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 can induce (i) an increase 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 law in developing countries. Though development and labor economists have studied this issue extensively, the literature has not yet reached a consensus, since the effect of the law depends on the institutional structure of the countries. In particular, certain features prevalent in developing countries, such as a large proportion of informal sector economic activity[1], the imperfection in the formal sector labor market, and non-compliant behavior of firms to labor protection regulations, add even more 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 investigate 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 characteristics of the informal and formal sector labor market in Indonesia. Our review of the informal sector labor market shows significant income heterogeneity among informal sector laborers, of whom a sizable proportion earn more than formal sector wage earners. This feature of the informal sector labor market leads

[1] 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.

us to infer that the Indonesian labor market exhibits both aspects of informality: competitive and segmented informal sectors. As for 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) average 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 sector economy lead us to infer that an adequately set minimum wage increases formal sector employment due to the transit of informal sector workers into the formal sector as wage-earners (Card and Krueger, 1994).

Other developing countries primarily share these underlying features of the Indonesian labor market and motivate us to construct a coherent structural model that embodies features of labor market structure in a unified way. There have been critical theoretical works that unify empirical elements of labor markets in developing countries. Still, our model differentiates itself from previous works in that we emphasize employment status changes from informal self-employment into wage-earning jobs, exhibiting the mechanism of the formalization. Our structural model provides 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) the transition of some informal sector

workers into formal sector wage-earning jobs, (ii) increases in the wages earned by formal sector workers (the average wage paid by manufacturing plants)—both for initially sub-minimum wage-earning workers (sub-minimum wage paying plants) and over-minimum wage earning earners (over-minimum wage paying 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, our theoretical framework extends the existing search model with the monopsonistic competition (Burdett and Mortensen, 1998) and provides a rich mechanism to study the labor market in developing countries.[2] Importantly, our structural model assumes La Porta and Shleifer's viewpoint (2014) on informality, in that informal firms are incapable of legally registering and operating formally. In this viewpoint, formalization only occurs through an occupational choice of individuals to move from informal sector household businesses into formal sector wage-earning jobs. This assumption on informality differentiates our model from existing models. For instance, Ulyssea's model (2018) embraces various viewpoints of informality by introducing heterogeneity in firm productivity. Considering its productivity and the enforcement intensity of the regulation, each firm chooses formal registration and compliance with the existing labor protection regulation. Unlike Ulyssea (2018), who focuses on heterogeneous firms, whereby formalization mechanism arises, our model focuses on heterogeneous individuals who make choices over employment status. Meghir et al. (2015) extend the original Burdett-Mortensen model (1998) by introducing a firm's endogenous choice between the formal sector and informal sector economic activity. In their model, they also do not assume a formality mechanism through employment status changes from informal sector household business to formal sector wage-earning jobs. Leal Ordóñez (2014) also calibrates a model that only assumes a firm's optimal choice between formal and informal registration and

[2] To date, the Burdett and Mortensen model has been extended by numerous authors to analyze labor markets in developed economies where informal economy is not assumed. See van den Berg and Ridden, 1998; Postel-Vinay and Robin, 2002; Jolivet et al., 2006; Moscarini and Postel-Vinay, 2013; Lise et al., 2016; Lise and Robin, 2017; Moser and Engbom, 2018.

does not consider an individual's choice over employment status.

Our model attempts to incorporate the non-compliance behavior of firms with labor protection regulations in the search framework. Several papers follow industrial organization literature that includes the non-compliance behavior of firms. For instance, Ulyssea (2018) models a non-compliance decision of formally registered firms regarding existing labor market regulation. Basu et al. (2010) also incorporate imperfect compliance of a firm with labor laws into their model. However, models based on the industrial organization literature generally do not contain a mechanism that explains the movement of the entire wage distribution along with minimum wage, which is widely documented in developing countries (for instance, see Cunningham, 2007). Our attempt to incorporate the non-compliance behavior of the firms into the existing search literature is rewarding in that our model allows for the movement of wage distribution along with the minimum wage level. Overall, our model generates a rich mechanism to study labor supply and demand, a firm's non-compliance behavior, and wage dispersion.

Second, our study on the effect of the minimum wage complements a long-standing debate on how minimum wages affect labor market outcomes. There exist many studies analyzing the impact of the minimum wage on employment in developing countries, both in the formal and informal sectors (for example, 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 and decrease or have 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., 2012; Harrison and Scorse, 2010; Alatas and Cameron, 2008; Comola and de Mello, 2011; Magruder, 2013). Our work 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 Pigou's E. 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 chooses to stay in that sector out of their cost-benefit analysis, then an increase in the minimum wage may provide an additional incentive to work in the formal sector, and thus, formal-sector labor supply increases. 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 retracts labor demand. As for non-compliance with minimum wage laws commonly found in developing countries, previous research shows that it depends on the minimum wage level compared to firm productivity and enforcement intensity. 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 use IFLS and IS data to first document informal and formal sector labor market, respectively, and then, describe minimum wage policy in Indonesia as it is crucial 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 useful to use 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. We further restrict our sample to working individuals whose earnings and household assets are between the 1st and 99th percentile of real income and real value of household assets for each year. This leaves us with 58,717 valid observations.

Indonesia's National Statistics Agency (Badan Pusat Statistik, BPS) identifies enterprises as legal entities if they are registered with the Ministry of Manpower. Registered firms are considered formal enterprises. Unfortunately, IFLS data does not include identifiers for the legal classification of work, and we follow previous literature to define private or government workers as formal sector workers. However, IFLS data provides an excellent source of information on informal sector employment. 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.

We complement the IFLS data with the Indonesian manufacturing survey (IS) to study formal

sector economic activity. The data spans from 2000 until 2009, and it contains detailed information on a comprehensive set of plant-level characteristics. The dataset contains information on variables such as wages, the number of workers hired in production jobs, the number of workers in non-production jobs, total capital stock, investment, total materials and fuels purchased, and total revenues. We use IS data to estimate plant-level productivity, which then will be used to study the labor market imperfection. Appendix A provides a detailed description of our variable construction.

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, Harrison and Todaro (1970) and Fields (1990) 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 optd 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 seems to suggest that the informal sector in Indonesia does not fall into exactly one category. For instance, IFLS data shows that there is a rare movement between employers with permanent workers and employers with family workers. It is consistent with Rothenberg et al. (2016) where the paper shows the persistence of informal sector businesses that do not formally register despite the availability of a business registration program. In this sense, the informal sector in Indonesia seems to be consistent with the argument by La Porta and Shleifer (2014). However, IFLS data also documents that a significant number of informal sector business owners earn more income than formal sector workers. This leads us

to suppose that some informal sector business owners choose to go into business in the informal sector instead of working in the formal sector as wage earners.

Table 1 provides information on individuals who work in the formal and informal sectors. We observe that the majority of workers (60 percent) are involved in informal sector employment, and they usually work in companies with less than five workers. Their education level lags compared to employees in the formal sector, which implies that overall informal sector workers are less productive compared to formal sector wage earners. However, we also observe that there are significant overlaps between the informal and formal sectors, even within narrowly defined industries, suggesting the possibility that some workers may choose to change their employment status, depending on the market situation.

Figure 1 further indicates heterogeneity within the informal labor sector. The graph illustrates the distribution of formal versus informal workers by income decile. Whereas informal sector workers constitute 78 percent of the lowest income decile, we still find a significant overlap between the income of informal and formal sector workers. Specifically, we 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 enough heterogeneity among the informal sector laborers to support the argument that a sizable portion of informal sector workers chooses to stay in the informal sector economy out of their cost-benefit analysis. In Appendix B, we further explore the heterogeneity in the informal sector, employing the marginal treatment effect (Björklund and Moffitt, 1987; Heckman et al., 2006).

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 lack of information (Bhaskar et al. (2002)), monopsony, lack of governmental monitoring for illegal hiring, and formal registration. The labor market in

Indonesia also exhibits these common features discussed in the literature. In this sub-section, we use IFLS and IS data to portray some features of the labor market imperfection.

Two recent rounds of IFLS data (IFLS 4 and 5) contain useful survey information that asks how respondents found their current job. The table shows that 48-49 percent of total respondents found their job through friends or relatives, and 48-50 percent of formal sector workers found their positions through friends or relatives. Considering that only 10 percent of the workers found their jobs through job fairs, the mechanism we unambiguously regard as an open market platform, the table illustrates that job seekers have limited information in their job search.

We also use IS data to complement our understanding of labor market imperfection. To illustrate this, we use a standard measure, Pigou's E, which is the normalized gap between the value of worker's marginal product of labor and wage: $E = \frac{R'(L)-W(L)}{W(L)}$ where $R'(L)$ is marginal product of labor and $W(L)$ is wage (see Appendix B). With no labor market imperfection, profit-maximizing employers should hire workers until the marginal product of labor equals the wage. Thus, a higher value of Pigou's E indicates more severe labor market distortions. To calculate Pigou's E, we use a standard semi-parametric approach to estimate the production function. We estimate the production function at the 2-digit industry level, calculating marginal productivity of labor (MPL) for production and non-production workers. We then directly compare MPL to average wage paid by each firm (See Dobbelaere and Mairesse, 2013; Dobbelaere et al., 2015; Petrin and Sivadasan, 2013; Olley and Pake, 1996; Blundell and Bond, 1998; Levinsohn and Petrin, 2003; Wooldridge, 2009; Ackerberg et al., 2015; Brummund, 2013). In Tables 3 and 4, we report the main descriptive statistics for manufacturing firms and a sizable gap between the value of labor products and wages across all industries. Though this significant gap between the marginal product of labor and wage clearly reflects an imperfect formal sector labor market, the role of labor protection regulations such as minimum wage on this gap is still not yet clear. An increase in minimum wage may prevent employers from hiring more workers and thus generates increased Pigou's E, or the regulation may correct an already distorted labor market so that it

helps the equilibrium wage to be closer to competitive market wages. In Section 4, we formally test the role of minimum wage and show that the minimum wage increase reduces Pigou's E 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 (Fig 2). 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 5 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 less than the minimum wage. This non-compliance ratio is rather severe, which shows that enforcement of the minimum wage regulations is far less than complete.

This non-compliance issue is quite prevalent in the 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 6 illustrates the non-compliance ratio of minimum wage regulation by (i) firm size and (ii) education level of employees. 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 the labor market imperfections, it is evident that highly educated workers have higher bargaining power compare to poorly-educated workers.

Overall, our baseline study for the labor market in Indonesia shows the following aspects: (i) large proportion of the informal economy and a substantial 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 commonly found 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 start to 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 Moser and Engbom (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 distribu-

tion 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. [3]

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. We assume that worker's outside option, x, are positively related with his ability as an employee; if $z_1 < z_2$, then $H_{z_1}(x) \preceq_{FOSD} H_{z_2}(x)$. 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, and it occurs from both informal and formal sector workers in each labor market segment. Workers maximize their lifetime income discounted at a rate ρ.

[3] 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.

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 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 worker's expected wage, $\widetilde{\omega}$, other firms' wage posting, and distribution of outside option, $H_z(x)$. We define the distribution of the firm's expected wage payment as $F_z(\widetilde{\omega})$.[4]

Formal sector jobs 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 agent whose expected wage is $\widetilde{\omega}$, and outside option, x. 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 $\overline{\omega}_z$ and $\underline{\omega}_z$ denote highest and lowest wage payment in the labor market z accordingly. From these equations the reservation wage can be derived as follows:

[4]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 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.

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

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. To simplify our argument, we assume $\lambda_z^i = \lambda_z^e = \lambda_z$, and then reservation wage of a worker with outside offer x becomes $R_z = x$. Let $I_z(x|F_z)$ denotes the steady-state measure of informal sector workers in labor market z whose outside offer is x, conditional on the expected wage offer distribution F_z. As $\frac{\delta_z}{\delta_z+\lambda_z[1-F_z(x)]}$ denotes the rate of inflow to the informal sector at the steady state for workers whose outside option is x, we can write $I_z(x|F_z)$ as

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

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

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

where $F_z(\widetilde{\omega}) - F_z(y)$ represents the share of workers whose reservation wage is y who will accept an offer less than or equal to $\widetilde{\omega}$, and $dI_z(y|F_z)$ measure of informal sector workers with

reservation wage y. From (4), we have $[1 + k_z(1 - F_z(y))]dI_z(y|F_z) = m_z dH_z(y)$. We can now express (5) as follows:

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

From this expression, we use integration by parts to derive

$$\int_{\underline{x}_z}^{\widetilde{\omega}} \frac{(F_z(\widetilde{\omega}) - F_z(y))}{(1+k_z(1-F_z(y)))} dH_z(y) = \int_{\underline{x}_z}^{\widetilde{\omega}} H_z(y) \left(\frac{1}{(1+k_z(1-F_z(y))} + \frac{k_z(F_z(\widetilde{\omega}) - F_z(y))}{(1+k_z(1-F_z(y))^2} \right) dF_z(y).$$

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

$$(6)\ n_z(\widetilde{\omega}|F_z) = \frac{(m_z - I_z) dG_z(\widetilde{\omega})}{dF_z(\widetilde{\omega})} = \frac{k_z m_z H_z(\widetilde{\omega})}{(1+k_z(1-F_z(\widetilde{\omega})))^2}$$

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.

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

where $n_z(\widetilde{\omega}|F_z, H_z)$ is the labor hired at wage $\widetilde{\omega}$, given F_z and H_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, $H_z(x)$, and the measure of workers available with expected wage $\widetilde{\omega}$ in labor market z, $n_z(\widetilde{\omega}|F_z, H_z)$, 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 with sub-minimum wage. For instance, if the lowest reservation wage $\underline{x}_z$ 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 $\{n_z(\widetilde{\omega})\}_{z \in Z}$;and self-employment rates $\{I_z(x)\}_{z \in Z, x \in H}$ such that given ω_{min} and κ,

1. Worker optimality: Given x,z,ω, κ,and $F_z(\widetilde{\omega})$,workers solve their occupational choice according to to their reservation policies.

2. Entrepreneur optimality: Taking $F_z(\widetilde{\omega})$ as given and knowing $H_z(x), k_z$ 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 $I_z(\overline{x}_z|F_z) = \int_{\underline{x}_z}^{\overline{x}_z} \left(\frac{\delta_z m_z}{\delta_z + \lambda_z^i[1-F_z(y)]}\right) dH_z(y)$.

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 Moser and Engbom (2019). 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,

$$(p_2 z - \widetilde{\omega}_z^2) \frac{k_z m_z H_z(\widetilde{\omega}_z^2)}{(1+k_z[1-F_z(\widetilde{\omega}_z^2)])^2} \geq ((p_2 z - \widetilde{\omega}_z^1) \frac{k_z m_z H_z(\widetilde{\omega}_z^1)}{(1+k_z[1-F_z(\widetilde{\omega}_z^1)])^2} > (p_1 z - \widetilde{\omega}_z^1) \frac{k_z m_z H_z(\widetilde{\omega}_z^1)}{(1+k_z[1-F_z(\widetilde{\omega}_z^1)])^2} \geq (p_1 z - \widetilde{\omega}_z^2) \frac{k_z m_z H_z(\widetilde{\omega}_z^2)}{(1+k_z[1-F_z(\widetilde{\omega}_z^2)])^2}$$

$$\Leftrightarrow (p_2 - p_1) z \frac{k_z m_z H_z(\widetilde{\omega}_z^2)}{(1+k_z[1-F_z(\widetilde{\omega}_z^2)])^2} > (p_2 - p_1) z \frac{k_z m_z H_z(\widetilde{\omega}_z^1)}{(1+k_z[1-F_z(\widetilde{\omega}_z^1)])^2}$$

$$\Leftrightarrow \widetilde{\omega}_z^2 > \widetilde{\omega}_z^1$$

$Q.E.D.$ □

As Mortensen (1990) 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 $\widetilde{\omega}^*$, $H_z(\widetilde{\omega}^*(p))$, 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 $H_z(\widetilde{\omega}_z^*(p))$, so that $H_z(\widetilde{\omega}_z^*(p)) = H_z(F_z^{-1}(J_z(p))) = (H_z \circ F_z^{-1} \circ J_z)(p) = Q_z(p)$. Thus, $Q_z(p)$ refers to the proportion of workers that a firm with productivity p can attract from informal sector. Thus from $F_z(\widetilde{\omega}_z^*(p)) = J_z(p)$ and $H_z(\widetilde{\omega}_z^*(p)) = Q_z(p)$, we can derive the following: $F_z^{'}(\widetilde{\omega}_z^*(p))\widetilde{\omega}_z^{*'}(p) = J_z^{'}(p)$ and $H_z^{'}(\widetilde{\omega}_z^*(p))\widetilde{\omega}_z^{*'}(p) = Q_z^{'}(p)$. As all wage offers must be at least as great as the lowest reservation wage, $\underline{x}_z$, only employers with productivity $pz \geq \underline{x}_z$ can make a profit and participate in the labor market z. Hence without loss of generality, we infer $\underline{p} = \frac{\underline{x}_z}{z}$ and $p \in (\frac{\underline{x}_z}{z}, \overline{p}]$. Now we can derive the equilibrium wage associated with the employer's productivity from the producers' profit maximization problem (Equation (8)). The details of derivation are discussed in Appendix D.

$$(8)\ \pi(p, z, \widetilde{\omega}|H_z, F_z) = Max_{\widetilde{\omega}} \left\{ (pz - \widetilde{\omega})\, n_z(\widetilde{\omega}) \right\} = \left\{ (pz - \widetilde{\omega}) \frac{k_z m_z H_z(\widetilde{\omega})}{(1 + k_z(1 - F_z(\widetilde{\omega})))^2} \right\}$$

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 expected wage correspondence, $\widetilde{\omega}_z^*(p)$, that maps underlying firm productivity to the expected wage, which can be derived as (9):

$$(9)\ \widetilde{\omega}_z^*(p) = z\left[p - \int_{\frac{\underline{x}_z}{z}}^{p} \frac{[1+k_z(1-J_z(p))]^2 Q_z(y)}{[1+k_z(1-J_z(y))]^2 Q_z(p)} dy\right]$$

We can see equilibrium expected wage, $\widetilde{\omega}_z^*(p)$, is determined by an effect of worker productivity, firm productivity, and wage posting strategies by other participating firms in labor market z. To understand this clearly, let us re-define equation (9) as $\widetilde{\omega}_z^*(p) = z\left[p - \int_{\frac{\underline{x}_z}{z}}^{p} \frac{A_z(p)}{A_z(y)} dy\right]$ where $A_z(p)$ is defined as $\frac{(\delta_z+\lambda_z(1-J_z(p)))}{Q_z(p)}$ $\left(A_z(p) = \frac{(\delta_z+\lambda_z(1-J_z(p)))}{Q_z(p)}\right)$. Remember that $(\delta_z + \lambda_z(1 - J_z(p)))$ denotes the outflow ratio of workers employed by the same productivity employers either into other formal sector employers or into informal sector at the steady state. Thus,$A_z(p)$ captures employment loss ratio for employer whose productivity is p. It is clear that $A_z(p)$ decreases with p, meaning that the employment loss is small for highly productive employers.

From $\widetilde{\omega}_z^*(p) = z\left[p - \int_{\frac{\underline{x}_z}{z}}^{p} \frac{A_z(p)}{A_z(y)} dy\right]$, we can first study the change in equilibrium wage in response with change in $\underline{x}_z$. It is straightforward to derive $\frac{\partial \widetilde{\omega}_z^*(p)}{\partial(\underline{x}_z)} = \frac{A_z(p)}{A_z(\underline{x}_z/z)} > 0$. As the lowest reservation wage in labor market z increases or as remaining 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)). Second, we can further deduce from the equation that, at the equilibrium, wage growth rate in response to lowest reservation wage increases with respect to the lowest reservation wage $\left(\frac{\partial \frac{\partial \widetilde{\omega}_z^*(p)}{\partial(\underline{x}_z)}}{\partial(\underline{x}_z)} = \frac{-A_z(p)A_z'(\underline{R}_z/z)}{z[A_z(\underline{R}_z/z)]^2} > 0\right)$. This result comes from the job ladder mechanism. Note that equilibrium wage growth in response to reservation wage $\left(\frac{\partial \widetilde{\omega}_z^*(p)}{\partial(\underline{x}_z)} = \frac{A_z(p)}{A_z(\underline{x}_z/z)}\right)$ can be interpreted as the relative importance of job ladder mechanism for the workers hired by lowest paying (least productive) firm, $\underline{x}_z/z$, compare to the firms with productivity p. As job ladder mechanism for workers hired by the least productive (lowest paying) firms are stronger than workers hired by firms with productivity, increase in $\underline{x}_z$ reduces the relative importance of job ladder mechanism for equilibrium wages in labor market z. Thus, firms have to depend more on the initial wage payment to attract workers rather than depending on job ladder mechanism as reservation wage increases, and the result is that $\widetilde{\omega}_z^*(p)$ is the convex function of $\underline{x}_z$.

Proposition 3: Minimum wage hike increases wages in the labor market z where $\underline{\widetilde{\omega}}_z \leq \kappa\omega_{min}$.

Proof:

$$\frac{\partial \widetilde{\omega}_z^*(p)}{\partial \omega_m} = \left[z \left[\frac{1+k_z(1-J_z(p))}{1+k_z(1-J(\frac{\kappa\omega_m}{z}))} \right]^2 \right] \left[\frac{Q_z\left(\frac{\kappa\omega_m}{z}\right)}{Q_z(p)} \right] > 0$$

Thus, for the labor market with a binding minimum wage ($\underline{\widetilde{\omega}}_z \leq \kappa\omega_{min}$), 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 $\frac{\kappa_z\omega_{min}}{z}$, $\left(\frac{\kappa_z\omega_{min}}{z} > p\right)$. [5]

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 $\frac{\kappa_z\omega_{min}}{z}$):

$$\frac{\partial n_z(\widetilde{\omega}_z^*)}{\partial \omega_{min}} = \frac{k_z m_z h_z(\widetilde{\omega}_z^*)(1+k_z(1-F_z(\widetilde{\omega}_z^*)))+2k_z f_z(\widetilde{\omega}_z^*)H_z(\widetilde{\omega}_z^*)}{(1+k_z(1-F_z(\widetilde{\omega}_z)))^3} \frac{\partial \widetilde{\omega}_z^*}{\partial \omega_{min}}$$

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 $\widetilde{\omega}_z^{sup_2} = sup\{\widetilde{\omega}_z^*(p)|\omega_{min}, p \in \Gamma\}$.

[5] 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 $z > \frac{\kappa_z\omega_{min}}{p}$. Thus, with a minimum wage increase, some firms may not find workers in a certain labor market z.

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

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

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 3, we also know that the minimum wage hike does not increase the wage distribution by the same magnitude of the minimum wage increase.

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

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.

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

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. The Consequence of Minimum Wage

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 afford and also the enforcement effort of the regulation is robust, labor demand and formal sector employment declines. However, a properly set minimum wage can create an increase in labor supply without reducing labor demand, which can increase formal sector employment (Card and Kruger, 1996; 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, and change in one firm's optimal wage posting strategy affects other's wage posting. Lastly, our model predicts that, with a minimum wage increase, monopsonistic gains from hiring workers are reduced. This section is devoted to testing these hypotheses. We first introduce our estimation strategy and then discuss the regression results.

4.1. Estimation strategy

4.1.1. 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 unemployment rate is low, and the 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 deal with heterogeneous trends, we use contiguous cross-border districts in the neighboring province (see Card and Krueger, 1996; Dube et al., 2010; Allegretto et al., 2017; Magruder, 2013). The key idea is to use the contiguous cross-border districts in the neighboring province to construct the right control group. This research design can account for heterogeneous time-trend issues and identify the causal effect even if the minimum wage is targeted to account for the economy of the overall province. Assuming that borderline districts across provinces share a similar economic circumstance, minimum wage changes in these contiguous districts can have a causal implication on labor market outcomes. This regression discontinuity type approach also has its limitation in that the approach assumes that the districts near the borderline of the province share the same economic environment. If provincial boundaries affect other legal differences other than minimum wage in the way that influence local labor market, regression discontinuity approach attributes differences in labor market outcome between districts to minimum wage variation. Magruder (2013) proposes to add on district dummies to loosen the assumption on regression discontinuity type approach (Difference-in-Spatial Difference; DSD henceforth). By controlling nonparametrically for differences among borderline districts which persists over the length of the panel, the approach can single out the effect of minimum wage, and generate causal inference. Magruder extends this approach by using the whole set of contiguous districts in the bordering provinces in Indonesia.

Our primary identification strategy extends Magruder's approach by using individual-level data. Using aggregated data in regression analysis can 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 $W^*_{st} = W_{st} - \frac{1}{n_{st}(\epsilon)} \sum_{s':d(s,s')<\epsilon} W_{i's't'}$ 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- and district-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):

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

Here i indicates an individual or a plant, s is the district of the respondent, and t represents time. MW_{st} represents the log of the minimum wage that varies by time and province/districts. MV_{st} represents province-specific macro variables. X_{ist} represents individual controls. With the IFLS data, X_{ist} contains the education level and its square, age and its square, a dummy for urban residence, and household assets. With the IS data, X_{ist} represents firm-specific controls such as a percentage of the firm owned by foreigners, a percentage of the firm owned by the local and the central government, capital used by firms, and intermediate goods used by the firm. 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. 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. Instead, 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. Thus, 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. Let $\widetilde{X}_{ist} = (X'_{ist}, d_{i1t}, \ldots, d_{iSt})'$ denote the individual-level covariate vector including district dummies indicating where individual i lived in period t. Then the estimation of the model is based on the following differenced regression equation.

$$y_{ist} - \frac{1}{n_{ist}(\epsilon)} \sum_{i',s':d(s,s')<\epsilon} y_{i's't} = \beta \left(W_{st} - \frac{1}{n_{ist}(\epsilon)} \sum_{i',s':d(s,s')<\epsilon} W_{i's't} \right)$$
$$+\eta \left(MV_{st} - \frac{1}{n_{ist}(\epsilon)} \sum_{i',s':d(s,s')<\epsilon} MV_{i's't} \right)$$

$$\gamma' \left(\widetilde{X}_{ist} - \frac{1}{n_{ist}(\epsilon)} \sum_{i',s':d(s,s')<\epsilon} \widetilde{X}_{i's't} \right)$$
$$+ \left(\alpha_s - \frac{1}{n_{ist}(\epsilon)} \sum_{i',s':d(s,s')<\epsilon} \alpha_s \right)$$
$$+ \left(\delta_{st} - \frac{1}{n_{ist}(\epsilon)} \sum_{i',s':d(s,s')<\epsilon} \delta_{s't} \right)$$
$$+ \left(u_{ist} - \frac{1}{n_{ist}(\epsilon)} \sum_{i',s':d(s,s')<\epsilon} u_{i's't} \right)$$

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 of y_{ist} on $\widetilde{X}_{ist}$ and W_{st}. This approach weakens assumptions of difference-in-difference estimation or the assumptions in regression discontinuity 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) spatial-temporal fixed effect, δ_{st}, loosens the assumption of symmetric 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.

4.1.2. 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. First, the firm's willingness to observe the minimum wage regulation depends on the intensity of government surveillance. However, there is not always

data available to measure the intensity of government monitoring (Andres, 2018). Second, it is challenging to identify the control and treatment groups. 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. However, some individuals may sort into larger firms if they are more likely to receive minimum wage in the larger firms, and thus contaminate control and treatment groups. Third, firm-level data has a misreporting issue. Firms may not report their wage payment truthfully 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 identify the treatment and control groups. Here we are interested in whether individuals who work in medium-sized firms (between 5 and 199 workers) have a higher probability of receiving less than the minimum wage compare to the large-sized firms (more than 200 workers). Several empirical works point out the relevance of firm size on minimum wage compliance as large companies are subject to more strict government monitoring and penalties.[6]

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-

[6] Harrison (2010) shows the impact of exogenous enforcement through the anti-sweatshop movement on wage growth in Indonesia. The result shows that targeted foreign-owned firms under the high intensity of surveillance increased their wage payment compare to small firms.

compliance ratio for middle-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:

$$(13)\ BMW_{ijt} = \alpha + \beta D_{ijt} + \gamma X_{ijt} + \lambda_i + \delta_t + u_{ijt}$$

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 created using a subsample of full-time formal sector workers who remained in a similar-sized 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 have been similar to that of the 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 during 2014. We 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 partial compliance with the minimum wage law. In the next session, we report estimates of the minimum wage impact on employment, wages, hours, Pigou's E, and non-compliance.

4.2. Labor market outcomes

In this sub-section, we report our empirical results. We report the effect of the minimum wage on employment, wage, and economic rents measured by Pigou's E. We also report the non-compliance ratio of medium-sized firms to compare to that of the large-sized firms.

Table 7 presents the regression results for various categories of employment in response to real minimum wages using a difference-in-spatial-difference method. In this table, estimates with different bandwidth used for spatial differences are reported to demonstrate the robustness of the results. Binary indicators for each category of employment are constructed and used as dependent variables. The regression results measure the probability of being in each employment category compared to being in another category of employment. The regression results for employment status show that a 10 percent increase in the minimum wage is estimated to lead to a roughly 1.5 - 1.7 percentage point increase in the probability that the individual works in the formal sector. The regression estimates are robust across different bandwidths. The results for full-time formal sector job shows an even more significant increase: a 10 percent increase in the minimum wage is estimated to lead to roughly 2 - 2.3 percentage point increase in the probability for full-time formal sector job. Our estimation results for part-timers is in the opposite direction: minimum wage increase relates to a 0.4 - 0.6 percentage decrease in probability for this group of employees. When we look at the results for informal sector workers, we see the opposite results: a 10 percent increase in the minimum wage is related to a 0.7 - 1.3 percentage point decrease in self-employment job, and 1.4 - 1.6 percentage point decrease in overall people in the family business (self-employment and family work). The results suggest that (i) informal sector workers sort into the formal sector in response to a minimum wage increase, (ii) marginal workers in the formal sector tend to lose their job due to minimum wage increase if we regard part-timers as marginal workers, and (iii) overall effect of minimum wage on formal sector job is positive as informal workers coming into the formal sector job is greater than marginal formal sector workers who leave their job.

In Table 8, we report our estimation results on employment with plant-level data. We report three sets of results by regressing on the total employment, employment for production workers, and employment for non-production workers. The results indicate that there is no unemployment effect of minimum wage on the manufacturing; the results show a somewhat positive relationship, though none of the results with different bandwidth are statistically significant. Considering that the manufacturing sector employment only consists of 14 percent of the total employment (IFLS), the results from IFLS and IS do not contradict each other. Overall, the results suggest a positive effect of the minimum wage on formal sector employment.

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 1990 - 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. 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 paper extends the DSD method by Magruder (2013) with individual-level data, and thus lessens the common trend assumption of fixed effect approach used by both papers.

Tables 9 and 10 report the effect of the minimum wage on the average wage. Using the IFLS sample, we find a point estimate of 11-13 percent wage increase for formal sector workers in response to a 10 percent increase in the minimum wage. 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 make an occupational choice to a wage-earning job. That is, the coefficient includes both wage increase and occupational choice effect. In addition to the overall effect, it is also interesting to study for the heterogeneous effect of minimum wage on workers who are initially paid below the minimum wage and workers 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, we observe that wage increase for the initial sub-minimum wage-paid group is more significant than for the other group whose initial wage is higher than the minimum wage. With the IFLS data, the coefficient of the log minimum wage is 1.2 - 1.35 for the sub-minimum wage workers depending on the choice of the bandwidth and 0.67 - 0.71 for the over-minimum wage workers. This analysis infers that there are informal sector workers who make an occupational shift into the wage-earning job with a sub-minimum wage offer, as

we also see the evidence of the composite effect of minimum wage on wage (wage increase and occupational choice into a wage-earning job).

Regression results with IS data are also consistent with the analysis with IFLS data, except that the coefficient is much smaller now. Using the IS data, we observe a 4-6 percent wage increase when there is a 10 percent increase in the minimum wage. We conduct our analysis with three different dependent variables: total workers, production workers, and non-production workers each firm hires. With a 10 percent increase in the minimum wage, average wage increases by 4.0 - 4.9 percent for all workers, 4.0 - 5.0 percent among production workers, and 2.8 - 4.0 among non-production workers, respectively. As did with IFLS data, we also divide each category of the dependent variable into the two different groups: non-compliant firms in the initial year of sampling, and compliant firms in the initial year of sampling. Our empirical results with IS data are qualitatively similar to those with IFLS data; both initial non-compliant and compliant firms increase wage payment in response to minimum wage increase. These empirical results substantiate the validity of our model: the model predicts that minimum wage affects the whole wage distribution, as employers are engaged with the wage-posting game, and one employer's wage posting affects others. Now, we report regression results on the relation between the minimum wage and the monopsonistic margin measured by Pigou's E.

Table 11 shows the relationship between the minimum wage and the economic rent for monopsonistic employers, measured by Pigou's E, across different bandwidth. As explained in Section 2, the minimum wage and other labor protection regulations might work as barriers to firms if they would not hire more workers due to the uncertainty of labor costs in the future. However, 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. We study this hypothesis by studying the relationship between minimum wage and Pigou's E measure. Our preferred Pigou's E measure is made with per capita output as we have a full sample across all years, and this measure does not need to impose any other additional assumptions as we

had when we estimated production function with a semi-parametric method (Section 2). We also use Pigou's E, calculated separately for production workers and non-production workers, using Wooldridge-LP method (Wooldridge, 2009). Note that we can only use samples from 2004 until 2009 to calculate Pigou's E, as IS data does not contain plant ID for the years 2002 and 2003. With our preferred measure, our estimation results show that a 10 percent increase in the minimum wage relates to 1.4 - 2.8 percent decrease in Pigou's E. However, when Pigou's E calculated separately for production workers and non-production workers, we do not see statistically significant adverse effects, except for non-production workers estimated at the bandwidth of 30 and 80 miles. We suspect that the lack of statistically significant results comes from the reduced sample. However, the overall results on Pigou's E indicate that minimum wage increase reduces economic rent for monopsonistic employers, and it is likely that minimum wage corrected the distorted labor market during the period of investigation.

Table 12 reports the impact of the minimum wage hike during 2013 on the firm's compliance with the regulation: it reports estimation results for equation (13) where it tests non-compliance practice of medium-sized firms (treatment group) compare to large-sized firms (control group) in response to unexpected minimum wage surge in 2013. The identification strategy assumes that in the absence of changes in the Indonesian minimum wage policy, the compliance practice of medium-sized firms would have behaved similarly to the large-sized firms. We also test an expanded version of the regression where the treatment identifier interacts with dummy variables for each year. Results in the table show that in response to the minimum wage hike in 2013, medium-sized firms, compared against large-sized firms, did not comply with the minimum wage increase. In response to a 10 percent increase in the minimum wage, we observe that the non-compliance ratio increases by 0.7-0.8 percent. 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.

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 in Indonesia 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 shows notable heterogeneity in income; there is some proportion of workers who voluntarily choose to work in the informal sector, whereas there are still others rationed out from formal sector. 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 firms and worker productivity allows for a rich mechanism that can explain both labor supply and demand in the formal sector. 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. Though the model does not give a precise prediction on the effect of minimum wage on employment, it does give an unambiguous conjecture for a reduced gap between marginal productivity of labor and wage, and increased non-compliance ratio on minimum wage regulation. 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), an approach that weakens the assumption of both regression discontinuity and difference-in-difference. Our regression results show that an increase in the minimum wage has a positive impact on employment and on the average wage (both the initially sub-minimum wage paid workers, and the over-minimum wage paid worker), and decrease profit margin of monopsonist. Our difference-in-difference results also confirm the prediction of the model in that minimum wage hike in 2013 increases on non-compliance ratio for medium-sized firms compare to the 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 bee studied 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 regulation. 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 that the sorting

behavior of informal sector workers suggests 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

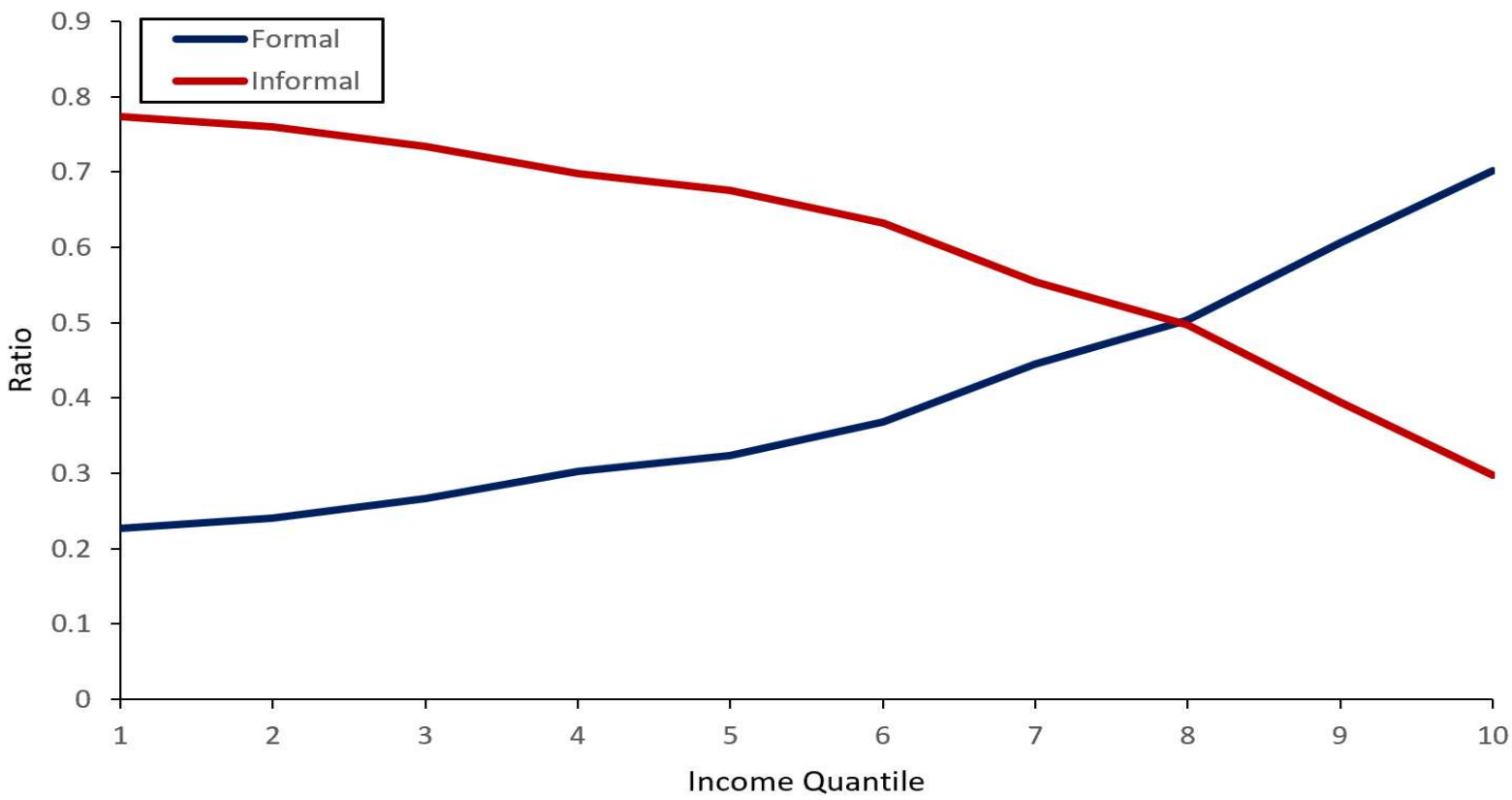
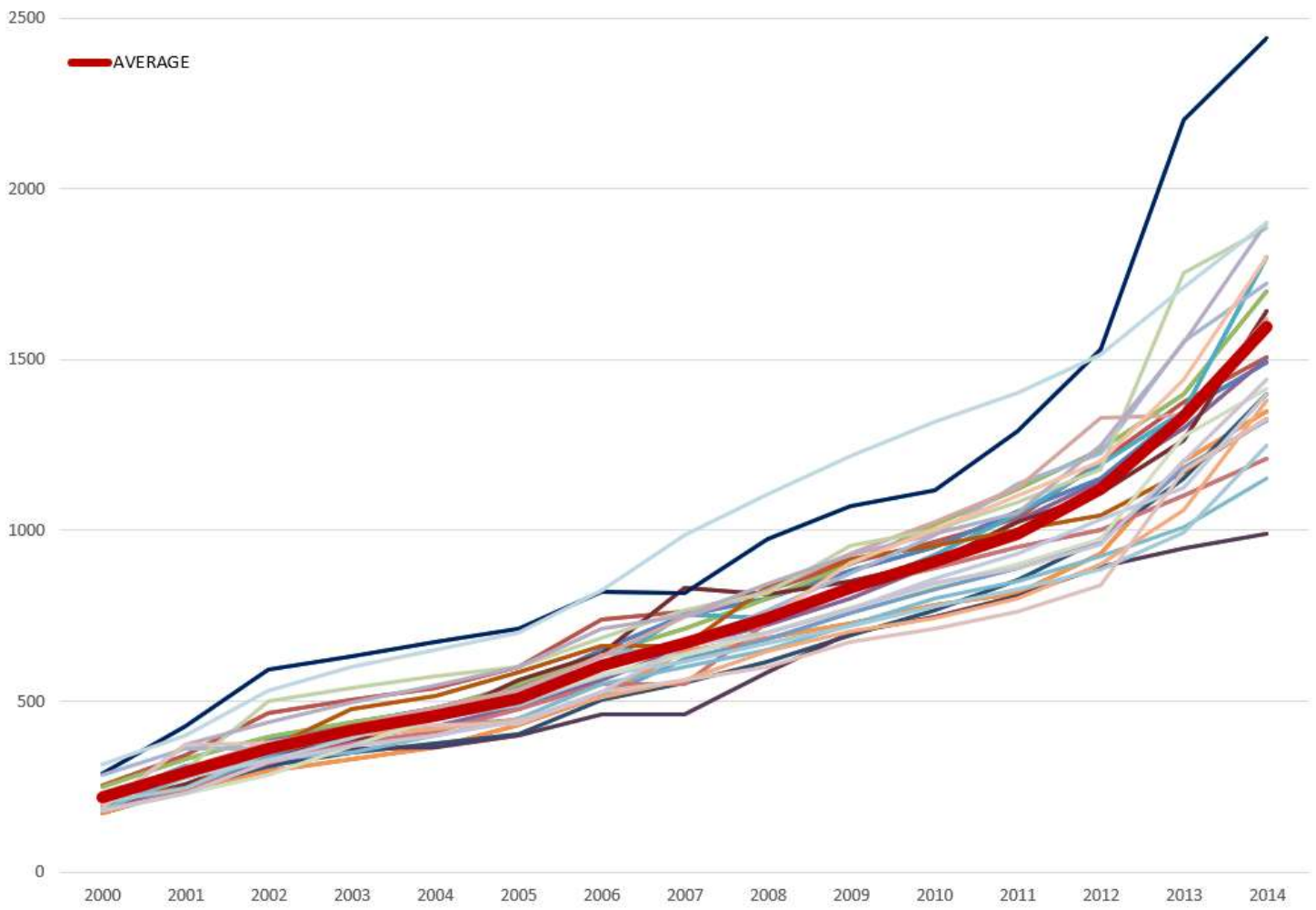


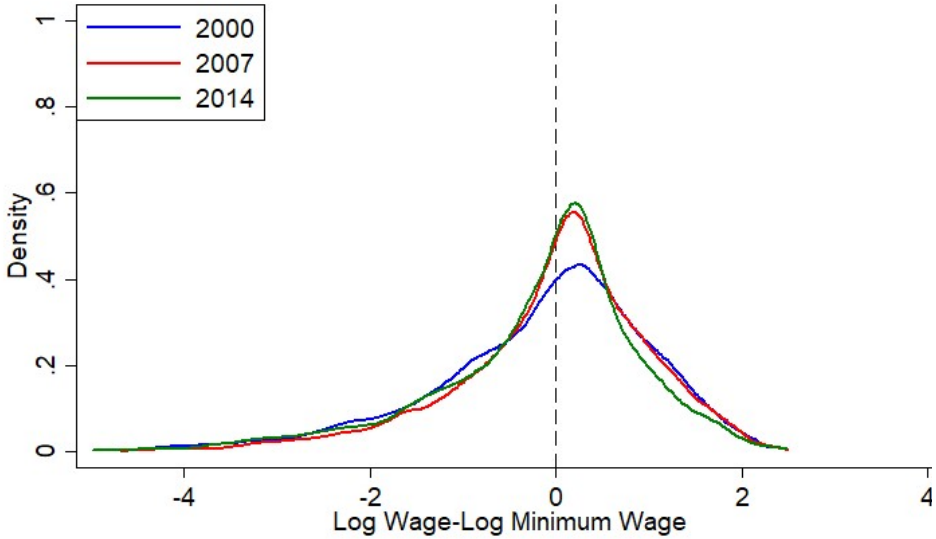
Figure 2. Real Minimum Wage by Province



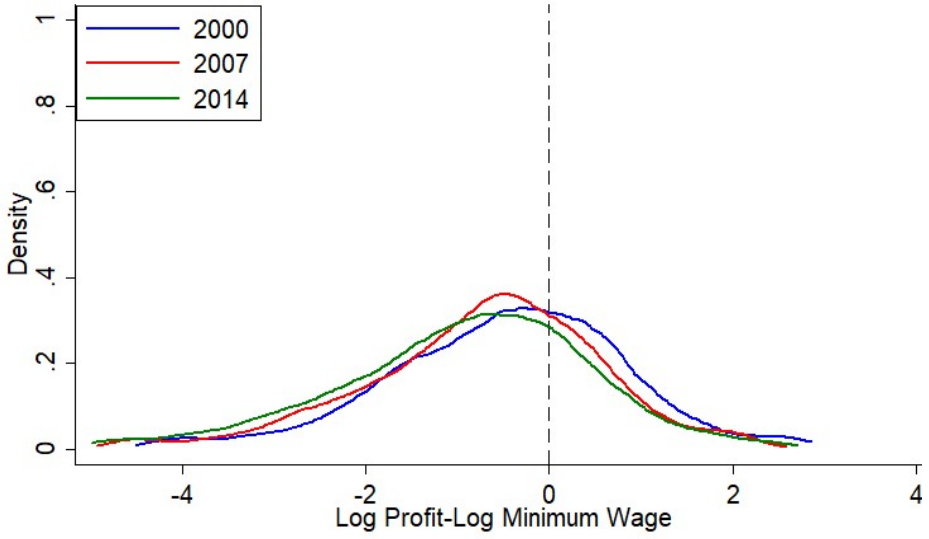
Notes: We use a province-specific CPI to deflate minimum wages. Both the CPI and the province level minimum wages are from the Indonesia's Central Bureau of Statistics (BPS). The BPS provides a CPI for different cities across the country. We match the CPIs of the capital city with each province to create 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 3A. Kernel Densities of Log Earnings Normalized to Minimum Wage

Panel A: Wage distribution

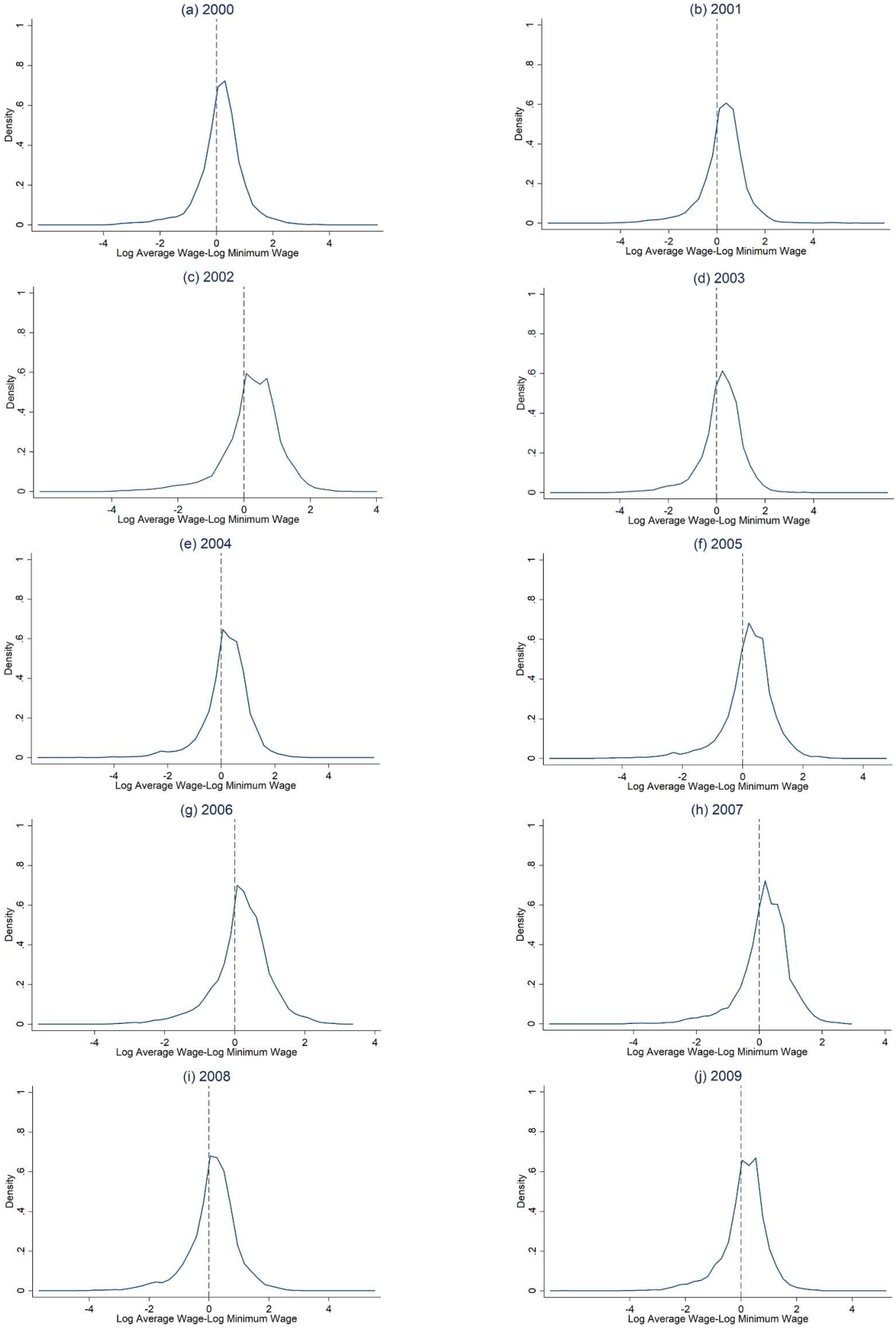


Panel B: Profit distribution



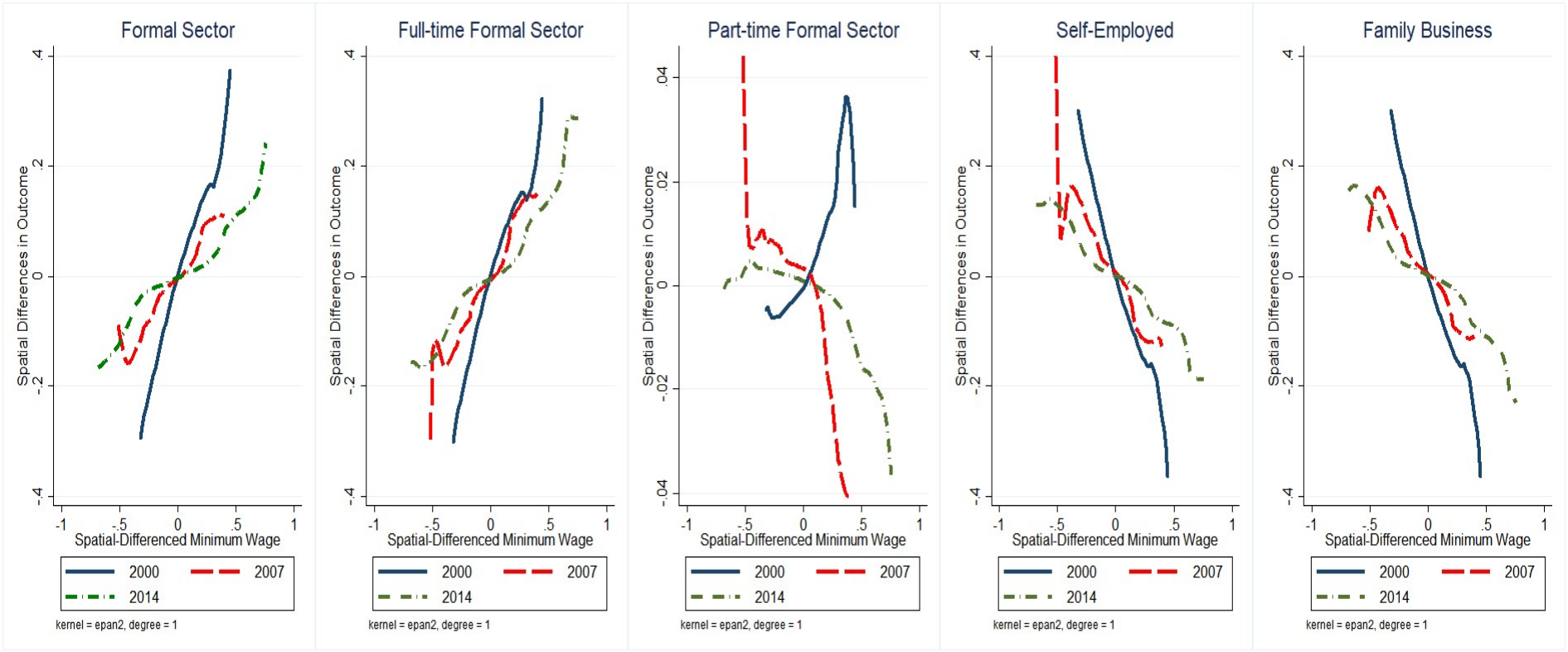
Source: Indonesian Family Life Survey (2000,2007,2014)

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

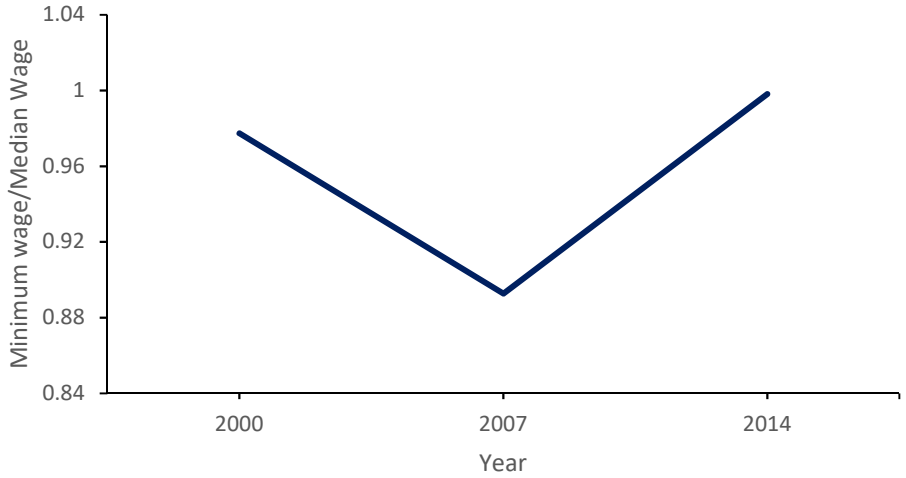


Source: Indonesian Family Life Survey (2000,2007,2014)

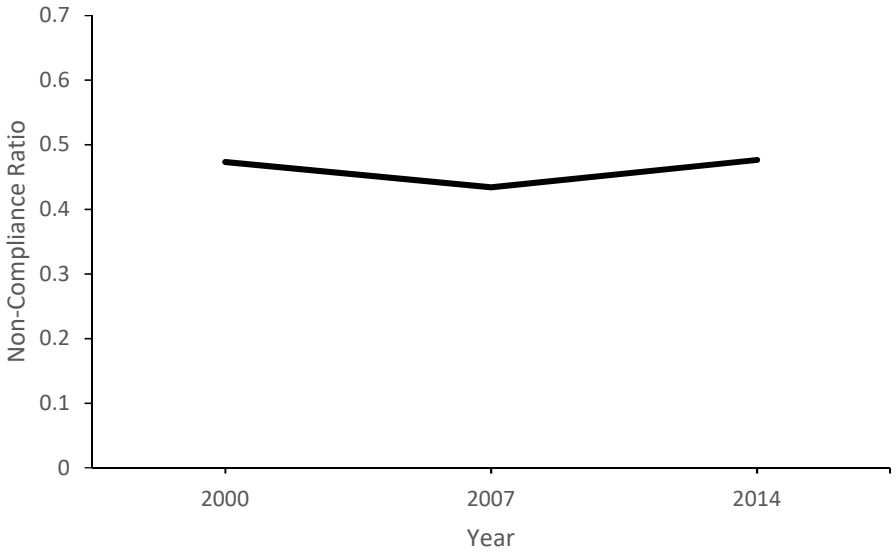
Notes: The graph plots the spatial difference in employment status as a function of the spatially-differenced minimum wage. We define respondents who work either in the government or private sector as formal sector workers (Formal Sector). Among them, respondents working more than 40 hours are defined 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

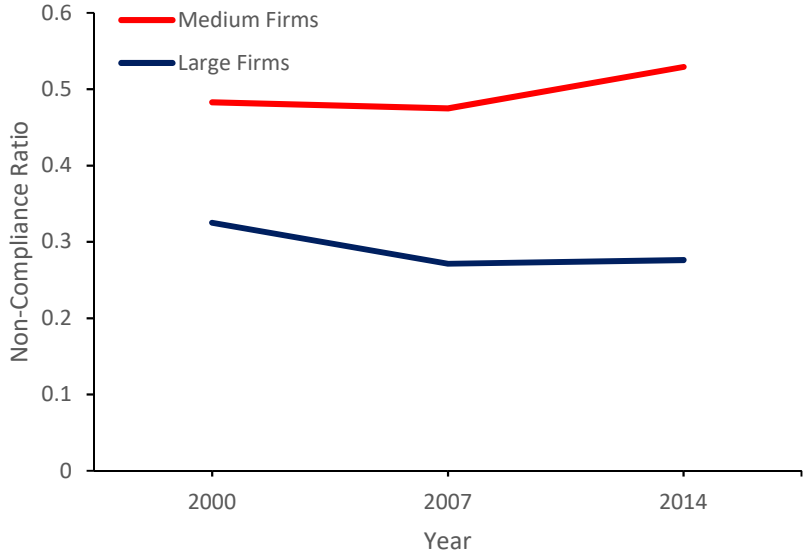
Panel A: Minimum Wage to Median Ratio



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. 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 3. Descriptive Statistics for Indonesian Manufacturing Plants

	Obs	Mean	SD	Min	Max
Employment					
Log Total Workers	234,078	4.172	1.169	2.890	10.627
Log Production Workers	234,017	3.981	1.160	2.398	7.492
Log Non-Production Workers	207,495	2.148	1.442	0	6.021
Average Wage					
Log Average Wage (Rp)					
All	216,107	15.793	0.850	8.582	23.043
Production Workers	216,026	15.723	0.829	7.791	23.439
Non-Production Workers	174,291	16.190	1.057	4.537	23.255
Pigou's *E*					
Log (Pigou's *E*) (Output) (Rp)	196,779	1.893	1.242	-16.657	12.141
Log (Pigou's *E*) (Wooldridge-LP) (Rp)					
Production Workers	117,961	1.030	1.540	-12.086	11.652
Non-Production Workers	96,215	1.702	1.634	-9.122	17.352
Log Output (Rp)	216,258	22.101	2.075	18.210	27.412
Log Material (Rp)	234,078	20.339	4.982	0	26.891
Log Fuel (Rp)	234,076	16.476	5.018	0	27.918
% of Foreign Ownership	234,078	6.807	23.779	0	100
% of Government Ownership	234,078	10.899	30.856	0	100

Source: Industry 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, which are then used to calculate Pigou's *E*. We calculate Pigou's *E* separately for each 2-digit industry, using coefficients estimated using Wooldridge (2009) modification of the Levinsohn-Petrin (2003) approach. All values are in constant 2007 Rupiah (Rp). Data covers 2000-2009.

Table 4. Summary Statistics for Pigou's Measure for Monopsony by 2-Digit Industry Code, 2004-2009 (Wooldridge-LP)

	Production Workers				Other Workers			
	Mean	**Min**	**Max**	**N**	**Mean**	**Min**	**Max**	**N**
Food products and beverages (15)	24.299	-0.973	115019	27308	269.605	-0.972	3342880	26054
Tobacco products (16)	1.897	-1.000	922	4148	24.037	-1.000	9611	3739
Textiles (17)	10.791	-1.000	17174	8928	26.112	-1.000	24177	8302
Wearing apparel; dressing and dyeing of fur (18)	4.601	-1.000	5204	8480	68.258	-1.000	165373	7421
Processing of leather; manufacture of luggage, handbags (19)	2.393	-0.970	540	2895	10.562	-0.990	8137	2747
Wood and of products of wood and cork (20)	12.284	-1.000	32202	6728	386.770	-1.000	1692793	6440
Paper and paper products (21)	6.799	-0.990	1854	2271	9.329	-0.998	10273	2250
Printing and reproduction of recorded media (22)	5.878	-1.000	3138	3292	13.442	-1.000	19742	3242
Coke, refined petroleum products and nuclear fuel (23)	47.380	-0.733	1748	319	62.541	-0.172	6718	317
Chemicals and chemical products (24)	42.060	-0.986	27143	5436	47.425	-0.995	38960	5405
Rubber and plastics products (25)	11.593	-0.985	3503	8085	80.752	-0.981	483339	7995
Non-metallic mineral products (26)	4.191	-0.993	2898	8323	5053.494	-0.982	34300000	6961
Basic metals (27)	86.736	-0.945	68175	1139	81.783	-0.920	25071	1125
Fabricated metal products, except machinery and equipment (28)	6.736	-0.987	2453	3954	64.100	-0.993	82565	3833
Machinery and equipment (29)	11.974	-1.000	718	1833	13.548	-1.000	1132	1802
Electrical machinery and apparatus (31)	6.462	-0.979	97	1230	8.558	-0.990	536	1226
Radio, television and communication equipment and apparatus (32)	12.413	-0.994	718	747	323.303	-1.000	117001	745
Motor vehicles, trailers and semi (34)	15.929	-0.969	3647	1461	44.967	-0.959	50082	1454
Other transport equipment (35)	7.423	-0.989	328	1441	12.425	-0.997	3169	1417
Furniture; manufacturing (36)	11.006	-1.000	39812	11379	173.703	-1.000	778039	10636
Recycling (37)	9.413	-0.915	1738	539	16.766	-0.949	2438	529

Source: Own calculations from IS surveys.

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 payment for production-related workers and non-production-related workers, which are then used to calculate Pigou's *E*. We calculate Pigou's *E* separately for each 2-digit industry, using coefficients estimated using Wooldridge (2009) modification of the Levinsohn-Petrin (2003) approach. All values are in constant 2007 Rupiah (Rp). Data covers 2000-2009.

Table 5. 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 6. 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 7. The Effect of Minimum Wage on Employment Status (DSD)

VARIABLES	(1) Formal		(2) Full-Time Formal		(3) Part-Time Formal		(4) Self-Employed		(5) Family Business	
25 miles	0.173	**	0.234	***	-0.052	***	-0.130	***	-0.166	**
	(0.067)		(0.061)		(0.017)		(0.043)		(0.067)	
30 miles	0.169	***	0.234	***	-0.053	***	-0.112	***	-0.159	**
	(0.062)		(0.058)		(0.015)		(0.038)		(0.063)	
35 miles	0.167	***	0.230	***	-0.050	***	-0.109	***	-0.157	***
	(0.056)		(0.046)		(0.019)		(0.036)		(0.057)	
40 miles	0.162	***	0.225	***	-0.056	***	-0.104	***	-0.154	***
	(0.053)		(0.048)		(0.013)		(0.039)		(0.055)	
60 miles	0.146	***	0.215	***	-0.056	***	-0.076	**	-0.138	***
	(0.045)		(0.043)		(0.012)		(0.030)		(0.047)	
80 miles	0.153	***	0.203	***	-0.041	***	-0.079	***	-0.148	***
	(0.039)		(0.040)		(0.012)		(0.029)		(0.040)	
Mean	0.401		0.275		0.131		0.497		0.580	
Observations	50,453		50,453		50,453		50,453		50,453	

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, a dummy variable for urban/rural residence, age and age squared, education level and education squared.

Table 8. The Effect of Minimum Wage on Plant-level Employment (DSD)

VARIABLES	(1) Total Workers	(2) Production Workers	(3) Non-Production Workers
25 miles	0.022	0.018	0.093
	(0.066)	(0.065)	(0.086)
30 miles	0.065	0.053	0.203
	(0.076)	(0.066)	(0.135)
35 miles	0.075	0.055	0.184
	(0.086)	(0.068)	(0.169)
40 miles	0.053	0.04	0.121
	(0.082)	(0.066)	(0.151)
60 miles	0.018	0.004	0.104
	(0.125)	(0.107)	(0.168)
80 miles	0.089	0.067	0.208
	(0.122)	(0.104)	(0.183)
Mean	4.185	3.984	2.158
Observations	196,815	196,803	181,510

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 capital, material, and Macro variables.

Table 9. The Effect of Minimum Wage on Income by Employment Status (DSD)

VARIABLES	(1)		(2)		(3)		(4)		(5)	
	Full-Time Wage Earner									
	All		Sub-Minimum Wage Workers Initial Year		Over-Minimum Wage Workers Initial Year		Part-Time Wage Earner		Family Business Profit Earner	
25 miles	1.102	***	1.346	***	0.676	***	0.749	***	0.804	***
	(0.044)		(0.100)		(0.093)		(0.095)		(0.066)	
30 miles	1.118	***	1.280	***	0.690	***	0.754	***	0.719	***
	(0.033)		(0.117)		(0.083)		(0.105)		(0.061)	
35 miles	1.127	***	1.255	***	0.711	***	0.800	***	0.758	***
	(0.056)		(0.108)		(0.072)		(0.127)		(0.052)	
40 miles	1.080	***	1.263	***	0.696	***	0.717	***	0.692	***
	(0.051)		(0.089)		(0.083)		(0.144)		(0.068)	
60 miles	1.049	***	1.198	***	0.685	***	0.579	***	0.609	***
	(0.056)		(0.110)		(0.087)		(0.113)		(0.058)	
80 miles	1.051	***	1.238	***	0.688	***	0.630	***	0.573	***
	(0.060)		(0.108)		(0.066)		(0.109)		(0.049)	
Mean	15.954		15.093		16.593		15.330		15.094	
Observations	13,646		5,775		7,694		6,452		18,340	

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. We Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, a dummy variable for urban/rural residence, age and age squared, education level and education squared.

Table 10. The Effect of Minimum Wage on Average Wage (DSD)

	(1)		(2)		(3)	(4)		(5)		(6)	(7)		(8)		(9)
	Total Workers					Production Workers					Non-Production Workers				
VARIABLES	All Firms		Non-Compliant Plants		Compliant Plants	All Firms		Non-Compliant Firms		Compliant Firm	All Firms		Non-Compliant Plants		Compliant Plants
25 miles	0.397	***	0.421	***	0.235	0.397	***	0.445	***	0.423 ***	0.279	**	0.454		0.471 ***
	(0.064)		(0.113)		(0.468)	(0.055)		(0.146)		(0.147)	(0.115)		(0.320)		(0.129)
30 miles	0.424	***	0.348	***	0.298	0.410	***	0.379	***	0.509 ***	0.375	***	0.477	**	0.626 ***
	(0.081)		(0.061)		(0.527)	(0.064)		(0.091)		(0.093)	(0.077)		(0.224)		(0.097)
35 miles	0.469	***	0.443	***	0.391	0.471	***	0.473	***	0.562 ***	0.389	***	0.540	**	0.728 ***
	(0.104)		(0.105)		(0.529)	(0.083)		(0.120)		(0.087)	(0.099)		(0.259)		(0.114)
40 miles	0.459	***	0.466	***	0.368	0.466	***	0.498	***	0.547 ***	0.363	***	0.592	**	0.679 ***
	(0.083)		(0.097)		(0.552)	(0.064)		(0.111)		(0.093)	(0.090)		(0.252)		(0.109)
60 miles	0.465	***	0.575	***	0.721	0.484	***	0.614	***	0.550 ***	0.365	***	0.762	***	0.758 ***
	(0.077)		(0.096)		(0.483)	(0.055)		(0.079)		(0.122)	(0.081)		(0.202)		(0.082)
80 miles	0.487	***	0.533	***	0.651	0.497	***	0.577	***	0.578 ***	0.395	***	0.740	***	0.772 ***
	(0.092)		(0.088)		(0.493)	(0.065)		(0.075)		(0.119)	(0.097)		(0.206)		(0.085)
Mean	15.820		15.351		16.046	15.742		15.362		15.954	16.184		15.509		16.332
Observations	194,954		63,406		96,697	194,928		69,791		90,292	168,324		30,287		106,812

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." We use the average wage of total workers, production workers, and non-production workers as our dependent variables. Within each category of the dependent variables, we further divide the sample into the two different groups: plants whose average wage payment at the initial year of sampling is greater than minimum wage(Compliant Plants), and plants whose average wage payment at the initial year of sampling is smaller than minimum wage (Non-Compliant Plants). Note that we cannot include samples in the years 2002 and 2003 for the regression analysis of these sub-categories as we cannot observe plant ID for these years. 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 capital, material, and Macro variables.

Table 11. The Effect of Minimum Wage on Pigou's *E* (DSD)

VARIABLES	(1) Y/L		(2) Wooldridge-LP Production Workers		(3) Wooldridge-LP Non-Production Workers	
25 miles	-0.144	*	0.129		-0.355	
	(0.086)		(0.254)		(0.228)	
30 miles	-0.179	**	-0.087		-0.353	*
	(0.086)		(0.275)		(0.201)	
35 miles	-0.243	***	-0.153		-0.170	
	(0.090)		(0.197)		(0.122)	
40 miles	-0.239	***	-0.172		-0.128	
	(0.090)		(0.183)		(0.123)	
60 miles	-0.246	***	-0.085		-0.192	
	(0.072)		(0.208)		(0.190)	
80 miles	-0.284	***	-0.187		-0.441	***
	(0.073)		(0.198)		(0.151)	
Mean	1.802		0.131		1.391	
Observations	183,257		103,261		90,897	

Sources: Own calculation from IS 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 Pigou's *E* measure calculated with different methods. For the first column, total output per worker is used to calculate Pigou's *E*. For the second and third columns, we estimate a gross output Cobb-Douglas function, using Wooldridge (2009) modification of the Levinsohn-Petrin (2003). 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 capital, material, and Macro variables.

Table 12. Tests for Partial Compliance with Legal Minimum Wages

	Workers in Medium Firms (5~199) (Treatment Group) and Large Firms (>200) (Control Group)			
2014 × T	0.074	***	0.082	***
	(0.026)		(0.025)	
2007 × T			0.038	
			(0.025)	
2000 × T			-0.054	
			(0.045)	
Individual, Year, Occupation FE	Yes		Yes	
Macro Variables	Yes		Yes	
Number of Observation	10,521		10,521	

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. Clustered-robust standard errors by the province in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, a dummy variable for urban/rural residence, age and age squared, education level and education squared.

Appendix

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

Minimum Wage is the nominal minimum wage deflated by the CPI. The BPS provides constructed CPIs for different cities across the country. Matching the CPIs of the capital city with each province, we have created a CPI measure for provinces across years. We choose 2007 as the base year.

Self-reported Income (IFLS) is the self-reported income variables that are annualized to be consistent with the minimum wages prescribed by law for annual wage income. IFLS data only contains information on the total wage (monetary remuneration and other benefits), and we cannot dissect monetary remuneration from other benefits. All these values are adjusted by a province-level CPI published by the Indonesian Central Bureau of Statistics (BPS)

Household Asset (IFLS) is the total summation of the various household asset values. This includes the house occupied by the household, other house/building, 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 for our regression analysis. IFLS consists of several different books, and respondents sometimes choose to answer in book two or book three. Unfortunately, categories of an asset listed in book3 of IFLS5 is not consistent with book2 of IFLS5 and the rest of the IFLS series. That is, it does not contain information on several asset values that are available in the previous rounds. These are poultry, livestock/fishpond, hard stem plant not used for farm or non-farm business, vehicles, household appliances, furniture, and utensils. To deal with the missing information, we impute the missing value by applying the standard Oaxaca method. Since we have information for a

sample who answered in book2, we aggregate for the list of items that are in the book3, and the list of the items not listed in book3. Using these two values, we proceed with the standard Oaxaca method, and impute values for the missing items for the information in book3 and construct a household asset value that is 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 at December 31 of the year in question. When the capital value is not reported, we use the reported value of the capital in the previous year for constructing 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 value where we used a price deflator based on Wholesale Price Indices for new machinery and equipment.

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.

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. Heterogeneous Informal Sector Worker

B.1. Introduction

In this appendix, we further investigate the nature of informal sector employment. Following the lead of Radchenko (2014, 2017), we study the characteristics of the informal sector economy by drawing on the model with essential heterogeneity and the non-parametric estimation techniques proposed by Heckman, Urzua, and Vytlacil (2006). The model with essential heterogeneity allows for different treatment effects on an outcome where the preference for the treatment varies across the population. We take formal sector employment as treatment and then analyze for the heterogeneous effect of formal sector employment on income gain across populations whose preference for formal sector employment differs. The study on heterogeneous treatment effects is conceptualized as the marginal treatment effect (MTE) by Bjorklund and Moffitt (1987) and extended in a series of papers by Heckman and Vytlacil (1999, 2001, 2005, 2007). This literature aims to identify a continuum of treatment effects along with the distribution of the individual unobserved characteristics that drive a decision on treatment. Identifying the marginal treatment effect across a population-based on an individuals' preference for treatment is particularly informative as the shape of the MTE curve across individuals' unobserved characteristics allows us to infer the driving mechanism for informal sector employment. We first introduce the model to expound this.

B.2. Estimating Marginal Treatment Effect

The framework to describe the MTE method in the literature is a generalized Roy model based on the potential outcomes model and latent index model, as in Heckman and Vytlacil (1999,

2001, 2005, 2007). We regard the formal sector workers as the treated population and workers in the informal sector as the untreated population. Earnings from formal and informal sector jobs represent the outcomes of being treated and untreated, respectively. Let W_1 be the potential outcome of an individual in the formal sector (treated group; $D = 1$) and W_0 denote the potential outcome for the individual in the informal sector (untreated group; $D = 0$). The observed outcome W can be linked to the potential outcomes through the switching regression model:

$$W = (1 - D)W_0 + DW_1 \text{ (B.1)}$$

We model the potential outcomes W_j as a function of observed individual characteristics, X, and unobserved individual characteristics, U_j.

$$lnW_j = X\beta_j + U_j,\ j = 0, 1 \text{ (B.2)}$$

where U_j is normalized to $E(U_1|X = x) = E(U_0|X = x) = 0$ for $j = 0, 1$, and for all x in the support of X. By applying the switching regression model, we can express the above equation as

$$lnW = X\beta_0 + \triangle * D + U_0 \text{ (B.3)}$$

where $\triangle = (\beta_1 - \beta_0)X + (U_1 - U_0)$, and can be interpreted as an individual treatment effect. We can use the following latent index model to describe selection into treatment group:

$$I_D = Z\gamma - V_D \text{ (B.4)}$$

That is, individual's net benefit of working in the formal sector, I_D, depends on observed variables Z and an unobserved component V_D, where $Z = (X, \widetilde{Z})$ implies that Z includes all the same covariates X in the outcome equation, and also contains instruments $\widetilde{Z}$, excluded from the outcome equation but enters the selection equation. Note that finding instruments are a necessary condition to identify MTE as the treatment heterogeneity comes from the correlation between unobserved gains from the outcome model, $U_1 - U_0$, and unobserved term in the latent

index model,V_D. More formally, the necessary conditions on instruments for the identification of MTE are the following: (i) the instruments, $\widetilde{Z}$, should be independent on U_0, U_1, V_D conditional on $X\Big(\widetilde{Z} \perp (U_0, U_1, V)|X\Big)$. (ii) instruments should affect to the decision on treatment $\Big(cov(\widetilde{Z}, D) \neq 0\Big)$. In other words, the instrument variables should affect to the outcome only through its effect on treatment, and the instruments should be as good as randomly assigned given other control variables X. Let us interpret V_D as "unobserved resistance" or "distaste" to the treatment as V_D enters into the equation with a negative sign. Individuals select the treated state if the benefit, which is explained by the observables Z, is greater than the unobserved resistance. We can re-write this selection equation as follows:

$$Z\gamma - V_D \geq 0 \Longleftrightarrow Z\gamma \geq V_D \Longleftrightarrow \Phi(Z\gamma) \geq \Phi(V_D) \text{ (B.5)}$$

where Φ denotes the cumulative distribution function of V_D. The term $\Phi(Z\gamma)$, also denoted as $\Phi(Z\gamma) = P(Z)$, is the propensity score, and $\Phi(V_D)$ can be normalized as a uniform distribution on the unit interval. Let us define the quantiles of the distribution of unobserved resistance to treatment as $U_D(\equiv \Phi(V_D))$. Thus, individuals whose propensity to work in the formal sector based on observables are higher than the unobserved distaste for formal sector job sort into the formal sector ($D = 1\text{if } P(Z) > \Phi(V_D)$). MTE is then defined as the expected treatment effect among individuals whose observable and unobservable controls are $X = x$ and $U_D = u_D$, respectively.

$$MTE(X = x, U_D = u_D) = E(lnW_1 - lnW_0|X = x, U_D = u_D) \text{ (B.6)}$$

That is, MTE is the average treatment effect for individuals with observed characteristics $X = x$ who are at the u_Dth quantile of the $\Phi(V_D)$ distribution. As U_D is proxied by the propensity score when it is estimated, we can express MTE as $MTE(X = x, U_D = p) = E(lnW_1 - lnW_0|X = x, U_D = p)$. Then the definition of MTE implies the average treatment

effect of individuals whose probability of sorting into the treatment based on observables is p and who are indifferent between participation and non-participation into the treatment.

In practice, applied researchers estimate MTE with a semi-parametric approach, following Heckman, Urzua, and Vytlacil (2006). The approach assumes (i) additive separability between an observed and an unobserved component in the expected potential outcomes conditional on U_D, (ii) conditional independence of instruments $Z \perp (U_0, U_1, V)|X$. Under these two assumptions, the marginal treatment effect can be decomposed into an observed and unobserved component in the additively separable way.

$$\begin{aligned} MTE(X = x, U_D = u_D) &= E(lnW_1 - lnW_0|X = x, U_D = u_D) \\ &= x(\beta_1 - \beta_0) + E(U_1 - U_0|U_D = u_D) \end{aligned}$$

One can describe this equation from the switching regression model, controlling the unobserved gains from treatment non-parametrically. From $lnW = X\beta_0 + (X(\beta_1 - \beta_0) + (U_1 - U_0)) * D + U_0$, unobserved component in the outcome equation and its relation with selection equation can be non-parametrically modelled with polynomial of propensity score so that the equation becomes

$$E(lnW|X = x, P(z) = p) = x\beta_0 + x(\beta_1 - \beta_0)p + K(p) \quad \text{(B.7)}$$

where $K(p)$ is a polynomial of the propensity score. We take a derivative with respect to p, which then generates $MTE(X = x, U_D = p)$ (Carneiro et al. (2011)).

$$\frac{\partial E(lnW|X=x,P(Z)=p)}{\partial p} \mid_{p=u_D} = x(\beta_1 - \beta_0) + \frac{\partial K(p)}{\partial p} = MTE(X = x, U_D = p) \quad \text{(B.8)}$$

From this equation, it is clear that the heterogeneous treatment effect comes from the correlation between unobserved gain from the treatment, $(U_1 - U_0)$, and unobserved characteristics that affect the sorting on the treatment V_D, and the slope of MTE trajectory are driven by $E(U_1 - U_0|U_D = p)$. The observed controls, $x(\beta_1 - \beta_0)$, determines the intercept of MTE. As the trajectory of the MTE curve is driven by the relationship between U_D and $U_1 - U_0$, the shape of the MTE curve illustrates the sorting behaviors of individuals, which then become an

inference for the characteristics of the informal sector labor market. We discuss this in the next section.

B.3 Model Implication on the characteristics of the informal sector

It is a standard practice to put the trajectory of the MTE curve along with the resistance to the treatment (U_D). When the marginal treatment effect is estimated with a non-parametric method, the trajectory of the curve can take any shape. However, for the sake of the discussion on inference for the characteristics of the informal sector market, we only discuss three different types of the curve.

(1) MTE decreasing with U_D.

A negative sloping MTE curve along U_D means that a group of workers with the least resistance toward formal sector work earn the most by moving into the formal sector. We can observe this pattern of the graph when the unobserved resistance that discourages individuals from sorting into formal sector work is negatively related to the person's relative efficiency in the formal sector. That is, a person who has high prowess in the wage-earning environment and thus has a low resistance to the formal sector wage-earning job tends to get a formal sector job and gain a higher-earning compared to the counter-factual earning in the informal sector. Though the negative sloping MTE curve indicates the positive gain on the sorting, that does not necessarily mean that the informal sector labor market is mostly integrated. For instance, if the negative sloping MTE curve is greater than 0 across all U_D, this may indicate that even individuals whose distaste for formal sector jobs is highest due to her/his ineptitude in the wage-earning environment still gain by taking a formal sector job. In other words, if the downward sloping MTE curve shows only positive values, the whole sample whose propensity score is estimated may get better off by taking formal sector work if we assume the cost of working in the formal sector is negligible.

Thus this MTE curve may indicate a segmented labor market. However, if the downward sloping MTE curve shows negative values for some population whose resistance to formal sector work is high, it indicates that there is a portion of workers who are better off by working in the informal sector. Considering that there is typically an entry cost to the formal sector, the negative values of the MTE curve reinforce the intuition of rational choice for informal sector work. Then this shape of the MTE curve implies that there is a group of competitive informal sector workers who choose to stay in the informal job for their benefit. Thus MTE function decreasing with U_D and where the MTE function becomes negative at considerable resistance indicates the existence of a competitive informal sector for some segment of the labor market. Though, at another segment of the informal sector, workers are rationed out from the formal sector. Overall, this pattern could indicate the interposing of a competitive informal sector and marginalized informal sector. Then the graph infers that the allocation process between the formal and informal sector worker is guided by both the supply and demand sides of the market.

(2) MTE^U increasing with U_D

A positive sloping MTE curve along U_D implies that a group of workers with the highest resistance to formal sector jobs earn the highest relative gain by working in the formal sector. Though an upward sloping MTE curve is unlikely to be observed in our setting, this may occur if unobserved distaste for working in the formal sector reflects an unobserved inability for working in general. To be more concrete, let us assume that workers with a low resistance to the formal sector have a higher capacity for work in general. These workers are not particularly affected by the sector they work; they are capable of earning a similar amount of income in either sector. These workers may even earn a higher income in the informal sector due to increased independence in the informal sector work. However, workers who have high resistance to formal jobs, and thus are not capable in general, earn much higher relative income once they work in the formal sector. If this is the scenario, though it is unlikely, then the positive sloping MTE curve may indicate that the most capable workers do not sort into the formal sector and are

better off with their choice in informal sector work. If the upward sloping MTE curve is greater than 0 across all U_D, then it indicates all workers in the market are better off by working in the formal sector, which refers to the segmented labor market. If the upward sloping MTE curve shows negative values for some population whose resistance to the formal sector is low, then this can indicate a rational sorting into either the formal or informal sector.

(3) MTE^U orthogonal to U_D

This shape of the MTE curve indicates either (i) no relationship between expected gains from the formal sector and worker's preference or (ii) the gap between formal and informal sector workers across the resistance is monotone. Both interpretations infer labor market segmentation: despite heterogeneous resistance, the average formal-informal earning gap due to the resistance is the same across the whole population of workers. In short, among the possible scenarios discussed, the clear indicator for the existence of labor segments for integrated formal-informal labor market can be found in a negative (positive) sloping MTE curve where the value of MTE goes negative with a large (small) resistance.

We can also aggregate treatment effects to make an inference on the informal sector economy. As shown by Heckman (2007), the average treatment effect ATE, the treatment effect on the treated TT, and the treatment effect on the untreated $ATUT$ can be recovered by integrating MTE. Since we consider treatment as working in the formal sector, TT estimates the average gains of working in the formal sector compared to the informal sector among formal sector workers. ATE calculates the effect of working in the formal sector relative to informal one among the overall population, and TUT measures the counter-factual earnings of working in the formal sector relative to those in the informal sector among informal sector workers. As discussed, the downward sloping MTE curve with a negative value of MTE at some resistance level gives a clear inference on the existence of a competitive informal sector labor market. We focus our discussion on the relationship among aggregated estimators when the MTE curve is downward sloping. The negative slopingMTE curve is related to $TT > ATE > TUT$. This means that

the effect of working in the formal sector among formally employed workers is greater than the earning effect among the overall population. Also, the earning effect of being in the formal sector among informal sector workers are less than the earning effects among the overall population. Especially, the sign of TUT represents the average gain of informal sector workers from choosing a formal sector job. If $TUT < 0$, that indicates that the average counter-factual earning in the formal sector is less than what informal sector workers gain. If this is the case, on average, informal employment is voluntary and chosen based on comparative advantage considerations. When $TUT > 0$, the opposite is true. The average counter-factual earning in the formal sector among informal sector workers is greater than their average actual earning in the informal sector. As such, average TNT_U in the informal population depends on the relative importance of the upper versus lower tier in the informal labor market and the average gains and losses in the two sub-populations (see Radchenko 2014, 2017).

B.4. Results.

B.4.1. Selection into Formal or Informal Employment

A standard requirement of any treatment evaluation estimator is to ensure the comparability of the treated and untreated. In our analysis, we need to have a reasonably large sample of people in both the formal and informal sector whose observable characteristics are similar. Formally, the requirement is written as a non-zero probability of being in the treated or untreated population with the same observable characteristics (Heckman et al. 2006). As such, we have to choose the right observable characteristics to ensure that there is a large portion of both formal and informal sector workers with the same characteristics. For instance, if we control for the number of employment in the current job, we lose a large number of a comparable sample as informal sector workers tend to work with a small number of coworkers. Also, if we do not control for weekly working hours, then we lose the comparability between the treated and untreated group. Considering these, we choose to control for the log of household assets, log minimum wage,

binary variables for living in an urban area, being a female, education variables, age variables, provincial macro variables, fixed effects for a year, district, and occupation. After controlling for these variables, we still find a significant portion of formal and informal workers whose propensity scores (probability of working in the formal sector) overlap. However, as a small portion of workers in the informal sector earns too high of an income compared to the formal sector workers with similar observable characteristics. We regard this small sample as an outlier and remove it from our regression analysis.

Table B.1. reports the results of the selection equation (B.5). We use a probit model to estimate propensity scores. Other than control variables X used for the outcome equations (B.7), we used a binary variable, which indicates whether a respondent has a household member(s) working in the formal sector. This indicator has been used by Radchenko (2014) as an exclusion variable that provides exogenous variations of the propensity score necessary to identify MTE. As one can see in the propensity score analysis, there is a strong relation between our instrument and treatment (full-time formal job). After controlling for education, residency, working hours, and occupation and district dummies, it seems that having a household member in the formal sector does not directly affect the respondent's income. Consistent with the descriptive statistics (Table 1), young people and females, tend to work in the informal sector. Higher education, weekly working hours, and living in an urban area is positively related to full-time formal sector employment. Our preliminary analysis shows that minimum wage positively relates to the full-time formal sector job, which infers sorting behaviors of individuals from their cost-benefit analysis.

B.4.2. Earnings from Formal versus Informal Employment

The above graph illustrates the downward sloping MTE curve. As the resistance to the treatment increases, the effect of the treatment decreases, and at a certain point, we see the negative effect of the treatment. We change our polynomials from two until five and still observe this downward sloping curve throughout the different specifications. As discussed above, the graphs indicate positive sorting. People with a low resistance to formal sector jobs tend to get higher

remuneration if they choose to work in that sector, whereas people with high resistance to formal jobs are worse off if they choose to work in the formal sector. Various aggregate measures for treatment effect support this inference. In Table B3, we report that treatment effect among the formal sector workers, TT, is greater than the effect on the average population, ATE. The treatment effect among informal sector workers, TNT, is not only the smallest among the three measures but shows a negative value, which implies a positive average gain from working informally in the population of informal workers. Note that the average TNT in the informal population depends on the relative importance between upper versus lower tier and the average gain or loss in these two sub-populations (Radchenko (2017)). Thus this indicates that the laborer's cost-benefit analysis primarily drives informal sector employment in Indonesia.

We discuss the estimated coefficient on several observed variables. Note that education is remunerated in formal employment, whereas we do not find a statistically significant effect of education on earning among informal sector workers. In other words, education not only helps individuals find a formal sector job but also increases their earnings in the formal sector. We find the same effect on the minimum wage, which is the focus of the current study. Table B2 shows the positive effect of minimum wage on formal sector employment, contrary to the prediction from the viewpoint of the neo-classical perfect labor market. Not only does minimum wage induce some individuals to sort into the formal sector, but it also increases earned income for individuals in the formal sector. These preliminary results already indicate that the minimum wage gives incentives for formal sector jobs. The effect on gender deserves to be mentioned, as well. In our propensity score analysis, we observed that being female negatively affects the ability to earn a formal sector job. When we look at the effect of gender on earning in the informal sector and formal sector, respectively, we observe that being female negatively affects earned income in the informal sector, and their relative earning in the formal sector increases compared to their earnings in the informal sector.

B.3. Discussion and implication for the economic model

In this appendix, we study the distribution of the individual treatment effect (the effect of taking a formal sector job on earning) and its relationship with job allocation. If there is a positive correlation between unobservables and treatment effect, it indicates that individuals know how formal sector employment may benefit their income and act on it. A zero correlation between individual characteristics and treatment effect signals that there is no cost-benefit analysis behind worker's allocation. Radchenko (2014) argues that positive sorting on the gain as opposed to zero sorting on the gain works as a discriminating condition between voluntary and involuntary informal employment. We employed the analysis of Radchenko (2014, 2017) in the context of the Indonesian labor market. The negative sloping MTE curve, coupled with aggregate treatment measures, indicates that individuals' cost-benefit analysis has primarily driven informal sector employment in Indonesia. Note that our analysis does not exclude the possibility of rationing. It is not possible to conduct a counter-factual analysis without the existence of informal sector workers whose observable and unobservable traits are similar to those of formal sector workers and whose remuneration in the informal sector job is smaller than their potential earning in the formal sector. Thus our MTE analysis in the context of Indonesia infers that the informal sector economy constitutes both segmented and competitive markets. This analysis indicates that the effect of formalization incentives such as minimum wage is far from clear, as both the supply and demand side of the labor market responds to the minimum wage hike. In the main body of the paper, we construct the search-theoretic model that comprises both the supply and demand side of the labor market that responses to the minimum wage.

C. Pigou's E

C.1. Concept

We follow Brummund (2013) to study labor market imperfection and the firm's monopsonistic

behavior. Pigou's E is a widely used measurement to capture labor market imperfection. Under the assumption of the perfect market, firms are expected to hire laborers until the marginal value of the last hired worker equals the wage paid to the worker. If there exists a gap, especially when the marginal revenue of hiring one more labor is higher than wage payment, then this can be an indicator of labor market imperfection. Pigou's E captures this distortion by normalizing the gap with wage payment.

$$E = \frac{R'(L) - W(L)}{W(L)}$$

where $R(L)$ is the revenue function, $R'(L)$ marginal revenue product of labor, and $W(L)$ the inverse labor supply curve. Under the perfectly competitive labor market, Pigou's E will equal to 0, and the index will increase as the normalized gap widens. The distortion can be caused by the monopsonistic labor market, insufficient information, or workers' preference heterogeneity (See Robinson 1933; Card and Krueger 1993; Burdet and Mortensen 1998; Moser and Engbom 2018 among many). On the contrary, the gap between the marginal revenue of labor and wage can be induced by the rigid labor market regulation such that though firms want to hire until the marginal revenue of labor equals wage, they are discouraged from doing so because of high employment cost.

If we assume that Pigou's E shows a positive sign due to the monopsonistic behavior of the firms, we have an intuitive interpretation of Pigou's E concerning the elasticity of the labor supply curve, $\epsilon = \frac{WL'(W)}{L(W)}$. This measure has been estimated in several previous works to show evidence of a monopsonistic labor market. We can deduce the relationship based on the firm's optimization behavior, where the marginal revenue of labor is equal to the marginal cost of payment. $R'(L) = W(L) + W'(L)L$.

$$E = \frac{R'(L) - W(L)}{W(L)} = \frac{W'(L)L}{W(L)} = \epsilon^{-1}$$

One can see that when the elasticity of the labor supply curve approaches infinity (perfectly elastic) that Pigou's E approaches zero, and the firms do not have monopsonistic market power.

C.2. Calculating Pigou's E

We use the existing production function estimation method to calculate the marginal revenue product of labor, and then directly obtain Pigou's E. There is vibrant research on the production function estimation using plant-level panel data. Following Petrin and Sivadasan (2013), we apply the Wooldridge-LP method for our estimation method as the method addresses the simultaneity problem from Levinsohn-Petrin (2003) and Olley and Pakes (1996) and it also addresses the multicollinearity issue pointed out by Ackerberg, Caves, and Fraser (2015). As we are interested in investigating the endogenous decision of labor input with minimum wage regulation, we cannot use the OP or LP method where the method does not allow for firms to make endogenous labor choice. Though the method assumes unobserved productivity to be scalar it has a more robust assumption on unobserved productivity as it assumes unobserved productivity to follow the Markov process, not the linear AR(1) process presumed by System GMM approach (Blundell and Bond). Another advantage of using the Wooldridge-LP method is when we have variables such as capital that does not vary much; by utilizing moment conditions from differenced equations, the System GMM approach occasionally generates an unreasonably low coefficient on capital (sometimes even negative) when the use of capital does not vary much. Since the Wooldridge-LP GMM method does not form moment conditions from differenced data, we can get a more reasonable coefficient on capital. Also, as the Wooldridge-LP set up only uses a one-step estimation procedure for coefficients, it is easy to attain sufficiently robust standard errors, and it is more efficient than the two-stage estimation procedures (OP, LP, ACF).

Now we describe the Wooldridge-LP approach by positing a Cobb-Douglas production function:

$$y_{it} = \beta_s l_{it}^m + \beta_u l_{it}^o + \beta_k k_{it} + \beta_m m_{it} + \beta_e e_{it} + \epsilon_{it}$$

where y_{it} is the log of real output, l_{it}^m is the log of number of manufacture employee, l_{it}^o is the log of number of other employees, m_{it} is the log of real value of intermediate materials, e_{it} is the log of of fuels used and error term ϵ_{it} is assumed equal to:

$$\epsilon_{it} = \omega_{it} + \eta_{it}$$

with ω_{it} the transmitted component of the firm-specific productivity shock that is unobserved by econometricians and causes endogeneity, and η_{it} representing the firm-specific *i.i.d.* productivity shock or measurement errors.

Following Petrin and Sivadasan (2013), we assume labor as state variable due to rigid labor protection regulation including minimum wage, and following LP, we assume m_{it} as of the proxy variable:

$$\omega_{it} = g(x_{it}, m_{it}), \text{ where } x_{it} = \{l_{it},\, l_{it},\, k_{it}\}$$

Assumption 1. Strict monotonicity condition, $m_{it} = f(\omega_{it}, x_{it})$, can be inverted such that $\omega_{it} = f^{-1}(x_{it}, m_{it}) = g(x_{it}, m_{it})$. ω_{it} is a function of the state variables and the proxy variable (material)

Assumption 2. Unobserved productivity follows the Markov process, $\omega_{it} = \omega_{i,t-1} + a_{it}$ where a_{it} is *i.i.d.* innovation.

Assumption 3. Current Productivity shock, $a_{it} = \omega_{it} - E(\omega_{it}|\omega_{i,t-1})$, is uncorrelated with the current state variables.

Assumption 4. Lagged state and proxy variables are uncorrelated with a current productivity shock

Under these assumptions, we can deduce $E[\omega_{it}|x_{it-1}, e_{i,t-1}, m_{i,t-1}, ..., e_{i1}, x_1, m_1] = E[\omega_{it}|\omega_{i,t-1}] = h(g(k_{i,t-1}, l^u_{i,t-1}, l^s_{i,t-1}, m_{i,t-1}))$, which then can be used to re-write the above equation as

$$y_{it} = \beta_s l^m_{it} + \beta_u l^o_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_e e_{it} + h(g(k_{i,t-1}, l^u_{i,t-1}, l^s_{i,t-1}, m_{i,t-1})) + a_{it} + \eta_{it}$$

Following Petrin and Sivadasan (2013), we approximate $h(g(k_{i,t-1}, l^u_{i,t-1}, l^s_{i,t-1}, m_{i,t-1}))$ with second order polynomial. As for instruments, we use first and second lag of fuel and second order lags of manufacturing labor and other labor. We estimate the production function separately by two-digit industry.

Table B1 summarizes the coefficient estimates. These coefficient estimates appear reasonable, with materials and production workers having the highest coefficients, followed by other workers, capital, and then fuels. Coefficients on capital, which can be unreasonably low in some fixed estimates, are positive, though we have several negative coefficients on fuels. With these industry-specific estimates for the parameters of the Cobb-Douglas production function, we generate firm-year specific measures for the average revenue product of each firm, which are then used to calculate Pigou's E. Table 4 is the summary result of our calculation.

D. Model

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

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

$$\iff (pz - \widetilde{\omega}_z) \left[\frac{H'_z(\widetilde{\omega}_z)[1+k_z[1-F_z(\widetilde{\omega}_z)]]+2k_z F'_z(\widetilde{\omega}_z)H_z(\widetilde{\omega}_z)}{[1+k_z[1-F_z(\widetilde{\omega}_z)]]H_z(\widetilde{\omega}_z)}\right] =$$
$$(pz - \widetilde{\omega}_z(p)) \left[\frac{[1+k_z[1-J_z(p)]]Q'_z(p)+2k_z J'_z(p)Q_z(p)}{[1+k_z[1-J_z(p)]]Q_z(p)\widetilde{\omega}'_z(p)}\right] = 1$$

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

$$(pz - \widetilde{\omega}^*_z(p)) \left[\frac{Q'_z(p)\big(1+k^i_z(1-J_z(p))\big)(1+k^e_z(1-J_z(p)))+Q_z(p)\Big[k^i_z J'_z(p)(1+k^e_z(1-J_z(p)))+k^e_z J'_z(p)\big(1+k^i_z(1-J_z(p))\big)\Big]}{(1+k^i_z(1-J_z(p)))(1+k^e_z(1-J_z(p)))Q_z(p)\widetilde{\omega}^{*\prime}_z(p)}\right] = 1$$

We can rearrange this equation as

$$(pz - \widetilde{\omega}_z^*(p)) \left[\frac{Q_z^{'}(p)}{Q_z(p)} + \frac{2\kappa_z J_z^{'}(p)}{1+k_z(1-J_z(p))} \right] = \widetilde{\omega}_z^{*'}(p)$$

Now let us define $D_z(p) = -2log(1 + k_z(1 - J_z(p)))$ and $S_z(p) = log(Q_z(p))$. Then $B_z^{'}(p) = \frac{2k_z J_z^{'}(p)}{1+k_z(1-J_z(p))}$ 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

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

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

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

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

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

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

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

$$(10)\ \widetilde{\omega}_z^*(p) = z\left[p - \int_{\frac{\underline{x}_z}{z}}^{p} \frac{(1+k_z(1-J_z(p)))Q_z(y)}{(1+k_z(1-J_z(y)))Q_z(p)} dy\right]$$

Now we show $\frac{\partial \widetilde{\omega}_z^*(p)}{\partial p} > 0$ to check whether the closed-form solution 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

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

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

Q.E.D. □

E.1. Robustness Check

E.1. Spatial Difference and Two-way fixed effect

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 Newmark, Salas, and Wascher (2014) (NSW). NSW argues 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. In this section, we conduct a regression analysis with a traditional two-way fixed effect approach for robustness checks. With IFLS data, we take advantage of individual-level panel data by controlling the individual fixed effect. However, with IS data, we present two different results: one with district fixed effect and one with individual fixed effect. We make this decision as IS data does not contain information on plant ID for the years 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 robustness check. For instance, when we use IFLS data, we do not control for the district-specific time trend, though it is a standard practice in the literature. The reason is that we have only three rounds of data where the period between surveys is seven years, and we cannot limit the identification information from the deviation around district-specific linear time trends. Instead, we include provincial specific macro variables, log income per capita, and the unemployment rate(MV_{jt}), to reduce omitted variable bias. 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. When we use the IS data, we include district-specific time trends for a robustness check if we use district fixed effect. However, when we use a firm-fixed effect, we do not include time-trend as we have two missing years in our sample. The following three equations are the two-way fixed effect regression model used for the robustness check:

$$y_{ist} = \beta MW_{st} + \gamma X_{ist} + \eta MV_{st} + \lambda_i + \delta_t + u_{ist} \ (E.1)$$

$$y_{ist} = \beta MW_{st} + \gamma X_{ist} + \eta MV_{st} + \alpha_s + \delta_t + u_{ist} \ (E.2)$$

$$y_{ist} = \beta MW_{st} + \gamma X_{ist} + \eta MV_{st} + \alpha_s + \delta_t + t * trend_s + u_{ist} \ (E.3)$$

We additionally present the regression results with a spatial differencing (SD) specification.

This specification is an extension of the spatial discontinuity type approach embedded to all districts on the borderlines. Compare with our preferred DSD method, SD specification excludes district dummy variables, α_s. This exercise is useful in that it shows the importance of controlling for district fixed effects that affect the setting of minimum wage and labor market outcomes. If the innate difference between nearby districts persists over the length of the panel, then the SD estimator is biased.

$$y_{ist} = \beta MW_{st} + \gamma X_{ist} + \eta MV_{st} + \delta_{st} + u_{ist} \ (E.4)$$

We first report our results from the IFLS sample. Estimation results with the two-way fixed effect and the SD approach do not show a qualitative difference compared to our main regression results with the DSD specification. The results with the SD specification show that the effects of the minimum wage are the same in sign, though more significant in magnitude. The difference of the results compared to the DSD method can be attributed to district dummies; the DSD approach controls any other regional specific effect that may have been caused by the regional boundaries non-parametrically with the inclusion of district dummies, whereas SD method attributes any differences between provinces to minimum wage. When we look at the results with the traditional two-way fixed effect, we find the same sign, though smaller in magnitude, compare to the DSD approach; positive effect on formal sector employment and negative impact on family business are found. To compare with the DSD estimation, where the method controls for district fixed effect, controlling for individual fixed effects seems to absorb more substantial effects previously allotted to minimum wage. The only noticeable difference we find is that coefficient on Part-Time formal sector workers. The results with the two-way fixed effect differ from our main DSD results.

When we look at the regression results with IS data, our estimation results with two-way fixed effects are similar to those of DSD, whereas the results from SD shows a positive employment

effect of the minimum wage. Considering that estimation results from three different specifications of the fixed effect (district fixed effect, district fixed effect with district time trend, and plant fixed effect with reduced sample) are qualitatively similar to our results with main DSD specification, it seems that SD results are biased upward. We see the importance of controlling for fixed effects. Though our estimation results with SD estimation are not consistent with DSD, none of our results indicate a negative employment effect of the minimum wage, consistent with the hypothesis of monopsonistic competition. This conjecture is confirmed when we look at the effect of minimum wage on wage, which we report below.

With the IFLS sample, we see a significant impact of minimum wage on wages. Notably, we observe again that minimum wage affects both initially sub-minimum wage earners and initially over-minimum wage earners, confirming the hypothesis of monopsonistic competition. Just like the DSD approach, the estimation results with SD methods capture both the occupational choice of individuals and the wage increase. We find a 10 percent increase in minimum wage increases wages more than 10 percent. In contrast, our estimation results with individual fixed effects method only capture the wage increase of the same individuals across periods in response to a minimum wage change and thus nets out the occupational choice mechanism.

Our regression results with IS data also show the positive effect of minimum wage on the average wage, though the magnitude of coefficient varies significantly depending on the regression specification. Our estimation results from two-way fixed effect with the inclusion of district time trend are similar to our main specification, and our results with SD specification is upward-biased. This positive effect of minimum wage on wage payment is consistent with most findings in the literature. Overall, we find our results to be significant in that the increase in wage occurred with no disemployment effect, suggesting that the labor market in Indonesia was primarily operated in a monopsonistic way during the period of investigation.

Our last results on Pigou's E also shows qualitatively similar results, even though we only have negative and statistically significant results with Pigou's E measured by per capita outcome.

Pigou's E measure from Wooldridge-LP method only has half observations compared to the measure calculated with the per capita outcome variable. Still, with our less preferred measure, we observe a negative correlation with minimum wage. Overall, our robustness tests provide ample evidence for the monopsonistic behavior of the firms in Indonesia and the role of the minimum wage as a market-correcting device.

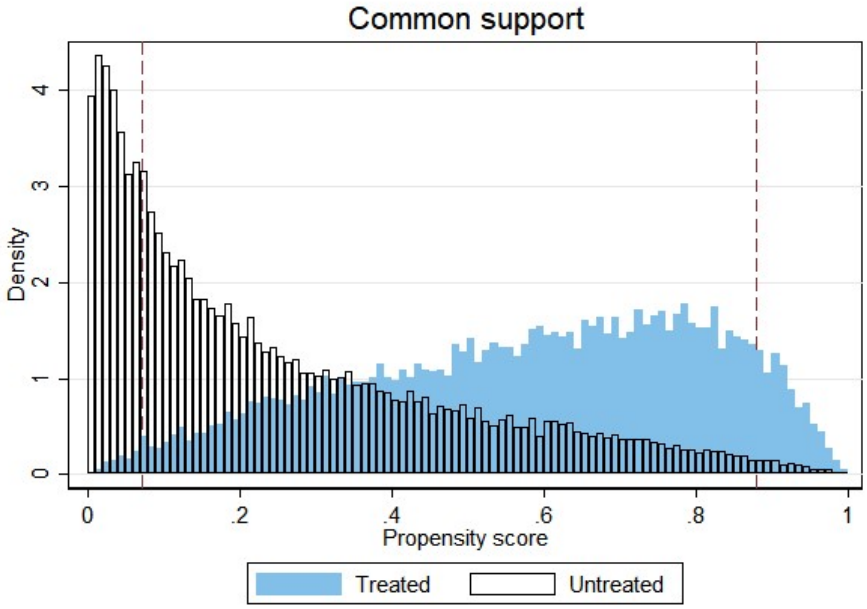
E.2. Migration

We also report the DSD 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 if unemployed workers migrate out of higher minimum wage provinces to search for jobs. We conduct robustness analysis excluding samples who migrated from the initial place where observation began. This analysis will allow us to look at how much our estimation could be contaminated by the migrating population. 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.

The positive effect on the formal sector employment slightly decreases when we exclude the migrated population. This finding is evidence that some people migrated into the provinces with a higher minimum wage to find a formal sector job. The regression results show more significant coefficients on wages compare to the results with the migrated population. The results indicate that the migrated population earned lower wages compared to the incumbent population. Finally, our estimation results for non-compliance show a similar coefficient compared to the results with the migrated population. Overall, our estimation results, excluding the sample of migration populations, show robust results.

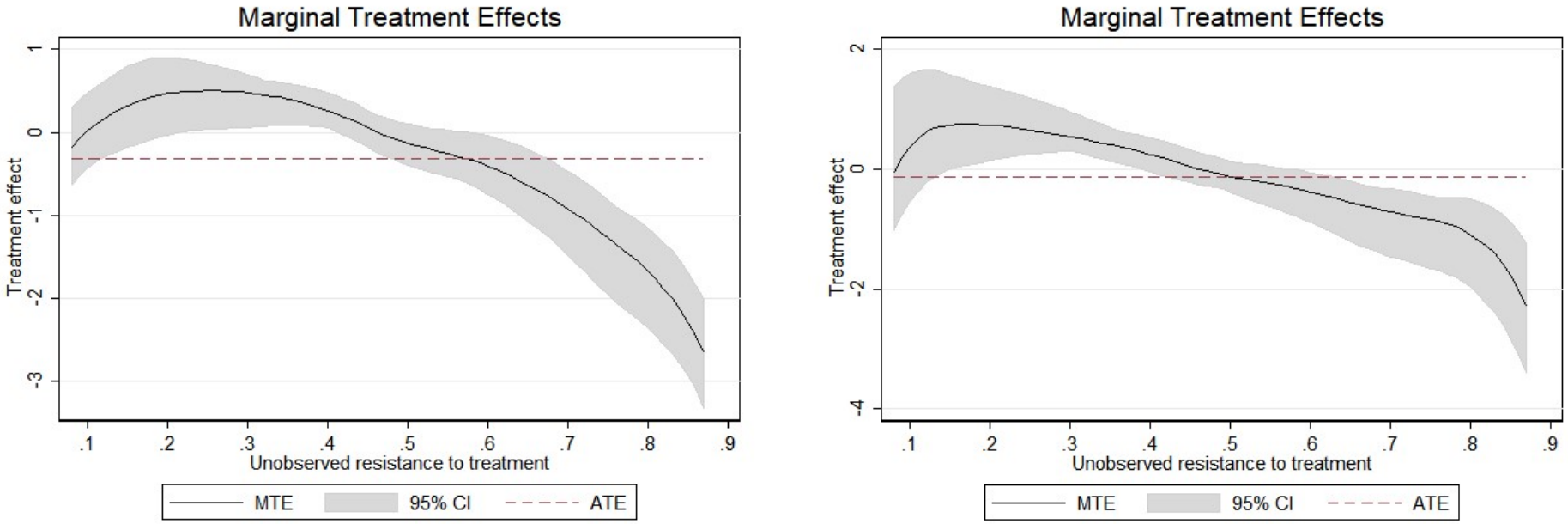
Appendix Figures

Figure B1. Distribution of Propensity Scores for Formal and Informal Sector Workers



Source: Indonesian Family Life Survey (2000,2007,2014)
Notes: A propensity score is the estimated probability of working in the formal sector as a full-time worker. It is estimated from a probit regression of working in the formal sector full time on log values of household asset and minimum wage, dummy variables for female, urban residence, and having household members working in the formal sector, age and age polynomial, education and education polynomial, log values of provincial GDP, provincial unemployment rate, fixed effects for year, district and occupation (see Table B1).

Figure B.2.Marginal Treatment Effects Curve with the Second and Third Order Polynomials



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

Notes: The figure displays MTE curves with 95% confidence interval bounds for the outcome of log value of income, evaluated at mean values of covariates. 95% standard error bands are obtained using the bootstrap (200 replications). The MTE curve on the left refers to the specification with the second-order polynomials, and the MTE curve on the right relates to the specification with the third-order polynomials. The propensity score is ordered by the horizontal axis. Low abscissa values correspond to the workers who are less likely to be employed formally based on their observable characteristics. It can be interpreted as low resistance to the treatment based on unobservable characteristics.

Appendix Tables

Table B1. Selection Equation: Propensity Score Analysis

	Full-Time Formal
Formal Sector Worker Among HH Member (Dummy)	0.363***
	(0.018)
Log Household Asset	-0.041***
	(0.005)
Log Real Minimum Wage	0.412***
	(0.087)
Female	-0.294***
	(0.018)
Education	-0.044
	(0.035)
Education^2	0.080***
	(0.007)
Urban/Rural	0.302***
	(0.025)
Weekly Working Hours	0.017***
	(0 .000)
Age	-0.036***
	(0.005)
Age^2	0.000
	(0.000)
Provincial Macro Variables	Yes
Year FE	Yes
District FE	Yes
Occupation FE	Yes
Observations	35,472

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

Notes: The table reports average marginal effects from a probit selection model in which the dependent variable is equal to one for the respondents working in the formal sector. We use a dummy variable for the existence of formal sector workers in the household as an instrument. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table B2. Income Equations: Semi-Parametric Regression Estimates

Treatment	Full-Time Formal			
	Semi-Parametric Model (Second Polynomial)		Semi-Parametric Model (Third Polynomial)	
Dependent Variable	Return from Informal Employment β_0 (SE)	Gap in Formal-Informal Return ($\beta_1 - \beta_0$)(SE)	Return from Informal Employment β_0 (SE)	Gap in Formal-Informal Return ($\beta_1 - \beta_0$)(SE)
	(1)	(2)	(3)	(4)
Log HH Asset	0.181***	-0.120***	0.181***	-0.120***
	(0.008)	(0.012)	(0.006)	(0.012)
Log Real MW	0.097	1.088***	0.099	1.082***
	(0.101)	(0.184)	(0.102)	(0.201)
Female	-0.771***	0.487***	-0.772***	0.491***
	(0.028)	(0.052)	(0.030)	(0.059)
Education	0.054	0.053	0.054*	0.054
	(0.048)	(0.115)	(0.032)	(0.097)
Education^2	0.015	0.062***	0.016	0.061***
	(0.012)	(0.024)	(0.010)	(0.021)
Urban/Rural	0.058**	0.043	0.136***	0.038
	(0.028)	(0.065)	(0.040)	(0.076)
Weekly WH	0.012***	-0.007***	0.012***	-0.008***
	(0.001)	(0.002)	(0.001)	(0.002)
Age	0.072***	0.028***	0.071***	0.028**
	(0.007)	(0.012)	(0.007)	(0.014)
Age^2	-0.001***	-0.000***	-0.001***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Provincial MV	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes
Observations	35,472	35,472	35,472	35,472
P1		4.989***		6.077
		(1.510)		(5.317)
P2		-8.534***		-10.958
		(1.469)		(10.430)
P3				1.685
				(6.833)
ATE		-0.323**		-0.128
		(0.130)		(0.165)
ATT		0.481***		0.644***
		(0.156)		(0.213)
ATUT		-0.818***		-0.603***
		(0.170)		(0.235)

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

Notes: This table reports estimated coefficients of the income equations obtained from the double residual semi-parametric regression detailed in this appendix. For the second and third column, we assume a second-order polynomial for our baseline specification, and we assume a third-order polynomial. We generally find similar results. The table also provides the estimates of various returns to college for the semiparametric model estimated on several samples: average treatment effect (ATE), treatment on the treated (TT), treatment on the untreated (TUT). The ATE, TT, and TUT estimates are computed such that the weights integrate to one in the interval [0.01;0.99]. Standard errors are bootstrapped (200 replications). *** p<0.01, ** p<0.05, * p<0.1.

Table C1. Coefficients of Baseline Production Function by 2-Digit Industry Code, 2004-2009 (Wooldridge-LP (2009))

	Production	Non Production	Capital	Material	Energy	N
Food products and beverages (15)	0.460	0.230	0.009	0.294	0.009	35,411
Tobacco products (16)	0.097	0.059	0.007	0.883	0.006	5,100
Textiles (17)	0.532	0.154	0.008	0.319	-0.001	11,713
Wearing apparel; dressing and dyeing of fur (18)	0.520	0.118	0.006	0.347	0.007	11,296
Processing of leather; manufacture of luggage, handbags (19)	0.359	0.109	0.004	0.532	0.014	3,927
Wood and of products of wood and cork (20)	0.365	0.110	0.018	0.531	0.014	9,627
Paper and paper products (21)	0.277	0.045	0.009	0.709	0.006	3,107
Printing and reproduction of recorded media (22)	0.365	0.129	0.005	0.590	-0.001	4,187
Coke, refined petroleum products and nuclear fuel (23)	0.272	0.225	0.005	0.701	0.012	407
Chemicals and chemical products (24)	0.373	0.280	0.015	0.439	0.004	7,564
Rubber and plastics products (25)	0.384	0.132	0.009	0.481	0.004	10,993
Non-metallic mineral products (26)	0.392	0.134	0.008	0.499	0.025	11,204
Basic metals (27)	0.414	0.227	0.006	0.370	0.011	1,604
Fabricated metal products, except machinery and equipment (28)	0.323	0.138	0.010	0.593	-0.003	5,565
Machinery and equipment (29)	0.613	0.194	0.001	0.319	-0.000	2,554
Electrical machinery and apparatus (31)	0.205	0.068	0.004	0.526	0.008	1,721
Radio, television and communication equipment and apparatus (32)	0.336	0.052	0.004	0.586	0.004	1,118
Motor vehicles, trailers and semi (34)	0.263	0.109	0.006	0.696	0.007	1,876
Other transport equipment (35)	0.291	0.093	0.009	0.635	-0.011	2,032
Furniture; manufacturing (36)	0.325	0.100	0.007	0.578	0.006	14,826
Recycling (37)	0.236	0.106	0.002	0.772	0.002	732

Source: Own calculations from IS surveys.

Notes: All values are in constant 2007 Rupiah (Rp). Data covers 2004~2009. Production function coefficient estimates are from a gross output (revenue deflated by industry-specific deflators) Cobb-Douglas production function specification, which is estimated using Wooldridge (2009) modification of the Levinsohn-Petrin (2003) approach to address the simultaneous determination of inputs and productivity.

Table E.1.1. The Effect of Minimum Wage on Employment Status (FE and SD)

VARIABLES	(1) Formal		(2) Full-Time Formal		(3) Part-Time Formal		(4) Self-Employed		(5) Family Business	
					A. Fixed Effect					
	0.080	**	0.051	*	0.071	***	-0.004		-0.084	**
	(0.034)		(0.027)		(0.017)		(0.028)		(0.041)	
					B. Spatial Difference					
25 miles	0.179	***	0.244	***	-0.062	***	-0.140	***	-0.172	***
	(0.058)		(0.058)		(0.015)		(0.046)		(0.059)	
30 miles	0.196	***	0.266	***	-0.063	***	-0.139	**	-0.189	**
	(0.073)		(0.075)		(0.015)		(0.056)		(0.076)	
35 miles	0.183	***	0.249	***	-0.060	***	-0.123	**	-0.175	**
	(0.067)		(0.064)		(0.019)		(0.053)		(0.070)	
40 miles	0.161	***	0.220	***	-0.055	***	-0.113	**	-0.156	***
	(0.053)		(0.050)		(0.018)		(0.049)		(0.057)	
60 miles	0.137	***	0.194	***	-0.056	***	-0.074		-0.129	**
	(0.052)		(0.044)		(0.021)		(0.046)		(0.055)	
80 miles	0.144	***	0.186	***	-0.044	**	-0.069	*	-0.136	***
	(0.044)		(0.035)		(0.022)		(0.039)		(0.048)	
Mean	0.401		0.275		0.131		0.497		0.580	
Observations	50,453		50,453		50,453		50,453		50,453	

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, a dummy variable for urban/rural residence, age and age squared, education level and education squared.

Table E.1.2. The Effect of Minimum Wage on Plant-Level Employment (FE and SD)

VARIABLES	(1) Total Workers		(2) Production Workers		(3) Non-Production Workers	
			A1. District Fixed Effect			
District FE	0.086		0.069		0.155	*
(2000~2009)	(0.075)		(0.073)		(0.088)	
District FE with district time-trend	-0.032		-0.064		0.093	
(2000~2009)	(0.079)		(0.083)		(0.088)	
Mean	4.185		3.984		2.158	
Observation	196,815		196,803		181,510	
			A2. Plant Fixed Effect			
Firm FE	-0.004		-0.026		0.068	
(2000,2001,2004~2009)	(0.050)		(0.019)		(0.048)	
Mean	4.170		3.970		2.153	
Observation	161,875		161,866		148,024	
			B. Spatial Difference			
25 miles	0.633	***	0.578	***	1.020	***
	(0.156)		(0.161)		(0.131)	
30 miles	0.668	***	0.616	***	1.059	***
	(0.139)		(0.143)		(0.136)	
35 miles	0.643	***	0.576	***	1.125	***
	(0.139)		(0.146)		(0.123)	
40 miles	0.627	***	0.556	***	1.121	***
	(0.138)		(0.146)		(0.116)	
60 miles	0.518	***	0.453	***	1.035	***
	(0.132)		(0.138)		(0.148)	
80 miles	0.520	***	0.460	***	1.022	***
	(0.146)		(0.151)		(0.179)	
Mean	4.185		3.984		2.158	
Observations	196,815		196,803		181,510	

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 capital, material, and Macro variables.

Table E.1.3 The Effect of Minimum Wage on Income by Employment Status (FE and SD)

VARIABLES	(1)		(2)		(3)		(4)		(5)	
	Full-Time Wage Earner									
	All		Sub-Minimum Wage Workers Initial Year		Over-Minimum Wage Workers Initial Year		Part-Time Wage Earner		Self-Employed Profit Earner	
					A. Fixed Effect					
	0.443	***	0.600	***	0.546	***	-0.285		0.229	*
	(0.090)		(0.144)		(0.081)		(0.276)		(0.133)	
					B. Spatial Difference					
25 miles	1.232	***	1.276	***	0.719	***	0.861	***	0.923	***
	(0.088)		(0.069)		(0.086)		(0.125)		(0.100)	
30 miles	1.304	***	1.276	***	0.746	***	0.868	***	0.934	***
	(0.124)		(0.063)		(0.086)		(0.121)		(0.090)	
35 miles	1.286	***	1.270	***	0.761	***	0.947	***	0.958	***
	(0.114)		(0.068)		(0.078)		(0.116)		(0.118)	
40 miles	1.213	***	1.272	***	0.751	***	0.862	***	0.871	***
	(0.106)		(0.064)		(0.088)		(0.117)		(0.132)	
60 miles	1.139	***	1.204	***	0.742	***	0.621	***	0.712	***
	(0.073)		(0.062)		(0.085)		(0.088)		(0.121)	
80 miles	1.128	***	1.196	***	0.762	***	0.647	***	0.683	***
	(0.057)		(0.037)		(0.066)		(0.066)		(0.080)	
Mean	15.954		15.093		16.593		15.330		15.094	
Observations	13,646		5,775		7,694		6,452		18,340	

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. We Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, a dummy variable for urban/rural residence, age and age squared, education level and education squared.

Table E.1.4. The Effect of Minimum Wage on Average Wage (FE and SD)

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	All Workers						Production Workers						Non-Production Workers					
VARIABLES	**All**		**Non-Compliant Firms**		**Compliant Firm**		**All**		**Non-Compliant Firms**		**Compliant Firm**		**All**		**Non-Compliant Firms**		**Compliant Firm**	
A1. District Fixed Effect																		
District FE	0.547	***	0.558	***	0.613	***	0.555	***	0.620	***	0.584		0.485	***	0.609	***	0.762	***
(2000~2009)	(0.061)		(0.087)		(0.069)		(0.058)		(0.082)		(0.069)		(0.080)		(0.104)		(0.093)	
District FE with district time-trend	0.404	***					0.428	***					0.371	***				
(2000~2009)	(0.068)						(0.065)						(0.087)					
Mean	15.820		15.351		16.1192		15.742		15.362		16.031		16.184		15.509		16.36752	
Observation	194,954		63,406		96,697		194,928		69,791		90,292		168,324		30,287		106,812	
A2. Plant Fixed Effect																		
Firm FE	0.237	***	0.449	***	0.364	***	0.279	***	0.506	***	0.386	***	0.041		0.349	**	0.284	***
(2000,2001,2004~2009)	(0.066)		(0.132)		(0.067)		(0.075)		(0.132)		(0.067)		(0.082)		(0.136)		(0.070)	
Mean	15.815		15.351		16.119		15.740		15.362		16.031		16.178		15.509		16.368	
Observation	160,103		63,406		96,697		160,083		69,791		90,292		137,099		30,287		106,812	
B. Spatial Difference																		
25 miles	1.367	***	1.297	***	1.195	***	1.258	***	1.298	***	0.898	***	1.468	***	1.277	***	1.366	***
	(0.131)		(0.237)		(0.200)		(0.127)		(0.228)		(0.065)		(0.217)		(0.302)		(0.238)	
30 miles	1.382	***	1.298	***	1.343	***	1.276	***	1.299	***	0.891	***	1.472	***	1.268	***	1.348	***
	(0.105)		(0.213)		(0.160)		(0.101)		(0.206)		(0.059)		(0.202)		(0.286)		(0.211)	
35 miles	1.466	***	1.462	***	1.328	***	1.351	***	1.455	***	0.933	***	1.523	***	1.425	***	1.422	***
	(0.094)		(0.166)		(0.180)		(0.089)		(0.161)		(0.055)		(0.199)		(0.285)		(0.176)	
40 miles	1.478	***	1.500	***	1.310	***	1.366	***	1.494	***	0.925	***	1.512	***	1.441	***	1.402	***
	(0.097)		(0.159)		(0.175)		(0.092)		(0.156)		(0.059)		(0.199)		(0.276)		(0.176)	
60 miles	1.431	***	1.494	***	1.278	***	1.325	***	1.474	***	0.881	***	1.449	***	1.398	***	1.361	***
	(0.082)		(0.123)		(0.182)		(0.081)		(0.128)		(0.079)		(0.178)		(0.245)		(0.178)	
80 miles	1.422	***	1.490	***	1.291	***	1.315	***	1.478	***	0.863	***	1.442	***	1.394	***	1.337	***
	(0.085)		(0.129)		(0.187)		(0.083)		(0.130)		(0.074)		(0.181)		(0.257)		(0.164)	
Mean	15.820		15.351		16.046		15.742		15.362		15.954		16.184		15.509		16.332	
Observations	194,954		63,406		131,548		194,928		69,791		125,137		168,324		30,287		138,037	

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." We use the average wage of total workers, production workers, and non-production workers as our dependent variables. Within each category of the dependent variables, we further divide the sample into the two different groups: plants whose average wage payment at the initial year of sampling is greater than minimum wage(Compliant Plants), and plants whose average wage payment at the initial year of sampling is smaller than minimum wage (Non-Compliant Plants). Note that we cannot include samples in the years 2002 and 2003 for the regression analysis of these sub-categories as we cannot observe plant ID for these years. For that reason, we do not report the results with district time-trend for these two sub-categories.
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 capital, material, and Macro variables.

Table E.1.5. The effect of minimum wage on Pigou's E (FE and SD)

VARIABLES	(1) Y/L		(2) Wooldridge-LP Production Workers		(3) Wooldridge-LP Non-Production Workers	
			A1. District Fixed Effect			
District FE	-0.370	***				
(2000~2009)	(0.087)					
District FE with district time-trend	-0.145	*				
(2000~2009)	(0.077)					
Mean	1.802					
Observation	183,257					
			A2. Firm Fixed Effect			
(1) Firm FE	-0.065		0.046		-0.258	
(2000,2001,2004~2009)	(0.088)		(0.143)		(0.226)	
Mean	1.826		0.775		1.391	
Observation	150,938		103,261		90,897	
			B. Spatial Difference			
25 miles	-0.823	***	-0.246		-0.362	
	(0.199)		(0.290)		(0.233)	
30 miles	-0.847	***	-0.229		-0.353	*
	(0.175)		(0.218)		(0.203)	
35 miles	-0.900	***	-0.093		-0.177	
	(0.180)		(0.121)		(0.124)	
40 miles	-0.888	***	-0.081		-0.137	
	(0.176)		(0.116)		(0.125)	
60 miles	-0.802	***	-0.160		-0.207	
	(0.171)		(0.142)		(0.190)	
80 miles	-0.799	***	-0.403	***	-0.448	***
	(0.173)		(0.107)		(0.152)	
Mean	1.802		0.131		1.391	
Observations	183,257		103,261		90,897	

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 Pigou's *E* measure calculated with different methods. For the first column, total output per worker is used to calculate Pigou's *E*. For the second and third columns, we estimate a gross output Cobb-Douglas function, using Wooldridge (2009) modification of the Levinsohn-Petrin (2003). 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 capital, material, and Macro variables.

Table E.2.1. The effect of minimum wage on employment status (DSD, Migration)

VARIABLES	(1) Formal		(2) Full-Time Formal		(3) Part-Time Formal		(4) Self-Employed		(5) Family Business	
25 miles	0.194	**	0.261	***	-0.048	**	-0.144	***	-0.188	**
	(0.076)		(0.064)		(0.023)		(0.048)		(0.074)	
30 miles	0.189	***	0.260	***	-0.048	**	-0.122	***	-0.179	***
	(0.071)		(0.060)		(0.022)		(0.044)		(0.069)	
35 miles	0.188	***	0.254	***	-0.045	*	-0.116	***	-0.179	***
	(0.066)		(0.050)		(0.025)		(0.044)		(0.065)	
40 miles	0.180	***	0.245	***	-0.051	***	-0.112	**	-0.175	***
	(0.060)		(0.052)		(0.017)		(0.045)		(0.059)	
60 miles	0.165	***	0.234	***	-0.049	***	-0.084	**	-0.160	***
	(0.052)		(0.048)		(0.014)		(0.036)		(0.052)	
80 miles	0.171	***	0.222	***	-0.034	**	-0.086	**	-0.167	***
	(0.044)		(0.045)		(0.013)		(0.033)		(0.043)	
Mean	0.405		0.277		0.132		0.496		0.577	
Observations	46,830		46,830		46,830		46,830		46,830	

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, a dummy variable for urban/rural residence, age and age squared, education level and education squared.

Table E.2.2. The effect of minimum wage on income by employment status (DSD, Migration)

VARIABLES	(1)		(2)		(3)		(4)		(5)	
	Full-Time Wage Earner									
	All		Sub-Minimum Wage Workers Initial Year		Over-Minimum Wage Workers Initial Year		Part-Time Wage Earner		Self-Employed Profit Earner	
25 miles	1.115	***	1.366	***	0.600	***	0.669	***	0.778	***
	(0.047)		(0.120)		(0.100)		(0.120)		(0.101)	
30 miles	1.148	***	1.348	***	0.618	***	0.683	***	0.650	***
	(0.033)		(0.136)		(0.086)		(0.126)		(0.103)	
35 miles	1.145	***	1.319	***	0.627	***	0.735	***	0.689	***
	(0.056)		(0.137)		(0.074)		(0.146)		(0.092)	
40 miles	1.090	***	1.332	***	0.624	***	0.665	***	0.627	***
	(0.052)		(0.109)		(0.075)		(0.165)		(0.091)	
60 miles	1.043	***	1.201	***	0.606	***	0.518	***	0.562	***
	(0.060)		(0.118)		(0.079)		(0.135)		(0.084)	
80 miles	1.056	***	1.248	***	0.618	***	0.592	***	0.518	***
	(0.064)		(0.113)		(0.062)		(0.123)		(0.080)	
Mean	15.917		15.061		16.572		15.300		15.071	
Observations	12,758		5,498		7,160		6,052		16,862	

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. We Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, a dummy variable for urban/rural residence, age and age squared, education level and education squared.

Table E.2.3 . Tests for partial compliance with legal minimum wages (Migration)

	Workers in Medium Firms (5~199) (T) and Large Firms (>200) (C)	
2014 × T	0.073 **	0.084 **
	(0.032)	(0.032)
2007 × T		0.044
		(0.032)
2000 × T		-0.061
		(0.062)
Individual, Year, Occupation FE	Yes	Yes
Macro Variables	Yes	Yes
Number of Observation	9,497	

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. Clustered-robust standard errors by the province in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Controls: log values of household assets, a dummy variable for urban/rural residence, age and age squared, education level and education squared.