self-employed (Self-Employed). We include unpaid family workers to the previous category, Self-Employed, to define Family Business.

Figure 5. Relative Stance of Minimum Wage and Non-Compliance Ratio to Minimum Wage

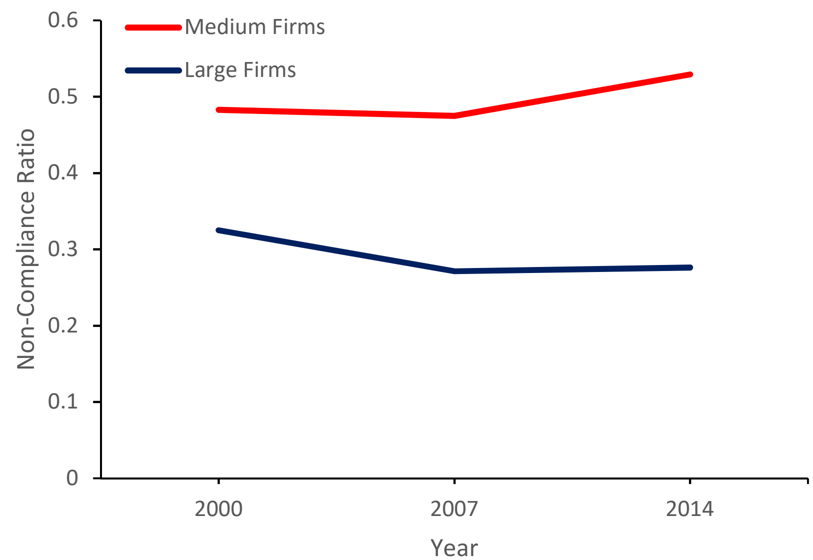
Panel A: Minimum Wage to Median Ratio



Panel B: Overall Ratio of Non-Compliance to Minimum Wage



Panel C: Ratio of Non-Compliance to Minimum Wage by Firm Size



Source: Indonesian Family Life Survey (2000,2007,2014)
Notes: The graphs come from the sample of full-time formal sector workers who remained in similar-sized firms more than two consecutive survey rounds. Sample of workers in the firms with size between 5 and 199 is categorized in medium-sized firms; more than 200 in large-sized firms accordingly.

Tables

Table 1. Descriptive Statistics by Formal and Informal Sector

	Formal Sector Worker	**Informal Sector Worker**
Employment		
Working Hours per Week	44.884 [18.418]	40.283 [24.644]
Log Real Earning	15.650 [1.334]	15.167 [1.404]
Job Size Category[1]	2.491 [1.316]	1.197 [0.565]
Composition across Industries		
Agriculture, Forestry, Fishing	0.222 [0.416]	0.770 [0.421]
Mining and Quarrying	0.472 [0.499]	0.510 [0.500]
Manufacturing	0.531 [0.499]	0.446 [0.497]
Electricity, Gas, Water	0.673 [0.469]	0.314 [0.465]
Construction	0.596 [0.491]	0.388 [0.488]
Wholesale, retail, restaurants	0.261 [0.439]	0.713 [0.452]
Transportation, storage, communication	0.473 [0.499]	0.513 [0.500]
Finance, Insurance, real estate, and business services	0.560 [0.496]	0.415 [0.493]
Social services	0.708 [0.455]	0.279 [0.448]
Individual Characteristics		
Share of Male	0.628 [0.483]	0.528 [0.499]
Age	33.373 [10.767]	38.514 [12.580]
Education Level[2]	2.499 [1.142]	1.719 [1.047]
Share of Urban Pop	0.680 [0.466]	0.416 [0.493]
Log Household Asset	21.391 [2.006]	21.408 [1.753]
Share of Sample	0.418	0.565
Sample Number	24,531	33,160

Source: Indonesian Family Life Survey (2000,2007,2014)

Notes: In each survey year, top and bottom 1 percentile of earnings and household assets are winsorized.

[1] Job size data is divided into 5 different categories: 1. Between 1 and 4; 2. Between 5 and 19; 3. Between 20 and 99; 4. Between 100 and 199; 5. Mover than 200.

[2] Education data is divided into four categories: 0. No education; 1. Elementary 2. Middle School 3. High Scholl 4. University or Above.

Table 2. Descriptive Statistics for Indonesian Manufacturing Plants

	Obs	Mean	SD	Min	Max
Employment					
Log Total Workers	218,632	4.158	1.159	2.890	7.835
Log Production Workers	218,583	3.970	1.157	2.197	7.662
Log Non-Production Workers	193,627	2.126	1.443	0	6.203
Average Wage					
Log Average Wage (Rp)					
All	207,560	15.791	0.826	12.557	17.798
Production Workers	207,508	15.720	0.817	12.500	17.707
Non-Production Workers	166,976	16.187	1.033	11.098	19.028
Log Output (Rp)	201,671	22.071	2.068	17.852	27.704
Log Capital (Rp)	127,877	11.986	2.567	6.659	19.323
Log Material (Rp)	218,632	20.308	4.975	0	27.217
Log Fuel (Rp)	218,630	16.440	5.002	0	23.897
% of Foreign Ownership	218,632	0.078	0.268	0	1
% of Government Ownership	218,632	0.107	0.307	0	1
% of Export Status	218,632	0.298	0.458	0	1
Monopsony Index					
Log of Pigou's *E* (Total Workers)	188,291	1.799	1.164	-1.431	5.319
Log of CRS Markup (Total Workers)	201,288	0.242	0.552	-16.557	6.648
Log of CD Markup (Total Workers)	201,288	-0.230	0.745	-16.529	7.321
Log of CRS Markdown (Production Worker)	190,962	-0.823	1.056	-2.853	9.008
Log of CRS Markdown (Non-Production Worker)	154,728	-3.415	1.314	-6.881	11.931
Log of CD Markdown (Production Worker)	190,962	-1.151	1.437	-17.210	9.136
Log of CD Markdown (Non-Production Worker)	154,728	-3.804	1.629	-17.909	11.175

Source: Own calculations from IS surveys. (2000-2009)
Notes: IS data contain information for the number of production-related workers, non-production-related workers, total wage payment for production-related workers, and non-production-related workers. We use this data to calculate average wage payments for production-related workers and non-production-related workers. All values are in constant 2007 Rupiah (Rp). To calculate Pigou's *E*, we use average wage payment across all workers, and output value per worker ((Y/L-wage)/wage). Market shares are computed using 4-digit industries and province. We winsorize the 3 percent in both sides of the markup/markdown estimates of each 2-digit industry in given year.

Table 3. The Effect of Minimum Wage on Employment Status

VARIABLES	(1) Formal		(2) Full-Time Formal		(3) Part-Time Formal		(4) Self-Employed		(5) Family Business	
Individual FE	0.083**		0.055**		0.069***		-0.004		-0.085**	
	(0.033)		(0.026)		(0.016)		(0.028)		(0.040)	
	SD	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**
25 miles	0.270***	0.036	0.294***	-0.035	-0.026	0.004	-0.241***	-0.036	-0.249***	-0.037
	(0.091)	(0.070)	(0.088)	(0.046)	(0.017)	(0.029)	(0.093)	(0.041)	(0.083)	(0.064)
30 miles	0.293***	0.051	0.319***	0.018	-0.016	-0.001	-0.253**	-0.037	-0.274***	-0.047
	(0.103)	(0.051)	(0.096)	(0.028)	(0.037)	(0.025)	(0.111)	(0.041)	(0.099)	(0.052)
35 miles	0.246**	0.086	0.268***	0.045	-0.022	-0.020	-0.204**	-0.051	-0.236**	-0.090
	(0.108)	(0.066)	(0.086)	(0.039)	(0.036)	(0.028)	(0.105)	(0.053)	(0.106)	(0.064)
40 miles	0.260**	0.074	0.285***	0.050	-0.031	-0.039**	-0.241*	-0.056	-0.254**	-0.085
	(0.121)	(0.067)	(0.096)	(0.036)	(0.034)	(0.019)	(0.124)	(0.064)	(0.117)	(0.064)
60 miles	0.220***	0.106*	0.269***	0.082***	-0.051***	-0.011	-0.181**	-0.072	-0.219***	-0.120***
	(0.082)	(0.058)	(0.066)	(0.029)	(0.018)	(0.019)	(0.079)	(0.045)	(0.084)	(0.051)
Mean	0.403		0.277		0.131		0.495		0.578	
Observation	51,174		51,174		51,174		51,174		51,174	

Source: Indonesian Family Life Survey (2000,2007,2014)

Notes: All estimates are coefficients on log real minimum wages where the dependent variable is the binary indicator for individuals who work in the category in the column heading. We define respondents who work either in the government or private sector as formal sector workers (Formal). Among them, respondents working more than 40 hours are defined as full-time workers (Full-Time Formal). Respondents working less than 40 hours are defined as part-time workers (Part-Time Formal). Respondents whose working status are either self-employed or self-employed with family members are categorized as self-employed (Self-Employed). We include unpaid family workers to the previous category to define Family Business. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, dummy variables for (i) urban/rural residence, (ii) gender status, and (iii) labor force participation status, age and age squared, education level and education squared, and log of provincial GDP.

Table 4. The Effect of Minimum Wage on Plant-Level Employment

VARIABLES	(1) Total Workers		(2) Production Workers		(3) Non-Production Workers	
District FE	-0.029		-0.038		0.078	
	(0.135)		(0.118)		(0.187)	
District FE with district time-trend	-0.141		-0.155		-0.036	
	(0.124)		(0.113)		(0.151)	
	SD	**DSD**	**SD**	**DSD**	**SD**	**DSD**
25 miles	0.736**	0.182	0.607*	0.181**	1.443***	0.268***
	(0.292)	(0.089)	(0.313)	(0.086)	(0.204)	(0.092)
30 miles	0.745*	0.058	0.610	0.058	1.449***	0.226
	(0.382)	(0.090)	(0.402)	(0.088)	(0.241)	(0.095)
35 miles	0.646*	0.065	0.526	0.078	1.309***	0.202
	(0.356)	(0.148)	(0.382)	(0.128)	(0.217)	(0.147)
40 miles	0.565	0.050	0.449	0.051	1.194***	0.190
	(0.343)	(0.170)	(0.350)	(0.157)	(0.254)	(0.146)
60 miles	0.650*	0.123	0.525*	0.110	1.351***	0.267
	(0.300)	(0.187)	(0.301)	(0.165)	(0.297)	(0.197)
Mean	4.138		3.952		2.095	
Observations	209,462		209,414		184,819	

Source: Industry Surveys (2000~2009)
Notes: All estimates are coefficients on log real minimum wages where the dependent variable is the log values of dependent variables in the column heading. Industry Survey contains information for the number of production-related workers (Production Workers), and other workers (Non-production Workers) each plant hired. We combine the two different sets of workers hired in each plant to create the category, "Total Workers." Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: percentage of government ownership, foreigner ownership, log values of used material, log of provincial GDP, and export status.

Table 5. The Effect of Minimum Wage on Income by Employment Status

	(1)		(2)		(3)		(4)		(5)	
	Full-Time Wage Earner									
VARIABLES	**All**		**Sub-Minimum Wage Workers Initial Year**		**Over-Minimum Wage Workers Initial Year**		**Part-Time Wage Earner**		**Self-Employed Profit Earner**	
Individual FE	0.460***		0.671***		0.515***		-0.238		0.247*	
	(0.094)		(0.199)		(0.089)		(0.268)		(0.131)	
	SD	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**
25 miles	1.137***	0.796***	1.067***	0.592***	0.846***	1.100***	0.599	-0.112	0.766**	0.341
	(0.264)	(0.246)	(0.196)	(0.223)	(0.137)	(0.210)	(0.457)	(0.484)	(0.307)	(0.321)
30 miles	1.475***	1.057***	1.345***	1.100***	1.007***	1.162***	1.013*	0.214	0.712**	0.106
	(0.354)	(0.266)	(0.260)	(0.248)	(0.138)	(0.230)	(0.520)	(0.388)	(0.331)	(0.334)
35 miles	1.195***	0.924***	1.068***	1.136***	0.882***	1.003***	0.776**	0.328	0.690***	-0.075
	(0.223)	(0.184)	(0.192)	(0.217)	(0.116)	(0.152)	(0.371)	(0.292)	(0.249)	(0.228)
40 miles	1.133***	0.872***	1.085***	1.291***	0.785***	0.786***	0.636*	0.403	0.678***	-0.013
	(0.194)	(0.140)	(0.172)	(0.221)	(0.100)	(0.171)	(0.330)	(0.245)	(0.195)	(0.136)
60 miles	1.083***	0.805***	1.050***	1.113***	0.801***	0.782***	0.567***	0.382*	0.727***	0.068
	(0.087)	(0.142)	(0.145)	(0.207)	(0.088)	(0.127)	(0.180)	(0.212)	(0.137)	(0.102)
Mean	15.956		15.095		16.598		15.324		15.097	
Observations	13,926		5,950		7,976		6,566		18,522	

Source: Indonesian Family Life Survey (2000,2007,2014)
Notes: All estimates are coefficients on log real minimum wages where each dependent variable is the log values of earning for individuals who work in the category in the column heading. We define respondents who work either in the government or private sector as formal sector wage earners. Among them, respondents working more than 40 hours are defined as full-time wage workers. We further divide the sample into the two different groups: respondents whose wage at the initial year of sampling is smaller than minimum wage (Sub-Minimum Wage Workers), and respondents whose wage at the initial year of sampling is higher than minimum wage (Over-Minimum Wage Workers). Respondents working less than 40 hours are defined as part-time workers (Part-Time Formal). Respondents whose working status are self-employed, self-employed with family members or unpaid family workers are defined as family business profit earner. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, dummy variables for (i) urban/rural residence, (ii) gender status, and (iii) labor force participation status, age and age squared, education level and education squared, and log of provincial GDP.

Table 6. The Effect of Minimum Wage on Average Wage

VARIABLES	(1) Log Wage		(2) Log Wage (Production Workers)		(3) Log Wage (Non-Production Workers)	
District FE	0.467***		0.484***		0.403***	
	(0.064)		(0.063)		(0.058)	
District FE with district time-trend	0.339***		0.368***		0.311***	
	(0.057)		(0.047)		(0.061)	
	SD	DSD	SD	DSD	SD	DSD
25 miles	1.220***	0.291***	1.105***	0.271***	1.326***	0.482***
	(0.086)	(0.101)	(0.068)	(0.077)	(0.231)	(0.065)
30 miles	1.319***	0.316***	1.209***	0.304***	1.346***	0.522***
	(0.087)	(0.070)	(0.065)	(0.054)	(0.247)	(0.067)
35 miles	1.281***	0.300***	1.156***	0.292***	1.306***	0.472***
	(0.104)	(0.058)	(0.082)	(0.051)	(0.268)	(0.086)
40 miles	1.152***	0.346***	1.030***	0.323***	1.187***	0.541***
	(0.174)	(0.097)	(0.150)	(0.072)	(0.331)	(0.102)
60 miles	1.168***	0.486***	1.048***	0.483***	1.159***	0.474***
	(0.200)	(0.162)	(0.177)	(0.147)	(0.354)	(0.162)
Mean	15.789		15.720		16.187	
Observations	207,575		207,507		166,975	

Source: Industry Surveys (2000~2009)

Notes: All estimates are coefficients on log real minimum wages where the dependent variable is the log values of dependent variables in the column heading. Industry Survey contains information for the number of production-related workers (Production Workers), and other workers (Non-production Workers) each plant hired. We combine the two different sets of workers hired in each plant to create the category, “Total Workers.” Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: percentage of government ownership and foreigner ownership respectively, log values of used material, log of provincial GDP, and export status.

Table 7. The effect of minimum wage on Monopsony (FE and SD)

VARIABLES	(1) Pigou's E		(2) Markdowns (CRS)		(3) Markdowns (CRS)		(4) Markdown (CD)		(5) Markdown (CD)		(6) Markup		(7) Markup	
			Production Workers		Non-Production Workers		Production Workers		Non-Production Workers		CRS		CD	
FE	-0.245***		-0.170***		-0.138		-0.244***		-0.201		-0.038		0.070	
	(0.096)		(0.083)		(0.103)		(0.111)		(0.151)		(0.080)		(0.050)	
FE with district time-trend	-0.111*		-0.061		-0.127**		-0.100		-0.172***		-0.018		0.031	
	(0.065)		(0.086)		(0.050)		(0.106)		(0.055)		(0.040)		(0.046)	
	SD	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**
25 miles	-0.500**	-0.218	0.250	-0.255	-0.831***	-0.293**	0.486	-0.280	-0.629**	-0.293*	0.181***	-0.038	0.010	0.198***
	(0.247)	(0.174)	(0.249)	(0.199)	(0.156)	(0.143)	(0.424)	(0.230)	(0.291)	(0.164)	(0.045)	(0.121)	(0.175)	(0.055)
30 miles	-0.465	-0.051	0.318	-0.140	-0.887***	-0.347**	0.548	-0.120	-0.681*	-0.303	0.200***	-0.003	0.020	0.177***
	(0.285)	(0.141)	(0.296)	(0.161)	(0.218)	(0.168)	(0.526)	(0.210)	(0.408)	(0.206)	(0.050)	(0.084)	(0.240)	(0.052)
35 miles	-0.575***	-0.039	0.147	-0.114	-0.882***	-0.231	0.307	-0.064	-0.744**	-0.163	0.168***	-0.035	0.034	0.072
	(0.221)	(0.134)	(0.207)	(0.207)	(0.190)	(0.180)	(0.353)	(0.305)	(0.311)	(0.256)	(0.038)	(0.062)	(0.165)	(0.055)
40 miles	-0.520*	0.035	0.170	-0.033	-0.829***	-0.279*	0.313	-0.024	-0.699	-0.253	0.133**	-0.057	0.008	0.058
	(0.267)	(0.106)	(0.224)	(0.186)	(0.302)	(0.152)	(0.365)	(0.256)	(0.434)	(0.200)	(0.059)	(0.089)	(0.186)	(0.098)
60 miles	-0.515***	-0.117**	0.218*	-0.017	-0.787***	-0.046	0.411*	-0.013	-0.591*	0.010	0.133***	-0.005	-0.044	0.083***
	(0.215)	(0.052)	(0.125)	(0.147)	(0.242)	(0.112)	(0.213)	(0.164)	(0.318)	(0.140)	(0.023)	(0.061)	(0.104)	(0.021)
Mean	1.799		-0.823		-3.415		-1.151		-3.804		0.228		-0.229	
Observations	188,289		190,961		154,727		190,961		154,727		192,774		192,774	

Source: Industry Surveys (2000~2009)

Notes: All estimates are coefficients on log real minimum wages where the dependent variable is the log values of dependent variables in the column heading. Each column represents market distortion index calculated with different methods and sample. For the first column, total output per worker is used to calculate Pigou's *E* ((Y/L-wage)/wage). For the next six columns, we apply Brooks et al (2021) to estimate market distortion index. *** p<0.01, ** p<0.05, * p<0.1. Controls: percentage of government ownership and foreigner ownership respectively, log values of used material, log of provincial GDP, and export status.

Table 8. Tests for Partial Compliance with Legal Minimum Wages

	Workers in Medium Firms (5~199) (Treatment Group) and Large Firms (>200) (Control Group)	
2014 × T	0.066**	0.074**
	(0.032)	(0.031)
2007 × T		0.038
		(0.023)
2000 × T		-0.059
		(0.045)
Individual, Year, Occupation FE	Yes	Yes
Macro Variables	Yes	Yes
Number of Observation	10,736	10,736

Sources: : Indonesian Family Life Survey (2000,2007,2014)

Notes: All estimates are coefficients on the interaction of dummies (treatment group dummy and year dummies) where the dependent variable is a binary indicator for non-compliant. The control group consists of full-time workers who remained in firms with more than 200 employees. The treatment group consists of full-time workers who remained in firms with 5-199 employees. Clustered-robust standard errors by the province in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, dummy variables for (i) urban/rural residence, (ii) gender status, and (iii) labor force participation status, age and age squared, education level and education squared, and log of provincial GDP.

Appendix

A. Construction of Household Asset Variable (IFLS) and Capital Variable (IS)

Minimum Wage is annualized and deflated by the CPI. The Indonesian Central Bureau of Statistics (BPS) provides constructed CPIs for cities across the country. Matching the CPIs of the capital city with each province, we have created a CPI measure for provinces across the years. We choose 2007 as the base year.

Self-reported Income (IFLS) is annualized and deflated by the CPI to match annualized minimum wage levels. The IFLS data offers only information on the total salary (monetary remuneration and other benefits), and we cannot separate monetary compensation from other benefits. Household Asset (IFLS) is the total summation of the various household asset values. The variable includes the houses and buildings occupied by the household, non-agricultural land, livestock/fishpond, vehicles (cars, boats, bicycles, motorbikes), household appliances (radio, tape recorder, TV, fridge, sewing or washing machine, computer), saving/certificate, receivables, jewelry, furniture, and utensils. There is some sample whose asset value data is missing. Considering that the questionnaire contains comprehensive items, including the value of utensils, it is reasonable to assume that those samples are misreported. We do not include those samples in our regression analysis. IFLS consists of several books, and respondents sometimes choose to answer in book two or three. Unfortunately, the asset categories in book3 of IFLS5 are inconsistent with book2 of IFLS5 and the rest of the IFLS series. That is, it does not contain information on several asset values available in the previous rounds. These are poultry, livestock/fishpond, hard stem plants not used for farm or non-farm business, vehicles, household appliances, furniture, and utensils. We impute the missing value by applying the standard Oaxaca method to deal with the missing information. Since we have information for a sample who answered in book 2, we aggregate the list of items in book 3 and the list of items not listed in book 3. Using these two values, we proceed with the standard Oaxaca method and impute values for the missing items for the information in book 3 and construct a household asset value comparable with samples who answered in book2. We deflate the value of the household assets by province-level CPI.

Education Level (IFLS) is divided into four categories. 0. No education, 1. Elementary, 2. Middle School, 3. High School, 4. University or above.

Capital (IS) is measured as the estimated value of machinery and equipment on December 31 of the year. When the capital value is not reported, we use the reported value of the capital in the previous year to construct the missing capital value. We assume that $K_{it} = 0.9K_{i,t-1} + I_{i,t-1}$ where I is an investment for machinery and equipment. K_{it} and I_{it} are the real values deflated to 2007 rupiah using sector-specific deflators based on Wholesale Price Indices provided by Peter Brummund (2013).

Output, Material, and Fuel (IS) are measured as the total reported value of output produced, raw materials, and fuels used by the plant during the calendar year, respectively. These were deflated to 2007 rupiah using sector-specific deflators based on Wholesale Price Indices provided by Peter Brummund (2013).

Average Total Production Workers (IS) is the average number of workers, paid and unpaid, used per working day.

Other Total Production Workers (IS) is the average number of all others, paid and unpaid, used per working day.

Average Total Wage (IS) is constructed as the sum of cash wages/salary and in-kind benefits per production worker, and per non-production workers deflated to 2007 rupiah using provincial consumer price index obtained from the BPS.

Average Wage (IS) is constructed as the cash wages/salary, and per production worker and per non-production workers deflated to 2007 rupiah using provincial consumer price index obtained from BPS.

B. Monopsony Indices

B.1. Pigou's E (1924)

The traditional index for monopsony comes from Pigou (1924), where a monopsonistic employer's maximization problem can be written as

$$Max_L \ \pi(L) = pF(L) - w(L)L$$

where $\pi(.)$ is firm profit, $F(.)$ is the firm production function that only requires labor, and $w(.)$ is the wage function. The first order condition of this problem imply the following wage setting rule:

$$\epsilon^{-1} = \frac{\partial w}{\partial L}\frac{L}{w} = \frac{pF'(L) - w(L)}{w(L)}$$

where ϵ is wage elasticity of labor supply and $pF'(L)$ is firm's marginal revenue of labor product. In a perfectly competitive labor market where wage elasticity approaches infinity, a slight wage decrease will cause all workers to leave their current employer. Instead, if the employer operates in a monopsonistic labor market, he may retain workers by paying them a lower salary. This monopsony index may also be examined via its right-hand side equation, in which the normalized difference between marginal labor productivity and wage payment represents the rate of labor market imperfection. Under the premise of a perfect market, companies are supposed to employ laborers until the marginal value of the final worker recruited matches the wage paid to that person. If a gap occurs, especially when the marginal value of adding one additional worker is greater than the wage payment, this may indicate monopsony activity on the part of employers.

To accurately estimate Pigou's E, one should calculate an unbiased estimate of the marginal value of labor product, $pF'(L)$, and the specific wage payment, $w(L)$, to each worker. However, our IS data only provides each plant's average wage, and IS data for 2002 and 2003 lack information on plant ID: applying the standard semi-parametric approach for the marginal product of labor estimation requires panel data, limiting our sample to 2004-2009. Thus, we employ average labor productivity, y/L, as a proxy for the marginal value labor product, $pF'(L)$, and average wage payment of the plant as a proxy for $w(L)$. With this method, we can use a full sample between 2000 and 2009.

B.2. Brooks et al. (2021)

Brooks et al.(2021) extend the standard markup index of de Loecker and Warzynski (2012) to construct monopsony indices, often known as markdowns. The basic idea of de Loecker and Warzynski (2012) is that the first-order condition may be used to calculate the firm-specific markup as the ratio of the factor's output elasticity to its firm-specific factor payment share for any flexibly chosen, price-taking input. Material input is typically considered to operate in a competitive market; firms generally accept the material price as given. Under a competitive output market, firms employ material, the price-taking input, until the output elasticity of the material equals the payment. Suppose there is a disparity between the production elasticity and payment share of material. In that case, it is attributed to the imperfection of the output market: companies exert market power by not fully using materials to produce less and retain higher prices for the goods they produce.

One can do the same exercise with labor input assumed to operate in an imperfect market. Unlike the case of material input, the discrepancy between labor's output elasticity and wage payment is assumed to capture not only the output market imperfection but also input market imperfection. The mark-down index is then calculated by dividing the two mark-up indices to separate input market concentration from output market imperfection. The construction of the index can be written as:

$$\mu_{it} = \frac{\mu_{it}^L}{\mu_{it}^M}$$

where $\mu_{it}^j \equiv \frac{\frac{\partial log(F_{it})}{\partial log(x_{it}^j)}}{\frac{q_{it}^j x_{it}^j}{p_{it} y_{it}}} \equiv \frac{\theta_{it}^j}{\alpha_{it}^j}$. $\theta_{it}^j = \frac{\partial log(F_{it})}{\partial log(x_{it}^j)}$ denotes input j's output elasticity and $\alpha_{it}^j = \frac{p_{it}^j x_{it}^j}{p_{it} y_{it}}$ is input j's share on the total payment. Markdown should be equal to one if there is no market power in the labor market.

The standard approach (de Loecker and Warzynski (2012)) is to estimate the production function by applying the method of Ackerberg et al. (2015). In our Indonesian plant-level data, we do not have plant ID for 2002 and 2003, limiting us to the sample from 2004 to 2009 had we resorted to the methodology. Also, as pointed out by Ackerberg (2015), the production function should be estimated with value-added production function or gross output production function where materials are Leontief. In each of these particular instances, estimating the output elasticity for materials and the precise parameter required to apply the de Loecker and Warzynski (2012) model is impossible. Thus we follow Brooks et al. (2021) and implement their two proposed methods to calculate markups and markdowns.

The first method uses gross profit margin as an estimate for markup, where the precise formula can be written as:

$$\frac{p_t y_{it}}{p_t^K x_{it}^K + p_t^L x_{it}^L + p_t^M x_{it}^M + p_t^F x_{it}^F}$$

We measure firm's sales (py), labor payment ($p^L x^L$),material expenditure ($p^M x^M$),and fuel expenditure ($p^F x^F$) directly from the data. As we do not have the payment to capital ($p^K x^K$), but only the stock of capital (x^K), As long as the production function is constant returns to scale and the firm is price-taking in its inputs, the gross profit margin is a reasonable approximation of the markup. We follow Brooks et al. (2021) and assume a standard rate of return $R = \delta + r = 0.15$ where depreciation rate, δ, is 0.05 and interest rate, r, is 0.10. This measure of markups is not appropriate in the presence of markdowns since it attributes all profits to markups (increased revenues per unit of output) when a portion of profits would be attributable to markdowns (lower costs per unit of output). This index is termed CRS markup.

Another markup index suggested by Brooks et al. (2021) is CD markup. CD markup uses a markup formular, $\mu_{it}^{M} \equiv \frac{\frac{\partial log(F_{it})}{\partial log(x_{it}^{M})}}{\frac{p_{it}^{M} x_{it}^{M}}{p_{it} y_{it}}} \equiv \frac{\theta_{it}^{M}}{\alpha_{it}^{M}}$, and assumes that the production function is Cobb-Douglas to the material. Under this strong functional assumption, the output elasticity of materials is constant for all firms ($\theta_{it}^{M} = \theta^{M}$), and we choose $\theta^{M} = 0.69$ so that the average level of our markups equals the average measured using the CRS method. This method has a stronger assumption than CRS markup in that the index assumes the same output elasticity of materials across all firms. However, unlike CRS markup, the index allows for potential monopsony power in the factor markets other than material input and is robust for non-CRS production functions.

For the next step, we construct labor-based markup using the CD approach, assuming a constant θ^{L} for all firms ($\theta_{it}^{L} = \theta^{L}$). Using the labor-based markup and material-based markup, we proceed to construct the markdown index, $\frac{\mu_{it}^{L}}{\mu_{it}^{M}}$. This can be expressed differently based on whether we use either the CRS or CD markdown:

$$\begin{aligned} \mu_{it}^{CRS} = \frac{\mu_{it}^{L}}{\mu_{it}^{M}} = &\quad \theta^{L} \frac{(p_t^K x_{it}^K + p_t^L x_{it}^L + p_t^M x_{it}^M + p_t^F x_{it}^F)}{p_t^L x_{it}^L} \\ \mu_{it}^{CD} = \frac{\mu_{it}^{L}}{\mu_{it}^{M}} = &\quad \frac{\theta^{L}}{\theta^{M}} \frac{p_t^M x_{it}^M}{p_{it}^L x_{it}^L} \end{aligned}$$

If we assume that the output elasticity of labor is constant over all firms, then CRS markup, μ_{it}^{CRS}, essentially boils down to the inverse ratio of the contribution of wage payment over the total payment. The index indicates that labor market imperfection diminishes as the ratio of wage payment to total payment increases. There are several assumptions to justify this index. First, the index is only valid if laborers' contribution to output production does not change across years of investigation. Second, this index assumes that firms do not have monopsony power except in the labor market. For instance, the presence of input market concentration on capital will bias the index. Compare to μ_{it}^{CRS}, μ_{it}^{CD} index is based on a weaker assumption in that it requires only one factor that firms do not exercise monopsony power. This substantial advantage from the weaker assumption on the factor market is countered by the stronger functional assumption for material inputs in the Cobb-Douglas production function.

The following step is to normalize our created markdown indices based on the assumption that, in the absence of market power in the factor market, the markdown should equal one. Specifically, we follow Brooks et al. (2021) to estimate the following equation:

$$\frac{\mu_{it}^{L}}{\mu_{it}^{M}} = \tau_t + \delta_i + \beta s_{it}^{L} + \epsilon_{it}$$

where $s_{it}^{L} = \frac{p_t^L x_{it}^L}{\sum_i^n p_t^L x_{it}^L}$ denotes firm i' share in the labor market at time t. To compute firms' labor market share, we assume that labor is segmented both geometrically (province-level) and by the type of work (ISIC 4-digit industries). After calculating each firm's labor share in the market, we rescale the ratio, $\frac{\mu_{it}^{L}}{\mu_{it}^{M}}$, so that the average intercept of the above equation is 1. Rescaling guarantees that removing labor market power (i.e., the component of this markdown that changes with labor market share) is equivalent to setting the average markdown to 1.

C. Model

C1. Proof for $H_z(x) = D_z(R_z(x))$

In this Appendix, we show that $H_z(x) = D_z(R_z(x))$. As H_z and D_z are CDF of outside option and reservation wage respectively, we only need to show that $R_z(x)$ is monotonically increasing in x. From

$$R_z(x) = x + (\lambda_z^i - \lambda_z^e)\int_{R_z(x)}^{\bar{w_z}} \frac{1-F_z(y)}{\rho+\delta_z+\lambda_z^e(1-F_z(y))}dy$$

we use Leibniz's formula to derive

$$\frac{\partial R_z(x)}{\partial x} = 1 - (\lambda_z^i - \lambda_z^e)\left(\frac{1-F_z(R_z(x))}{\rho+\delta_z+\lambda_z^e(1-F_z(R_z(x)))}\right)\frac{\partial R_z(x)}{\partial x}$$

$$\frac{\partial R_z(x)}{\partial x}\left[1 + (\lambda_z^i - \lambda_z^e)\left(\frac{1-F_z(R_z(x))}{\rho+\delta_z+\lambda_z^e(1-F_z(R_z(x)))}\right)\right] = 1$$

As $0 < \lambda_z^i < \lambda_z^e < 1$, we can deduce $-1 < (\lambda_z^i - \lambda_z^e)\left(\frac{1-F_z(R_z(x))}{\lambda_z^e(1-F_z(R_z(x)))}\right) < 0$. As $0 < \rho,\ \delta_z < 1$, we have

$$-1 < (\lambda_z^i - \lambda_z^e)\left(\frac{1-F_z(R_z(x))}{\rho+\delta_z+\lambda_z^e(1-F_z(R_z(x)))}\right) < 0$$

$$0 < 1 + (\lambda_z^i - \lambda_z^e)\left(\frac{1-F_z(R_z(x))}{\rho+\delta_z+\lambda_z^e(1-F_z(R_z(x)))}\right) < 1$$

Therefore,

$$\frac{\partial R_z(x)}{\partial x} > \frac{1}{1+(\lambda_z^i-\lambda_z^e)\left(\frac{1-F_z(R_z(x))}{\rho+\delta_z+\lambda_z^e(1-F_z(R_z(x)))}\right)} > 0$$

As $R_z(x)$ increases monotonically with x, now we proved $H_z(x) = D_z(R_z(x))$.

C2. Derivation for Equation (9)

In this appendix, we show our derivation of equation (9). From (8), We can derive

$$(pz - \widetilde{\omega})\left[\frac{n_z'(\widetilde{\omega}|D_z,F_z)}{n_z(\widetilde{\omega}|D_z,F_z)}\right] = 1$$

$$\Longleftrightarrow (pz - \widetilde{\omega}^*)\left[\frac{D_z'(\widetilde{\omega}^*)\left(1+k_z^i(1-F_z(\widetilde{\omega}^*))\right)(1+k_z^e(1-F_z(\widetilde{\omega}^*)))+D_z(\widetilde{\omega}^*)\left[k_z^iF_z'(\widetilde{\omega}^*)(1+k_z^e(1-F_z(\widetilde{\omega}^*)))+k_z^eF_z'(\widetilde{\omega}^*)\left(1+k_z^i(1-F_z(\widetilde{\omega}^*))\right)\right]}{(1+k_z^i(1-F_z(\widetilde{\omega}^*)))(1+k_z^e(1-F_z(\widetilde{\omega}^*)))D_z(\widetilde{\omega}^*)}\right] = 1$$

Substituting the corresponding productivity distribution into equation (9), we get

$$\Longleftrightarrow$$

$$(pz - \widetilde{\omega}_z^*(p))\left[\frac{Q_z'(p)\left(1+k_z^i(1-J_z(p))\right)(1+k_z^e(1-J_z(p)))+Q_z(p)\left[k_z^iJ_z'(p)(1+k_z^e(1-J_z(p)))+k_z^eJ_z'(p)\left(1+k_z^i(1-J_z(p))\right)\right]}{(1+k_z^i(1-J_z(p)))(1+k_z^e(1-J_z(p)))Q_z(p)\widetilde{\omega}_z^{*\prime}(p)}\right] = 1$$

This equation can be rearranged as

$$(pz - \widetilde{\omega}_z^*(p)) \left[\frac{Q_z^{'}(p)}{Q_z(p)} + \frac{\left[k_z^i J_z^{'}(p)(1+k_z^e[1-J_z(p)) + k_z^e J_z^{'}(p)\left(1+k_z^i(1-J_z(p))\right)\right]}{(1+k_z^i(1-J_z(p)))(1+k_z^e(1-J_z(p)))} \right] = \widetilde{\omega}_z^{*'}(p)$$

Now let us define $B_z(p) = -log[(1+k_z^i(1-J_z(p)))(1+k_z^e(1-J_z(p)))]$ and $S_z(p) = log(Q_z(p))$. Then $B_z^{'}(p) = \frac{\left[k_z^i J_z^{'}(p)(1+k_z^e[1-J_z(p)) + k_z^e J_z^{'}(p)\left(1+k_z^i(1-J_z(p))\right)\right]}{(1+k_z^i(1-J_z(p)))(1+k_z^e(1-J_z(p)))}$ and $S_z^{'}(p) = \frac{Q_z^{'}(p)}{Q_z(p)}$. We can re-write the above equation as

$$(pz - \widetilde{\omega}_z^*(p)) \left[S_z^{'}(p) + B_z^{'}(p)\right] = \widetilde{\omega}_z^{*'}(p)$$

Let us define $K_z(p) = S_z(p) + B_z(p)$ so that $K_z^{'}(p) = S_z^{'}(p) + B_z^{'}(p)$. Rewriting the equation, we get

$$(pz - \widetilde{\omega}_z^*(p))K_z^{'}(p) = \widetilde{\omega}_z^{*'}(p)$$

Multiplying the above equation with the integrating factor, $\mu_z(p) = e^{K_z(p)}$, on both sides and rearranging, we get

$$[\widetilde{\omega}_z^*(p)\mu_z(p)]^{'} = pz\mu_z^{'}(p)$$

Integrating both sides, we get

$$\widetilde{\omega}_z^*(p)\mu_z(p) = z \int_{\frac{\underline{R}_z}{z}}^{p} y\mu_z^{'}(y)dy + A$$

$$\iff \widetilde{\omega}_z^*(p)e^{K_z(p)} = z \int_{\frac{\underline{R}_z}{z}}^{p} yK_z^{'}(y)e^{K_z(y)}dy + A$$

From $\left(ye^{K_z(y)}\right)' = e^{K_z(y)} + yK_z'(y)e^{K_z(y)}$, we deduce$\int_{\frac{\underline{R}_z}{z}}^{p} yK_z'(y)e^{K_z(y)}dy = \int_{\frac{\underline{R}_z}{z}}^{p} \left[ye^{K_z(y)}\right]' dy - \int_{\frac{\underline{R}_z}{z}}^{p} e^{K_z(y)}dy$, and thus we can rewrite the above equation as

$$\widetilde{\omega}_z^*(p) = pz + e^{-K_z(p)}\left[A - be^{K_z(\frac{\underline{R}_z}{z})}\right] - e^{-K_z(p)}z\int_{\frac{\underline{R}_z}{z}}^{p} e^{K_z(y)}dy$$

As the wage offered by the least productive firm with $\frac{\underline{R}_z}{z}$ is $\underline{R}_z(\widetilde{\omega}_z^*(\frac{\underline{R}_z}{z}) = \underline{R}_z)$, and $e^{-K_z(\frac{\underline{R}_z}{z})}z\int_{\frac{\underline{R}_z}{z}}^{\frac{\underline{R}_z}{z}} e^{K_z(y)}dy = 0$, we can infer$A = be^{K_z(\frac{\underline{R}_z}{z})}$. We can re-write the above equation as

$$\widetilde{\omega}_z^*(p) = z\left[p - e^{-K_z(p)}\int_{\frac{\underline{R}_z}{z}}^{p} e^{K_z(y)}dy\right]$$

$$\widetilde{\omega}_z^*(p) = z\left[p - e^{-(S_z(p)+B_z(p))}\int_{\frac{\underline{R}_z}{z}}^{p} e^{(S_z(y)+B_z(y))}dy\right]$$

$$(9)\ \widetilde{\omega}_z^*(p) = z\left[p - \int_{\frac{\underline{R}_z}{z}}^{p} \frac{\left(1+k_z^i(1-J_z(p))\right)(1+k_z^e(1-J_z(p)))Q_z(y)}{(1+k_z^i(1-J_z(y)))(1+k_z^e(1-J_z(y)))Q_z(p)}dy\right]$$

Now we show $\frac{\partial\widetilde{\omega}_z^*(p)}{\partial p} > 0$ to check whether the closed form soltuion $\widetilde{\omega}_z^*(p)$ still satisfies the initial assumption on the monotone increasing correspondence between $\widetilde{\omega}_z^*$ and p. Using Leibniz's formula, we can take a derivative with respect to p, and then

$$\frac{\partial\widetilde{\omega}_z^*(p)}{\partial p} = z\left[\int_{\frac{\underline{R}_z}{z}}^{p} \frac{\left[k_z^i J_z'(p)\left(1+k_z^e(1-J_z(p))\right)+k_z^e J_z'(p)\left(1+k_z^i(1-J_z(p))\right)\right]Q_z(p)+\left(1+k_z^i(1-J_z(y))\right)\left(1+k_z^e(1-J_z(y))\right)Q_z'(p)}{[Q_z(p)]^2}\frac{Q_z(y)}{\left(1+k_z^i(1-J_z(y))\right)}dy\right] > 0$$

Thus, $\widetilde{\omega}_z^*(p)$ monotonically increases with p.

$Q.E.D.$ □

D. Robustness Check-Migration

We report the SD, DSD, and TWFE estimation results from the IFLS data, excluding individuals who migrated to different districts during the sample period. The migrating population could skew statistics if informally employed individuals crossed the provinces to search for higher-paying formal sector jobs or unemployed workers migrate out of higher minimum wage provinces to search for jobs. We do a robustness analysis excluding individuals who migrated from the initial place where observation began. This analysis will allow us to examine how much the migrating population could contaminate our estimation. The migrating population is approximately 7.8 percent for our three rounds of the IFLS sample. We report estimates of minimum wage impact on employment, wages, and non-compliance incidence.

Our estimation results with the TWFE estimator show that the positive effect on formal sector employment decreases when excluding the migrated population. This finding can be interpreted as evidence for some people migrating into the provinces with a higher minimum wage to find a formal sector job. Finally, DSD, SD, and TWFE estimation results for income and non-compliance show similar coefficients compared to the results with the migrated population. Overall, our estimation results, excluding the sample of migration populations, show robust results.

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Table A.1. Proportion of Job Finding Mechanism

	All workers		All formal sector workers	
	2007	2014	2007	2014
Through government job fairs	0.084	0.065	0.066	0.053
Through private job fairs	0.026	0.018	0.035	0.027
School/University job fairs	0.014	0.009	0.015	0.010
Responded to job advertisement	0.034	0.023	0.050	0.032
Contacted company	0.164	0.182	0.212	0.226
Through friends/relatives	0.481	0.488	0.485	0.503
Contacted by company	0.196	0.206	0.136	0.139
Outsourcing/Recruitment Agencies	0.000	0.007	0.000	0.010
Employment Bureau	0.001	0.001	0.001	0.001
Total	1	1	1	1

Source: Indonesian Family Life Survey (2007,2014)

Table A.2. Real Monthly Minimum Wages by Province and Year

	MW/Median Wage[1]			MW/Median Wage[2]			MW/Median Profit[3]		
	2000	2007	2014	2000	2007	2014	2000	2007	2014
North Sumatera	0.770	0.951	0.837	0.996	1.522	1.506	1.270	1.668	2.259
West Sumatera	0.667	0.841	0.834	0.628	1.250	1.241	1.333	1.793	1.863
South Sumatera	0.543	0.867	1.188	0.912	1.013	2.400	1.900	1.891	3.000
Lampung	0.886	0.994	1.523	0.960	1.110	2.099	1.317	1.480	1.999
DKI Jakarta	0.715	0.700	0.999	0.953	1.632	1.555	0.953	1.166	2.441
West Java	0.719	0.527	0.544	1.533	1.433	1.747	1.533	1.074	1.667
Middle Java	0.910	1.000	0.919	1.850	2.008	1.680	1.755	2.500	1.950
Yogyakarta	0.973	0.767	0.824	0.519	0.794	1.404	2.223	1.903	2.197
East Java	0.894	0.715	0.800	2.356	1.747	2.222	1.430	1.495	1.589
Banten		0.641	0.513		2.335	1.767		1.764	2.208
Bali	0.713	0.889	0.721	0.504	1.333	0.979	1.427	1.866	2.273
NTB	1.200	1.650	1.338	1.210	1.650	2.420	1.440	1.833	1.370
South Kalimantan	0.667	0.742	0.774	1.154	1.292	1.584	1.333	1.625	2.268
South Sulawesi	0.800	1.346	1.200	0.500	1.496	2.139	1.500	3.048	3.086
Overall	0.805	0.806	0.854	1.362	1.558	1.872	1.512	1.772	2.037

Source: Indonesian Family Life Survey (2000,2007,2014).
[1] Ratio of minimum wage to median wage of full-time formal sector workers for each province
[2] Ratio of minimum wage to median wage of part-time formal sector workers for each province
[3] Ratio of minimum wage to median wage of informal sector workers for each province

Table A.3. Summary Statistics for Non-Compliance Ratio

	Firm Size[1]	Education Level[2]
Group 1	0.760 [0.427]	0.811 [0.392]
Group 2	0.576 [0.494]	0.665 [0.472]
Group 3	0.423 [0.494]	0.585 [0.493]
Group 4	0.329 [0.470]	0.372 [0.483]
Group 5	0.326 [0.469]	0.203 [0.402]
Total	0.462	0.462

Source: Indonesian Family Life Survey (2000,2007,2014).
Notes: We divide sample of formal sector workers into 5 groups based on firm size and education level accordingly.
[1] Group 1 comprises of workers in the firm whose size is between 0 and 4; group 2 between 5 and 19; group 3 between 20 and 99; group 4 between 100 and 200; group 5 more than 200.
[2] Group 1 comprises of workers with less than elementary school education; group 2 with elementary school; group 3 with middle school; group 4 with high school; and group 5 more than high school

Table D.1. The Effect of Minimum Wage on Employment Status (Migration)

VARIABLES	(1) Formal		(2) Full-Time Formal		(3) Part-Time Formal		(4) Self-Employed		(5) Family Business	
Individual FE	0.039		0.019		0.070***		0.029		-0.046	
	(0.035)		(0.031)		(0.019)		(0.040)		(0.044)	
	SD	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**
25 miles	0.294***	0.039	0.314***	-0.028	-0.019	0.000	-0.258***	-0.040	-0.269***	-0.043
	(0.083)	(0.075)	(0.077)	(0.044)	(0.018)	(0.033)	(0.082)	(0.040)	(0.078)	(0.065)
30 miles	0.316***	0.045	0.332***	0.014	-0.003	-0.003	-0.273***	-0.026	-0.294***	-0.039
	(0.095)	(0.062)	(0.090)	(0.027)	(0.035)	(0.037)	(0.098)	(0.046)	(0.093)	(0.062)
35 miles	0.267**	0.080	0.283***	0.041	-0.010	-0.016	-0.223**	-0.045	-0.253**	-0.083
	(0.104)	(0.075)	(0.082)	(0.041)	(0.036)	(0.035)	(0.100)	(0.056)	(0.104)	(0.072)
40 miles	0.280**	0.070	0.301***	0.042	-0.023	-0.033	-0.259**	-0.049	-0.270**	-0.080
	(0.118)	(0.073)	(0.093)	(0.038)	(0.035)	(0.024)	(0.121)	(0.068)	(0.116)	(0.069)
60 miles	0.237***	0.109*	0.287***	0.082***	-0.045***	-0.004	-0.195***	-0.068	-0.235***	-0.123**
	(0.083)	(0.062)	(0.065)	(0.030)	(0.019)	(0.023)	(0.079)	(0.048)	(0.084)	(0.053)
Mean	0.406		0.279		0.133		0.493		0.575	
Observation	47,490		47,490		47,490		47,490		47,490	

Source: Indonesian Family Life Survey (2000,2007,2014)

Notes: All estimates are coefficients on log real minimum wages where the dependent variable is the binary indicator for individuals who work in the category in the column heading. We define respondents who work either in the government or private sector as formal sector workers (Formal). Among them, respondents working more than 40 hours are defined as full-time workers (Full-Time Formal). Respondents working less than 40 hours are defined as part-time workers (Part-Time Formal). Respondents whose working status are either self-employed or self-employed with family members are categorized as self-employed (Self-Employed). We include unpaid family workers to the previous category to define Family Business. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, dummy variables for (i) urban/rural residence, (ii) gender status, and (iii) labor force participation status, age and age squared, education level and education squared, and log of provincial GDP.

Table D.2. The Effect of Minimum Wage on Income by Employment Status (Migration)

VARIABLES	(1)		(2)		(3)		(4)		(5)	
	Full-Time Wage Earner						Part-Time Wage Earner		Self-Employed Profit Earner	
	All		Sub-Minimum Wage Workers Initial Year		Over-Minimum Wage Workers Initial Year					
Individual FE	0.404**		0.593***		0.336***		-0.245		0.188	
	(0.150)		(0.159)		(0.131)		(0.366)		(0.153)	
	SD	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**	**SD**	**DSD**
25 miles	1.156***	0.823***	1.120***	0.819***	0.818***	1.089***	0.689	-0.031	0.754**	0.420
	(0.263)	(0.223)	(0.237)	(0.151)	(0.140)	(0.198)	(0.470)	(0.487)	0.345	0.371
30 miles	1.487***	1.086***	1.383***	1.290***	0.960***	1.152***	1.116**	0.313	0.658*	0.143
	(0.350)	(0.230)	(0.286)	(0.223)	(0.144)	(0.217)	(0.526)	(0.374)	0.338	0.373
35 miles	1.205***	0.932***	1.104***	1.274***	0.852***	0.979***	0.846**	0.454	0.672**	-0.006
	(0.220)	(0.168)	(0.210)	(0.192)	(0.120)	(0.176)	(0.366)	(0.284)	0.271	0.268
40 miles	1.145***	0.866***	1.113***	1.359***	0.772***	0.805***	0.662**	0.549**	0.647***	0.020
	(0.191)	(0.130)	(0.189)	(0.231)	(0.099)	(0.180)	(0.323)	(0.252)	0.201	0.167
60 miles	1.081***	0.828***	1.060***	1.185***	0.785***	0.760***	0.603***	0.502**	0.704***	0.069
	(0.089)	(0.127)	(0.145)	(0.215)	(0.082)	(0.136)	(0.186)	(0.223)	0.141	0.079
Mean	15.919		15.066		16.574		15.294		15.073	
Observations	13,016		5,657		7,359		6,157		17,022	

Source: Indonesian Family Life Survey (2000,2007,2014)

Notes: All estimates are coefficients on log real minimum wages where each dependent variable is the log values of earning for individuals who work in the category in the column heading. We define respondents who work either in the government or private sector as formal sector wage earners. Among them, respondents working more than 40 hours are defined as full-time wage workers. We further divide the sample into the two different groups: respondents whose wage at the initial year of sampling is smaller than minimum wage (Sub-Minimum Wage Workers), and respondents whose wage at the initial year of sampling is higher than minimum wage (Over-Minimum Wage Workers). Respondents working less than 40 hours are defined as part-time workers (Part-Time Formal). Respondents whose working status are self-employed, self-employed with family members or unpaid family workers are defined as family business profit earner. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, dummy variables for (i) urban/rural residence, (ii) gender status, and (iii) labor force participation status, age and age squared, education level and education squared, and log of provincial GDP.

Table D.3. Tests for partial compliance with legal minimum wages (Migration)

	Workers in Medium Firms (5~199) (T) and Large Firms (>200) (C)	
2014 × T	0.065 *	0.073 *
	(0.035)	(0.039)
2007 × T		0.033
		(0.031)
2000 × T		-0.069
		(0.066)
Individual, Year, Occupation FE	Yes	Yes
Macro Variables	Yes	Yes
Number of Observation	9,961	9,961

Source: Indonesian Family Life Survey (2000,2007,2014)

Notes: All estimates are coefficients on the interaction of dummies (treatment group dummy and year dummies) where the dependent variable is a binary indicator for non-compliant. The control group consists of full-time workers who remained in firms with more than 200 employees. The treatment group consists of full-time workers who remained in firms with 5-199 employees. Clustered-robust standard errors by the province in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, dummy variables for (i) urban/rural residence, (ii) gender status, and (iii) labor force participation status, age and age squared, education level and education squared, and log of provincial GDP.