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"Minimum wage through the looking glass"

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Minimum wage through the looking glass*

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Abstract

We investigate impacts of two major increases in minimum wage of Thailand in 2012, and 2013. In spite of the large increase in average wage induced by the hike, the effect on employment is positive. Given that roughly 40% of daily wage samples are less than the minimum wage, we build and estimate a model that incorporate (minimum wage) compliance decision. We use switching regressions to estimate the gap in wages between above and below minimum wage. This gap is sizable and statistically significant for daily wage, but small and statistically insignificant for monthly wage.

When the employer's probability for compliance is included in the employment probability of individuals, we find that the higher compliance rate positively influence the employment probability. These findings strongly suggest that the minimum wage hike in 2012~13 induced north-eastward shift of the equilibrium along the labor supply schedule. In the last part of the analysis, we offer a variety of circumstantial evidence in support of tacit collusion among large scale employers in setting daily wages.

Key words: minimum wage, minimum wage compliance, Thailand
JEL Classification numbers: J31, J38, J42

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1 Introduction

> The Red Queen shook her head. "You may call it 'nonsense' if you like," she said, "but I've heard nonsense, compared with which that would be as sensible as a dictionary!" [1]'

The literature on minimum wage has always been contentious, riddled with sociopolitical controversies. In the case of developing economies, the minimum wage controversies have added layers of complexity: problems of data availability, quality, and, above all, the (in-) effectiveness of the minimum wage law.

Among the more important issues of the effectiveness of minimum wage in developing countries is the low, and often *unknown*, compliance rate. There is little doubt that the limited capacity of government to implement and monitor the adherence to the legislation lies at the root of the problem. Del Capiro et al. (2014) take up this issue using Thailand data. After citing Leckcivilize (2013) on poor quality of monitoring and extremely low rate of imposition of penalty against labor law violations in the country, they ask themselves: *Therefore, noncompliance with Thai minimum wages may be relevant even for formal*[2] *employees, and the following questions are warranted: Are Thai covered employees actually paid at or above the minimum wage? Who are and who aren't?* (Del Capiro et al 2014). As a matter of fact, Del Capiro is not the first paper to address the issue of compliance of the minimum wage in developing countries. We have a fairly impressive list of papers, each one looking into the issue of non-compliance in a long list of developing countries[3].

In this paper, we take a step further and modify their question: *if the government cannot effectively enforce the minimum wage and there exists virtually no probability of substantive penalty against violation, why does any employer bother to comply with the minimum wage?* This question is relevant because, as we will show shortly, a significant portion of employers, actually a majority in the case of Thailand, *do* comply with the minimum wage in spite of the fact that there is little chance that the non-compliance is detected and penalized. The issue is important in assessing the impact of a change in minimum wage as there is every reason to believe that a change in minimum wage induces individual employers to reconsider their (non-) compliance decision. It also goes without saying that non-compliance does not imply that the minimum wage is ignored in setting (below minimum) wages. As a matter of fact, many studies of the wage impacts in developing countries show significant and quantitatively large positive effects of minimum wage changes on wages below minimum wage (Rama (2001)).

In this paper, we use micro data of Thailand labor force survey to estimate impacts of minimum wage changes on wage distribution, (non-) employment, and spill over

[1] Lewis Carroll *Through the Looking Glass*

[2] 'Formal' in the sense that the employees are covered by social security, such as unemployment benefits. Unfortunately, Labor Force Survey does not have information on individual coverages.

[3] Alatas and Cameron (2003), Rama(2003) and Bird and Manning (2008) use Indonesian data, Rani and coauthors (2013) compile studies using Latin America. See also Worldbank (2008) for a selected survey.

effects on self employment. Crucial to the whole range of the analysis is that they are jointly determined with employers' compliance decision.

Thailand offers an interesting case study for several reasons. For one thing, the country has underwent two major hikes in the minimum wage, in 2012, and 2013. In April 2012, minimum wage was increased by roughly 40%, and, in anticipation of the scheduled increase in the next year, the minimum wage of 8 provinces (including Metropolitan Bangkok area) were increased to 300 bahts per day. On January 2013, all provincial minimum wages were set at 300 bahts per day. After the two jumps, real minimum wage rose by 70%, compared to March 2012, one month before the start of major hikes. Using the latest data that covers up to second quarter of 2013, we can trace out the impact of these wage hikes.

The micro data on wages are comprised mostly of those paid daily or monthly wages. We show that these two types of wages exhibit contrasting patterns in terms of the impact on minimum wage. As workers paid daily wages tend to be less educated and less skilled, and on average paid lower wages, the distinction between daily and monthly wages is often useful in disentangling direct and indirect effects of the changes in minimum wage[4].

Historically, minimum wage in Thailand had been set for each province with (if any) very limited correlation with interprovincial variations in the cost of living, industry and employment structure, etc. In spite of the frequent changes in minimum wage, we show that the real value of minimum wage declined from 1997 until the 2012~2013 major increases. The long run effect of the decline of real minimum wage is indeed important not just by itself, but as a precondition in which the 2012~13 increases were played out.

Thailand is a very interesting example also in terms of the compliance decisions: as we will show shortly, the non compliance comprises a significant portion of employment, although in terms of total employment share, majority are indeed paid on or above minimum wage.

This paper focuses mostly, but not exclusively, upon the major minimum wage hikes taken place in 2012 and 2013. Moreover, we pay particular attention to the impact on employment and wages of those who receive daily wages. As we show below, daily wages are most directly influenced by minimum wage, whereas we find the impact on monthly wages are weaker and mostly statistically insignificant. Thus the analysis of wage and employment of monthly wage earners serves as the benchmark against which we highlight the minimum wage impacts on employment and wages of daily wage earners.

We summarize the major findings. First of all, we find that the employment impact of minimum wage increase in 2012-13 is overall positive, and that the positive impact is larger for those paid daily wage. The impact is either small or negative for those who are paid monthly wage. If we look more closely to those paid close to minimum wage, our estimate shows that the impact is positive if they are more likely to be employed by firms who comply with the minimum wage.

[4]In Labor Force Survey micro data, 58% of individual wage data are monthly wages, and 32% daily. Among workers paid different types of wages, average years of schooling is highest at 11.7 for monthly wage earners, whereas those paid daily wage have the lowest average, 6.0 years of schooling.

In short, we find strong employment *expansion at firms complying with the minimum wage increases*, *whereas those who fail to comply witness their employment to decline.* In the main empirical analysis, we employ a switching regression to estimate treatment effects, i.e., the estimate of the wage gap between those above and below minimum wage. Our estimate indicate that this gap is roughly .45 log points of the minimum wage. We show also estimated treatment effects vary inversely with the employer size.

When the effect of the compliance decision on labor supply are estimated using probit and m-probit model, we find statistically significant, and quantitatively large, *positive* impact of the average compliance shares in each province on employment probability. We also find counterbalancing negative impact on self employment. Thus the higher share of employers offering above minimum wage induces strong substitution away from self employment into employment.

These findings jointly suggest that the changes induced by the minimum wage hike can be understood as the north eastward shift along the labor supply curve if we limit our attention to daily wage sector. This observation leads us to examine a variety of evidence related to the change and we conclude that they are strongly suggestive of tacit collusion among large scale firms in setting daily wages, using the minimum wage as their focal wage. On the other hand, there is no such evidence for samples of monthly wage earners.

The remainder of the paper is organized as follows. In the next section, we overview changes in the minimum wage and employment in Thailand for the last twenty years. We show that the real wage as well as real minimum wages had declined since 1997 financial crisis until the most recent increases in minimum wage in 2012 and 2013. We also show the increase in wage polarization among monthly wages, but not in daily wages. In the latter half of the section, we look closely the non-compliance issue. We show that, even before the 2012 minimum wage increase, a significant portion of employment had been at below minimum wage: the non-compliance is not a new phenomenon caused by the most recent hikes in the minimum wage.

In Section 3, we develop a simple model of labor market with heterogenous labors incorporating endogenous compliance decision. We will show that the impact of minimum wage change on employment and wage differs markedly from the textbook model of competitive market with full compliance. In particular, we find that through the impact on compliance decision, the minimum wage changes exert largely uniform increase in wage in both above and below minimum wage (lighthouse effect). The impact on employment differs: it is negative for those paid below minimum wage, whereas it is positive for those above minimum wage. In the last part of the model analysis, we introduce collusion among firms offering on or above minimum wage and find that the increase in minimum wage in that case leads to increase in overall employment, and, at the same time the increase produces wage compression among colluding firms. Appendix 1 generalizes of the model in Section 3 to the case of imperfect substitution among heterogenous labor.

First part of main empirical results are in Section 4, wherein we estimate two key regressions. One is switching regressions in which compliance decision estimates are fed into two (below and above minimum wage) separate wage regressions. The estimated

treatment effect can be considered as the cost of non-compliance. The second main result is the probit and m-probit regressions for employment. In the probit regression, we estimate the probability that a sample individual choose to be employed over other choices (non-participation and self employment). In m-probit regressions, we estimate choice probabilities over non-participation, self employment and employed. In both types of regressions, we find highly significant and quantitatively large positive impact on employment by the average probability that their employers comply with the minimum wage. Namely, employment probability is higher if their potential employers are more likely to comply with the minimum wage. In m-probit regression, we also find counter-balancing negative effect of this variable on the probability of self-employed. Thus we conclude that the positive employment effect represents mostly the switching from self employment to employed when they are more likely to find employers offering above minimum wage.

Given these findings from Section 4, Section 5 presents a variety of evidence in support of the conjecture that the positive employment impact of minimum wage compliance is due to a tacit collusion among large scale firms in wage setting. We show that daily wage distribution of workers employed at large firms are highly concentrated around the minimum wage. We find that the share of workers both below and above minimum wage is significantly smaller than the corresponding shares at smaller firms. Those employed at large firms are mostly paid above minimum wage but they are under-paid relative to the prediction of a Mincerian wage model. We also show the positive correlations among compliance rate, wage distortion and employment. None of these peculiarities can be detected for those paid *monthly* wages at large scale firms. Taken together, we conclude that they comprise a fairly strong circumstantial evidence for the collusive wage setting among large scale employers. A brief concluding remark follows. The Appendix contains an extension of the model in section 3, details of data compilations, additional estimation results and figures.

2 Minimum wage and employment in Thailand

In this preview section, we offer a bird's eye view of Thailand labor market since late 1990's wherein the economy was hit by Asian financial crisis. The minimum wage policy appears deeply influenced by the severe impact of the crisis. We review historical changes in minimum wage and long run changes in the structure of the labor market in the last two decades.

2.1 Decline in real wage and real minimum wage after 1997 crisis

As is well documented in earlier works, the real value of minimum wage steadily declined from October 1996 until April 2012, in spite of the fact the minimum wage was adjusted

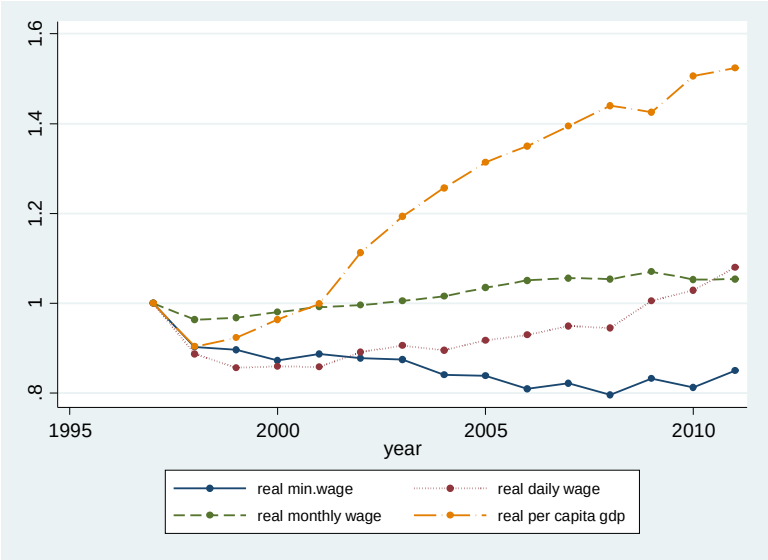

Figure 1: Except for real per capita GDP, all figures are converted into real values using 2005 CPI. Then all figures are normalized by February 1997 figures.

16 times[5]. See Appendix Table A2 for the details of changes in minimum wage from 1989 til 2013. Figure 1 shows real per capita GDP, real minimum wage, average real daily wage, and average real monthly wages[6] all normalized by respective February 1997 (immediately before the onset of financial crisis) figures. Figure 1 shows these indices up to March 2012, i.e., the situation immediately before the major minimum wage increases. As can be seen from the figure, the real minimum wage peaked out in 1996 and this peak figure was not regained until the 2012-13 increases in the minimum wage. By the end of 2011, immediately before the increases, the real minimum wage was lower than the 1996 value by more than 17%. The minimum wage lagged behind both daily and monthly wages, which in turn lagged way behind the steady increase in per capita GDP. Given the faster growth of real minimum wage prior to the financial crisis in 1997, it is possible that the subsequent decline of the real minimum wage reflects the conscious efforts by government to curtail wage growth, in response to the widespread concern that the country may lose the competitive edge against the emerging China in the international trade.

Against the background of stagnant growth in real wages during the period between the late 1990's until late 2000's, wage polarizations continued: both at the bottom and

[5]To be exact, there have been several isolated incidences of small downward adjustments: in July 2001 (2~3 bahts 7 provinces), January 2004 (17 provinces all by 1 baht), and January 2004 (1 province by 1 baht).

[6]In the rest of the paper, we use only daily and monthly wage samples for workers who reported 35 or more working hours. We exclude those working less than 35. Due to difficulty in conversion of reported wages into daily equivalent, and also due to small sample size, we do not include those paid hourly wages or in other forms.

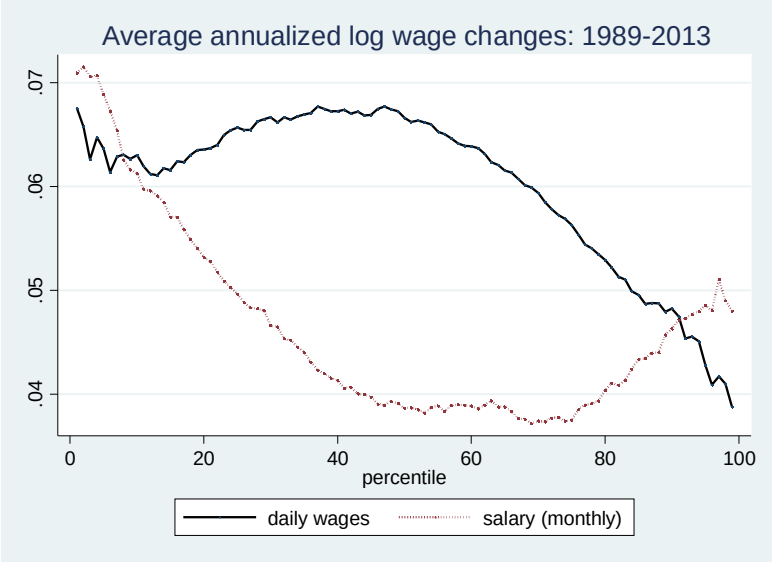

Figure 2: Daily and monthly wages of full time (35 hours per week or more) workers.

upper end of the wage distribution registered high wage growth, whereas the middle range wages stagnated. Figure 2 shows, however, this polarization is applicable only for those paid monthly wages. The wage growth pattern across percentile displays clear inverted U shape among daily wage earners (as opposed to U-shape for month wages).

Although the underlying factor responsible for polarization (among month wage earners) is not our principal research objective, it is worthwhile to confirm the following points. First of all, the impact of minimum wage on wage distribution seems quite different between daily and monthly wages. Among the daily wage samples, we detect strong trend of wage compression: wage growth is consistently higher at lower percentiles of daily wage distribution. On the other hand, among monthly wage samples, we see a clear pattern of wage polarization (Lathapipat 2009)

When we focus on the changes in distribution of daily wages, a different view emerges. At the least, the sharp wage increase following the two major hikes in minimum wage in 2012 and 2013 suggests that the declining real minimum wage may be responsible for the stagnation of daily wages in earlier periods. As a matter of fact, there is strong indication that the minimum wage hikes do induce upward wage adjustments for those around or below minimum wage.

In Figure 3, we show wage growths at each percentile point after minimum wage hikes, and those without changes in minimum wage. It is seen clearly that the wage increase is much higher for daily wages in months following minimum wage increases, especially so at lower percentiles of the distribution. The contrast is quite sharp between months after the change and months without change. No such major differences are observed for monthly wages, except at the extreme lower end of the percentile.

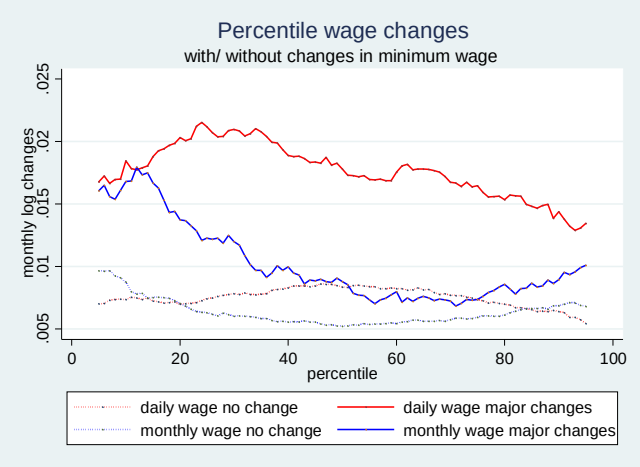

Figure 3: See Table A1 for the list of major changes in minimum wage. Wages for full time workers.

2.2 Minimum wage non-Compliance

Having confirmed the strong impact of minimum wage changes on daily wages, it may seem that the minimum wage is rather strictly adhered to in the country. Our data shows, however, non compliance is widespread[7]. Among daily wage workers, more than one third are paid less than the minimum wage in June 2013. The shares are much smaller for workers with monthly salary, but still sizable: 10.9% if we divide monthly salary by 22.5, or 25.3%[8], if we divide it by 30. See Figure 4. The figure shows the declining trend of the share of workers with less than minimum wage up until the two major hikes in the minimum wages in 2012 and 2013.

Needless to say, regional disparity exists: Table 1[9] shows the share of wage observa-

[7]The law stipulates the following workers are exempt from the minimum wage requirement. (1) employees of central and local governments, and government enterprises, (2) agricultural workers, home workers, self employed (3) short time (part time) workers. In this paper, we do not distinguish between non-compliance (i.e., wages below minimum paid to workers in the covered sector), and wages below minimum paid to workers in exempt sectors. As we will show in section 2, the distinction is not particularly meaningful in our model. We also conducted switching regressions using only non-exempt workers. The main findings are not materially affected by this change. See Appendix A3 and A4 for the results.

[8]There does not seem any well defined conversion method to compute daily equivalent of monthly wages. My preference is to divide monthly wage by 22.5, which is closest to the average actual work days per month. This is computed using 5 and a half work days per week with 15-17 national holidays added as non-work days. Dividing monthly wage by 30 is often used as convention. In what follows, we use monthly wage/22.5 as the daily wage equivalent of the monthly wage data, with occasional supplementary data using conversion by 30. Although the share of noncompliance does depends crucially on this conversion parameter,qualitative features and the regression analysis of monthly wages are robust to changes in the use of conversion ratio.

[9]The samples reporting less than 35 hours of work in the survey week is excluded, See Table A6 for the same tabulations further excluding workers exempted from minimum wage regulations. See also

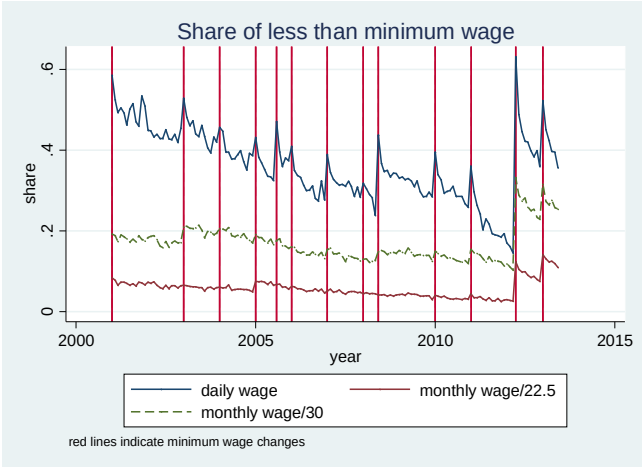

Figure 4: Wages for full time workers.

Table 1 Minimum wage compliance

	daily wage			monthly wage/22.5		
	compared to minimum wage					
	less than	equal to	more than	less than	equal to	more than
Bangkok	0.146	0.583	0.271	0.043	0.000	0.943
Central	0.315	0.223	0.462	0.073	0.000	0.924
East	0.321	0.197	0.482	0.074	0.000	0.922
West	0.427	0.188	0.385	0.099	0.000	0.895
North	0.530	0.129	0.341	0.109	0.001	0.885
Northeast	0.483	0.140	0.377	0.153	0.001	0.843
South	0.391	0.154	0.454	0.115	0.000	0.882
Total	0.395	0.222	0.383	0.096	0.000	0.897

Figures in each cell is the share of wage samples that are less than, equal to, or more than minimum wage. Full time workers (35 hours per week or more) only

tions with less than minimum wage across seven regions, using the last 18 months' samples (in 2012~2013). Not surprisingly, non-compliance shares are smallest in Bangkok, and largest in North and Northeastern regions, which are primarily rural and agriculture economy (see Figure 13 in Appendix). The strong impact of two major hikes are visible: in Bangkok and neighboring provinces, 58% of daily wage workers now receive exactly 300 thb, minimum wage. Adding 15% of those receiving less than minimum wage, more than 70% of daily wage workers in Bangkok earns less than or equal to minimum wage. Situations are somewhat less extreme in other regions, but still in all regions, majority of daily wage workers earns less than or equal to the minimum wage in 2012 to 2013.

In spite of widespread non compliance of daily wages, the impact of minimum wage change on wage distribution is strong, especially among those paid daily wages. For

footnote 6.

example, by comparing percentile wage distributions for each province and month, we find that after minimum wage increase, if a percentile wages is less than the new minimum wage at the month immediately before the change, the average percentile wage increases by .067 log points after 6 months, whereas in percentiles whose wages are more than the minimum wage in the month immediately before, the average increase is .042 log points after 6 months. Therefore daily wages do respond to changes in minimum wage, more strongly so if the wage falls short of the minimum wage.

To quantify the overall magnitude of non compliance, we compute the following *gap* measure

$$gap_t^i = \frac{1}{\#(J(i))} \sum_{j \in J(i)} \frac{\max(0, w_t^j - \overline{w}_t^i)}{\overline{w}_t^i}$$

wherein i denotes province and $J(i)$ is the set of wage observations in province i, time t. Thus gap_t^i is the sum of deficiency in wage compared to minimum wage divided by the number of wage samples in each province. For example, if this number is .2, it means that to increase all wages less than minimum wages up to the minimum wage, the magnitude of the needed wage increase is comparable to average wage increase by 20% of the minimum wage.

The point of this measure is that it represents overall depth and width of the wage deficiency relative to the minimum wage. For example, it is possible that the majority of workers are paid less than the minimum, but their wages are very close to the minimum. If so, even though the non compliance is widespread, the gap measure should be relatively small. Figure 5 shows two gap measures (for daily and monthly wages) over time. We again notice two sharp increases in gap measures after 2012-2013 minimum wage increases, and steady downward trends prior to these sharp increases. By mid 2013, the gap is about .12 for daily wages. It means that in order to lift all the below minimum wages to the minimum wage, you need the increase equivalent to 36 bahts increase of all daily wages.

Declines after sharp increases due to minimum wage increases show that the response of below minimum wages to the increase in minimum wage.

2.3 Impact of minimum wage changes on wage distribution

Figure 6 shows changes in percentile distribution after changes in minimum wage in 2011 and 2012~13. Four figures on the left compare distributions in March 2012, the month immediately before the first wage hike, and June 2013, 6 months after the second wage hike. The impact is highly visible in daily wage distribution: by June 2013, full 50% of wages (from 34 to 83 percentile) are exactly 300 thb, the national minimum wage. This can be compared against the distribution in March 2012, where only 7% (from 14 to 20 percentile) of wages are equal to minimum wage at that time. The sea change generated by the 2012~13 hike can be confirmed also by the lower left panel of the figure for percentile distribution of the daily wage/minimum wage ratio: In March 2012, only 13% of daily wage observations were below minimum wage, and top quartile (75%) wages are 50% or more higher than the minimum wage. By June 2013, only

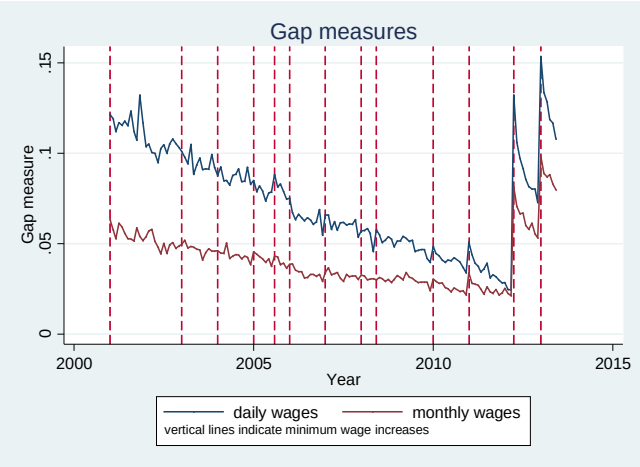

Figure 5: Gap measures as defined in the main text

top 2% daily wages are 50% or more higher than the new minimum wage. On the other hand, the impact of minimum wage changes look far more limited in the case of monthly wages shown on the right column of the figure. Even among monthly wages, by June 2013, a full quarter (from 28 to 52 percentile) of wage observations are exactly minimum wage (after converting monthly wages into daily equivalent by dividing 30), whereas, in March 2012, only 2% of monthly wages are equal to minimum wages then.

Thus it appears though that the 2012~13 hikes in minimum wage indeed exerted sizable impact on wages, especially on daily wages. By June 2013, daily wage distributions are highly concentrated around minimum wage, with roughly a one third of daily wages less than the minimum wage.

These visible impacts on wage distribution can be contrasted against earlier episode of the minimum wage increase in 2011. They are shown in four graphs on the right of Figure 6. In January 2011, the minimum wage was increased by about 6%. Although sizable, the change in minimum wage had very little, if any, impact on wage distributions. Especially on monthly wages, the distribution remained virtually unchanged.

Thus, except for the two major increases in 2012-2013, the effect of minimum wage adjustment in the past has been modest, and limited mostly to the daily wage earners. This is hardly surprising, however, in view of the fact that the real minimum wage has declined since 1997 financial crisis until the major increase in minimum wage in April 2012[10].

[10]Because of steady and sizable increase in CPI, the impact of sporadic increase in minimum wage had been washed away within a short period in real terms. For example, in January 2011, minimum wage was increased to 177 bahts from 166 bahts (both in national averages). Measured in real value, about one half of this impact was washed away within 6 months, and all but evaporated by the time of April 2012 increase.

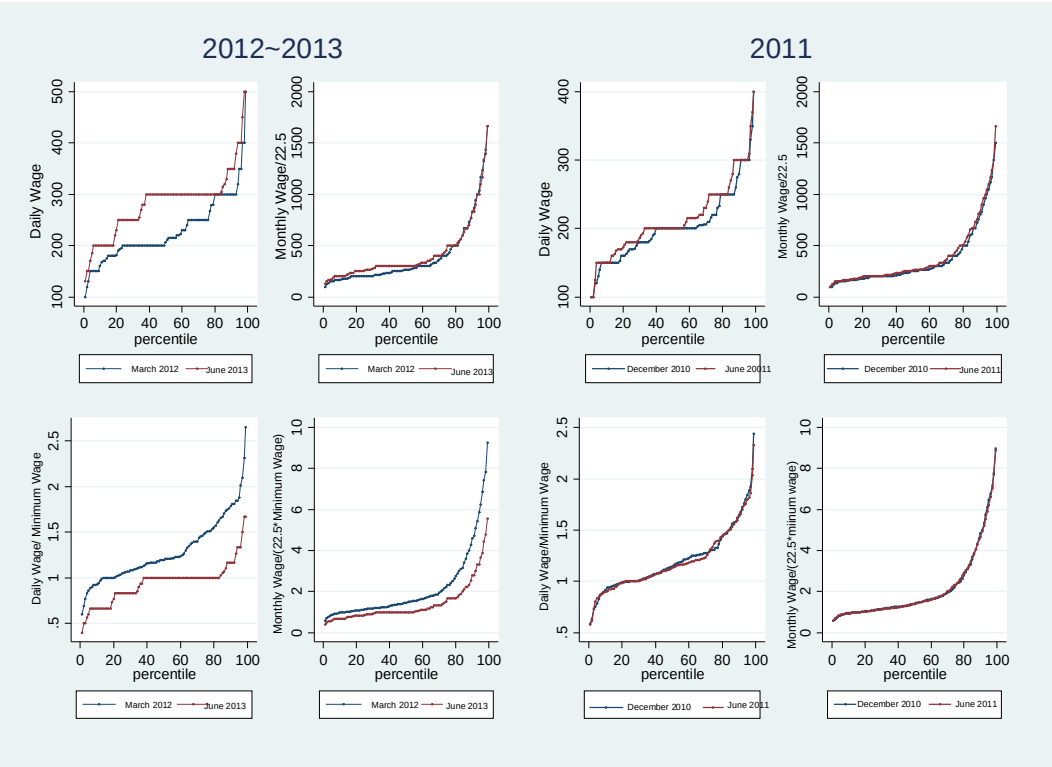

Figure 6: The figure contain 8 graphs. Four graphs in left are for 2012~2013, and the right half are for 2011. In each, upper row are for daily wages, and lower row for monthly wage. In each row, the figure on the left shows wage percentiles, whereas the one on the right shows percentile distribution of wage/minimum wage ratios.

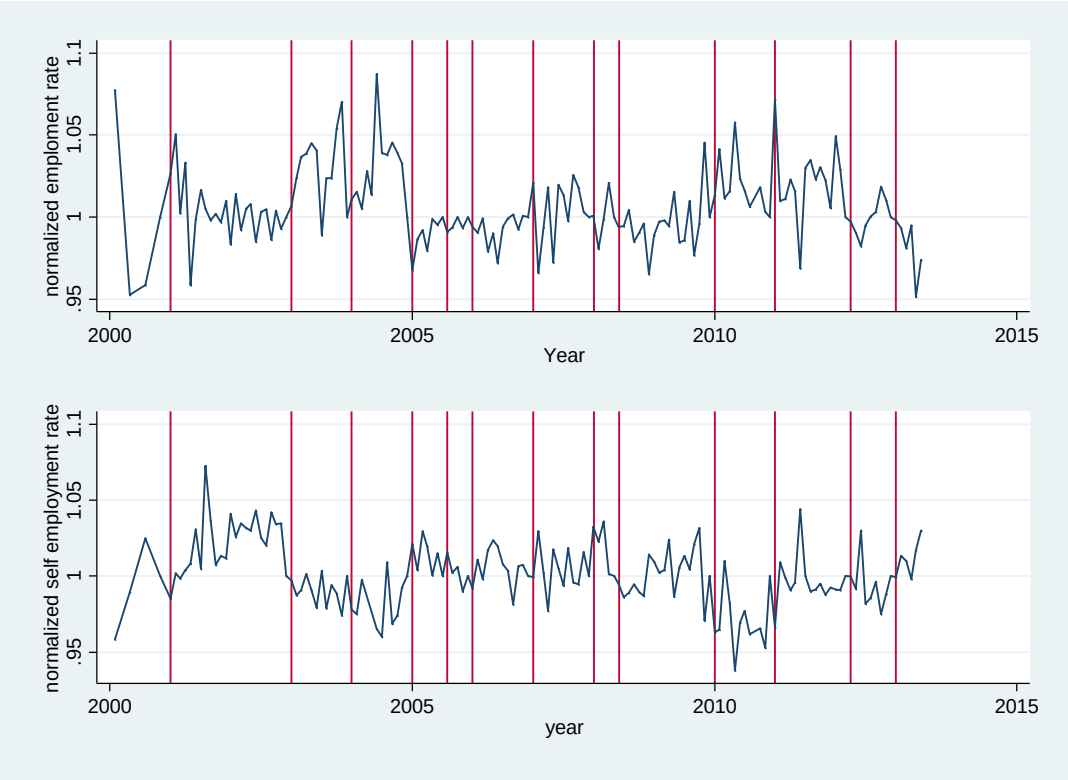

Figure 7: Upper panel shows normalize employment rate. The normalized share of self-employment is in the bottom panel. In both figures, we take the ratio of repsective shares to the ones immediately before the change in the minimum wage. These changes are marked by vertical lines.

2.4 Minimum wage impact on employment

To highlight changes after the changes in minimum wage, Figure 7 show employment and self employment rates normalized by taking the ratio to the value in the month immediately before the minimum wage change. Vertical lines indicate the timing of the increases in minimum wage. For example, figures in January 2013 and after are ratios of the employment rate in each month to the one in December 2012, one month before (the second wave of) the major increase in the minimum wage. For an naked eye, it is not at all clear that any major changes followed after the changes in minimum wage.

Table 2 shows changes in the employment rate after 5 major episodes of minimum wage increase. We compare 6 months average employment before and after each change[11]. Again, there is little indication that the minimum wage change exerted a major negative impact on employment, except possibly for two earlier episodes in 1992 and 1995. On the contrary, major hikes in 2012-2013 seems, if anything, generated sizable

[11] See Table A6 for the full tablulation.

Table 2 Employment Changes after Minimum Wage Increases

	Minimum wage changes	January 2013	April 2012	April 2012-January 2013	January 2008	July 1995	April 1992
Reference Period	Before change	July - Dec 2012	Oct 2011-March 2	Oct 2011-March 2	July - Dec 2007	Feb 1995	Feb Aug 1995
	After change	Jan-Jun 2013	Apr-Sep 2012	Jan-Jun 2013	Jan-Jun 2008	Apr 1992	Feb Aug 1992
Region	Bangkok	n.a.*	1.219	1.248	1.006	0.968	0.914
	Central	1.270	1.045	1.001	1.049	1.001	0.996
	East	1.297	1.004	0.998	1.104	0.961	0.962
	West	1.343	0.943	1.021	1.040	0.970	1.101
	Noth	1.274	0.975	1.034	1.150	0.854	0.908
	Northeast	1.452	0.993	1.187	1.268	0.624	0.660
	South	1.293	0.985	1.015	1.022	1.072	1.176
	Total	1.322	1.024	1.072	1.091	0.921	0.931

* Bangkok region minimum wage was increased to 300thb on April 2012 and no further changes made on January 2013

expansion in employment, especially in Bangkok and other high income areas[12]. This applies also to the increase in 2008. The apparent positive impact on employment in 2012-2013 may be misleading if, for example, those provinces where the compliance rate was low gained in employment at the expense of regions where most employers complied the regulation and increased their wage in line with the higher minimum wage. Figure 8 below shows this is not the case. On the contrary, when we compute province wise changes in employment, employment increases after minimum wage increase if wages are increased accordingly. Figure 8 indicates that, at province level, strong *positive* correlation between changes in employment and compliance rate[13].

On the other hand, we find no significant correlation between the two variables for the sample of workers receiving monthly wage[14]. In Appendix Table A6, we show changes in employment in 13 major episodes of increases in minimum wage. The increase in 2012~2013 produced roughly 7~8% increase in employment of daily wage workers, whereas the employment of monthly workers declined by 3%. There is indication also that employers increased their employment more if they complied with the higher minimum wage. All in all, these simple tabulations indicate strongly that a textbook model of minimum wage increase on wage and employment cannot be expected to explain the observed outcomes in wage and employment after changes in minimum wage.

Then, the crucial question is: why a sharp increase in wage after 2012 minimum wage hike apparently had no major detrimental effect on employment? Instead, the

[12]There is one catch on this number. In late 2011, Bangkok and nearby provinces were hit by a major flood of Chaoprhaya river that runs through the central regions and ends in Gulf of Thailand, directly south of Bangkok. Thus the employment before April 2012 is likely to be abnormally lower due to the stoppage of production at major manufacturing facilities. Fortunately, the main results reported below are not materially influenced by the impact of the flood. See Appendix 3.

[13]The correlation is more pronounced among the daily wage earners if we limit the sample to those with lower education attainment.

[14]In a simple regression of changes in employment over the average compliance rate, the coefficient is slightly negative but insignificant for the sample of monthly wage earners.

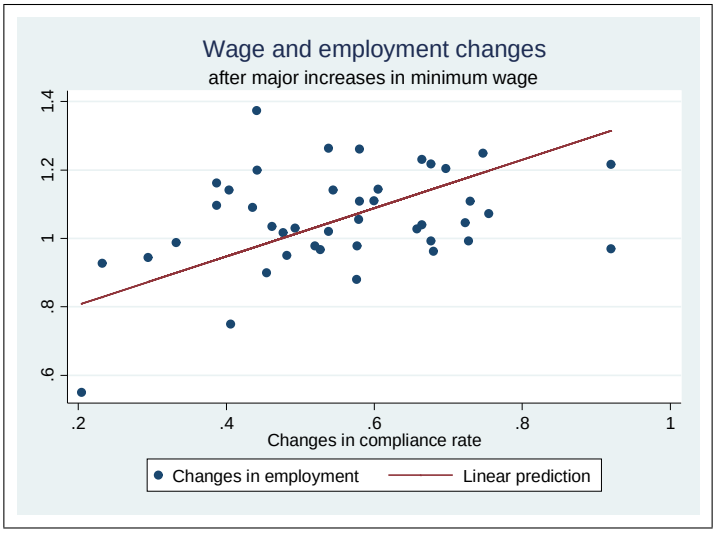

Figure 8: See Table 2 for the list of major changes in minimum wage. Each point represents respective averages of changes in employment and compliance rate in each cell defined by province and areatype.

wage hike seems to have generated expansion of employment among those paid daily wages.

It is not obvious how these findings can be reconciled with the analysis of minimum wage in the competitive labor market. At least we need to build a model that can capture three crucial aspects of the impact of minimum wage increase. First of all, given that the sizable and changing share of non-compliance to minimum wage, we need to incorporate minimum wage compliance decision. Worker heterogeneity seems also essential aspect as we found significant differences in impacts between daily and monthly wage earners. Finally, given the regional disparities, we need a model that can encompass wide ranges of outcomes, depending upon the market structure (to be defined below) and other pre-conditions. We take up these issues in the next section.

3 A model of voluntary compliance to minimum wage

3.1 Cost of non compliance

It is well known that non-negligible portion of employment in developing countries are at below minimum wage. Wages below minimum wage can be found not just in sectors exempt from the minimum wage legislations, but also among employment at formal sectors.

Starting from the pioneering work by Aschenfelter and Smith (1979), the most common approach for modeling the compliance decision invokes the probability that non

compliance is detected by regulatory agency and the penalty imposed[15]. The implied expected cost of non-compliance is then compared with the benefit from adjusting the wage freely (to below minimum wage). Under such a model, (partial) compliance is ensured only by the presence of detection and the penalty imposed for the violation of minimum wage[16].

Applying this model for empirical analysis requires data on inspection, monitoring, and penal actions taken by the regulatory agency. How plausible is this model of penalty and detection? For employer compliance decision in Thailand, it seems rather farfetched. In Leckcivilize (2013), he reports a record of inspection in Thailand by Department of Labor Protection and Welfare in which roughly 10~15% of establishments in the country are inspected each year. Roughly 15% of the inspections found violations and roughly a quarter of these violations are below minimum wage. The penal actions taken by the government are rather mild and a great majority of them were simply given warnings, with only .3% !! of all the violations found resulted in fine imposed or more severe judicial actions[17].

Setting aside empirical problems of identifying and quantifying detection probabilities and the size of penalty, compliance decision model based upon penalty leaves several key questions unanswered.

First of all, existing empirical works find that the non-compliance is systematically associated with a host of variables pertaining to the characteristics of employers[18]. For example, it is well known that the compliance rate is increasing in the size of employer. Industry characteristics also serves as good predictor on compliance. It is not immediately clear why these employer characteristics are systematically correlated with compliance if the decision is based solely on the probability of detection and the size of penalty.

Moreover, the model of detection and penalty is at best incomplete in so far as the model offers no prediction on *who* are more likely to be employed at non-compliance firms, whereas we have ample empirical evidence showing that the worker characteristics systematically predict the probability that she is employed at a (non-) compliance firm. The crucial ingredient lacking in monitoring-penalty models is the worker heterogeneity.

Our approach focuses on the *voluntary* aspect of compliance decision, or, to put it differently, on compliance decisions through (non-penalty) costs and benefits of com-

[15] See for example, Lemos(2009), Yanis(2007) for the extension of the base model, Basu et al (2010) examines the consequences of limited commitment ability of the government to enforce the law.

[16] The key condition for the compliance exploited in the empirical part of the paper are (1) the gap between competitive wage rate and the minimum wage, and (2) the demand elasticity. If the demand is elastic, the cost of compliance is larger, hence more likely to set below minimum wage.

[17] Leckcivilize also cites:In terms of penalty, according to Labour Protection Act 199821, any employers paying wages lower than the legislative minimum are liable for a fine not exceeding 100,000 baht or up to 6-month imprisonment or both. Based on minimum wages in 2001, the upper limit of this fine is worth more than 600 worker-days for every province, which is a high penalty for employers in smaller firms. But, again, these numbers hardly matter if the probability of detection and penatly charged is practically nil.

[18] See, for example, Weil(2005).

pliance, unrelated to the penalty of violation[19].

We believe that the *benefit from compliance* is particularly important when employers try to hire workers. Even if the effective monitoring of minimum wage compliance is virtually non-existent, no employer try to use public employment agency if they set (and announce) wage below the statutory minimum. By setting wage below the minimum, they are often denied access to (public and private) employment agencies and a variety of media used for vacancy posting, such as newspaper or web cites, as they obviously have their own reputation to keep and they are most likely to avoid posting job slots with a below minimum wage. The upshot of the argument is that by setting below minimum wage, a variety of organizations forming the labor market become unavailable or inaccessible. Thus we hypothesize that the employers incur additional cost in hiring if they do not comply the minimum wage regulation.

Below, we incorporate the cost of non-compliance in a simple model of labor market.

3.2 Model

3.2.1 A competitive equilibrium without minimum wage

Assume that the competitive labor market is populated by workers whose innate productivity, e, is drawn from the cumulative distribution, $F(e)$. F is continuous and its density, f, is strictly positive in the support $[e_0\ e_1]$. We drastically simplify the analysis by assuming that heterogenous workers are mutually perfect substitutes as employees so that the competitive employers care only about the total labor inputs and its cost measured in terms of efficiency unit. For subsequent analysis, it is convenient to convert the population distribution into efficiency unit. Define

$$n(e) = ef(e)$$

as the density of type e workers measured in efficiency unit. Define

$$\begin{aligned} N(x) &= \int_x n(e)de \\ N(e_0) &= \overline{N}, \\ N(e_1) &= 0 \end{aligned}$$

as the labor force measured in efficiency unit whose productivity is at least x. Denote by ω the wage rate per efficiency unit of labor. Thus type e workers facing wage per unit of efficiency ω is paid ωe. Per person wage rate for type e worker is denoted by $w(e)$. We assume a particularly simple participation decision: we use $\lambda(\omega)$ as the participation rate for all the workers when the wage rate per efficiency unit is ω. In

[19] This is not meant to deny the potential explanatory power of detection-penalty model. Our point here is that we simply lack any reliable data on establishment basis pertaining to the probability of detection and the expected size of penalty.

other words, $\lambda(\omega)$ is the share of workers whose self employment option yields at most ωe of outputs.

$$\lambda'(\omega) > 0, 0 < \lambda(\omega) < 1$$

Participation rate is assumed to be strictly positive and less than unity for any finite and positive value of ω. Then, the supply schedule facing potential employers are given simply by

$$S(\omega) = \lambda(\omega)\overline{N}$$

On employer side, consider a simple production function using only labor as inputs so that the first order condition is given by

$$\begin{aligned} Q'(D) &= \omega, \\ Q''(D) &< 0 \end{aligned}$$

The equation above can be solved to obtain the economy wide labor demand:

$$D = D(\omega)$$

Then, the balance between supply and demand implies

$$D(\omega) = \lambda(\omega)\overline{N}, \tag{E1}$$

which can be solved to obtain the equilibrium wage rate ω^* per efficiency unit of labor. Thus the equilibrium wage rate for type e worker is given by

$$w(e) = \omega^* e$$

3.2.2 Minimum wage with perfect compliance

Suppose now that the minimum wage,$\overline{w}$ is imposed. In the spirit of the minimum wage policy, it is set as the minimum wage per person, not in efficiency unit. Then, at an efficiency unit wage rate ω , workers whose innate productivity lower than

$$\widehat{e} = \frac{\overline{w}}{\omega}$$

are rationed out as their per person wage rate are below the minimum. Hence the effective labor supply becomes

$$S = \lambda(\omega)N\left(\frac{\overline{w}}{\omega}\right)$$

Then we obtain

$$\lambda(\widehat{\omega})N\left(\frac{\overline{w}}{\widehat{\omega}}\right) = D(\widehat{\omega}) \tag{E2}$$

as the equilibrium condition with binding minimum wage. We call a minimum wage to be binding if

$$\frac{\overline{w}}{\widehat{\omega}} > e_0$$

so that at least some of low productivity workers cannot find job because of the minimum wage. Comparing (E2) with (E1), it is immediate that

$$\begin{aligned} \omega^* &< \widehat{\omega}, \\ D(\widehat{\omega}) &< D(\omega^*) \end{aligned}$$

In what follows, we denote by $\boldsymbol{\eta}_x$ % change of variable x when minimum wage changes by 1%.

$$\boldsymbol{\eta}_x \equiv \frac{d\log(x)}{d\log(\overline{w})}$$

Log differencing (E2), we get

$$\boldsymbol{\eta}_{\widehat{\omega}} = \frac{\epsilon_N}{\epsilon_\lambda + \epsilon_N + \epsilon_D} > 0$$

wherein $\epsilon_x(x = \lambda, N, D)$ denotes respective elasticity with respect to its argument. Thus, as the minimum wage rises, the equilibrium wage rate also rises, but the change is less than proportionate so that the increase necessarily raises the threshold, $\frac{\overline{w}}{\widehat{\omega}}$, inducing more rationing. The flip side of the rationing is that for those above threshold, the employment *expands*. We have

$$\begin{aligned} \boldsymbol{\eta}_{D(\widehat{\omega})} &= -\epsilon_D \boldsymbol{\eta}_{\widehat{\omega}} = -\frac{\epsilon_D \epsilon_N}{\epsilon_\lambda + \epsilon_N + \epsilon_D} < 0, \\ \boldsymbol{\eta}_{\lambda(\widehat{\omega})} &= \epsilon_\lambda \boldsymbol{\eta}_{\widehat{\omega}} = \frac{\epsilon_\lambda \epsilon_N}{\epsilon_\lambda + \epsilon_N + \epsilon_D} > 0. \end{aligned}$$

To sum up:

Lemma 1 *When minimum wage is imposed and if it is binding, the efficiency unit wage rate exceeds the one under the competitive equilibrium without minimum wage, and, those workers below the threshold productivity, $\widehat{e} = \frac{\overline{W}}{\omega}$, will be rationed and cannot find a job. On the other hand, workers with productivity $\widehat{e}$ or above receive higher wage rate than before and their participation rate is higher. An increase in minimum wage brings about a less than proportionate increase in equilibrium wage. Hence more rationing and further expansion of employment above minimum wage.*

3.3 Equilibrium with Cost of non-compliance

We now consider the compliance decision. As we discussed earlier, our goal is to relate the compliance decision to the cost and benefit of compliance. We assume that offering a wage in compliance with the minimum wage grants the employer with the access to the

external labor market for hiring. If the employer decides not to comply, the recruitment must be done informally, through word of mouth communications, mediation by the current employee, etc. The upshot of relying upon informal recruitment is that it lacks information on applicants. We highlight this aspect by assuming that it costs c per applicant to ascertain his innate productivity, which is necessary to determine each productivity and appropriate wage.

Denote by ω^C the efficiency unit wage rate for complying employers. The corresponding wage rate per person is

$$w^C(e) = \omega^C e \geq \overline{w}$$

Since workers measured in efficiency unit are perfect substitute, the wage rate per person in non-complying sector must satisfy

$$w^N(e) = \omega^C e - c$$

so that the per capita wage rate plus the recruitment cost is equal to $w^C(e)$. In the competitive equilibrium, the cost c is born by workers taking up less than minimum wage jobs. Then, the wage rate per efficiency unit at the non-compliance employers is

$$\omega^N(e) = \omega^C - \frac{c}{e}$$

Then the supply is given by

$$S(\omega^C) = \lambda(\omega^C) N\left(\frac{\overline{w}}{\omega^C}\right) + \int^{\frac{\overline{w}}{\omega^C}} \lambda(\omega^C - \frac{c}{e}) n(e) de$$

whereas the demand schedule (including both complying and non-complying employers) remain unchanged. Thus the competitive equilibrium in this case is a solution to

$$D(\omega^C) = \lambda(\omega^C) N\left(\frac{\overline{w}}{\omega^C}\right) + \int^{\frac{\overline{w}}{\omega^C}} \lambda(\omega^C - \frac{c}{e}) n(e) de \tag{E3}$$

Notice that the supply to non-complying employers are depressed due to the cost imposed by the non-compliance. As the share of employment in non-compliance sector is increasing in the minimum wage, the equilibrium efficiency unit wage is increasing in the minimum wage.

Log differentiation of (E3), we have

$$\begin{aligned}
\boldsymbol{\eta}_{\omega^C} &= \frac{(1-s)\epsilon_N}{\epsilon_D + (1-s+\delta s)\epsilon_\lambda + (1-s)\epsilon_N}, \\
s &\equiv \frac{\lambda(\omega^C) N\left(\frac{\overline{w}}{\omega^C}\right)}{D(\omega^C)}, \\
\delta &\equiv \left[N\left(\frac{\overline{w}}{\omega^C}\right)\right]^{-1} \int^{\frac{\overline{w}}{\omega^C}} \left(\frac{\omega^C}{\omega^C - \frac{c}{e}}\right) n(e) de
\end{aligned}$$

Hence we get

$$\begin{aligned}\boldsymbol{\eta}_{\lambda(\omega^C)} &= \frac{(1-s)\epsilon_N\epsilon_\lambda}{\epsilon_D+(1-s+\delta s)\epsilon_\lambda+(1-s)\epsilon_N} > 0, \\ \boldsymbol{\eta}_{D(\omega^C)} &= -\frac{(1-s)\epsilon_N\epsilon_D}{\epsilon_D+(1-s+\delta s)\epsilon_\lambda+(1-s)\epsilon_N} < 0\end{aligned}$$

Thus, like in the complete compliance case, an increase in minimum wage has disemployment effect over all. The difference is that the disemployment effect is not rationing due to higher wage, but due to the negative effect of the cost of non-compliance on the labor supply. Moreover, the increase in equilibrium wage is smaller compared to the perfect compliance case. Hence both overall disemployment effect and expansion of employment above minimum wage are smaller.

Lemma 2 *Competitive equilibrium with endogenous compliance decision on minimum wage is a solution to (E3) and the equilibrium efficiency unit wage is*

$$\omega^C = \omega(c)$$

with

$$1 > \frac{\partial\omega}{\partial c} > 0$$

so that the equilibrium wage rate is higher for complying firms, and lower for non-complying firms. The total employment is smaller, compared to the competitive equilibrium without minimum wage, whereas it is larger in comparison to the case wherein the compliance is complete. An increase in minimum wage result in less than proportionate increase in equilibrium wage above minimum wage, whereas the wage below minimum remain unchanged.

The effect of minimum wage increase on employment comes from two parts. As the equilibrium efficiency unit wage increases, the participation rate is higher and that tends to increase employment. The negative impact comes from a subset of workers who had received above minimum wage but move to below minimum wage after the change. The compliance cost born by these workers depress their supply. Under the new equilibrium, this negative effect of compliance cost outweighs the positive effect from the wage increase. Therefore, for those whose wage relative to minimum wage did not change, their wage rate increases and their employment increases.

Unlike binding minimum wage model, the equilibrium with endogenous compliance decision involves no rationing (of low skilled workers). In our model of endogenous compliance decision, the minimum wage is essentially a tax on low productivity. As such, the distortionary and negative effect on employment by minimum wage increase is akin to the change in income bracket for this tax on the low productivity.

Before closing this part, it must be noted that the model equilibrium fails to represent one important empirical regularity: i.e., concentration of employment at the minimum wage[20].

[20] See however Appendix 1. If workers are imperfect substitute, we obtain the wage spike at minimum wage even in the case of endogenous compliance decision.

3.4 Tacit collusion

In the equilibrium above, the labor market is divided into below and above minimum wage at

$$e_c = \frac{\overline{w}}{\omega^*}$$

Suppose the employers paying above minimum wage, i.e., those employing workers with productivity e^C or higher, collude and set their wage to maximize joint profit. Note that as far as there is no change in this demarcation productivity, e_c,the non-complying sector is left undisturbed by the collusion of firms employing above threshold productivity workers. Assume m_M complying employers collude. They set their wage to maximize their joint profit subject to the minimum wage compliance. The remaining $m_N = m - m_M$ employers hire workers with productivity below e_c. They remain competitive and pay below minimum wage.

Lemma 3 *Under collusion, employers' optimal policy is given by*

$$\widehat{\omega}(e) = \max\left[\omega^M, \frac{\overline{w}}{e}\right] \tag{E4a}$$

wherein ω^M is monopsony efficiency wage given by

$$\begin{aligned} Q'(D^M) &= \left(1 + \frac{1}{\epsilon_\lambda}\right)\omega^M, \\ m_M D^M &= \int_{e_c} \lambda(\widehat{\omega}(e))n(e)de \end{aligned} \tag{E4b}$$

As for the non-complying sector, the same equilibrium condition continues to hold:

$$\begin{aligned} Q'(D^N) &= \omega^C, \\ m_N D^N &= \int^{e_c} \lambda(\omega^C - \frac{c}{e})n(e)de \end{aligned} \tag{E4c}$$

Proof. The optimal policy is a solution to the following maximization problem

$$\begin{aligned} \max \mathcal{L} \equiv\ & m_M Q(D^M) - \int_{e_c} \lambda(\omega(e))\omega(e)n(e)de + \Omega_M \left[\int_{e_c} \lambda(\omega(e))n(e)de - D^M\right] \\ & - \int_{e_c} \gamma(e)\left(\omega(e)e - \overline{w}\right) f(e)de \end{aligned}$$

wherein $\gamma(e)$ is the Lagrangian multiplier for the minimum wage constraint which we assume they comply, and Ω_M is the shadow price of composite labor input. If the minimum wage constraint is not binding so that $\gamma(e) = 0$, then the first order condition for such $\omega(e)$ is readily solved to get

$$\left(1 + \frac{1}{\epsilon_\lambda}\right)\omega^M = \Omega_M = Q'(D^M),$$

wherein ϵ_λ is the supply elasticity and the latter part of the equality follows from the first order condition on D^M. If the minimum wage constraint does bind, then, for such $\omega(e)$, we trivially get

$$\omega(e) = \frac{\overline{w}}{e}$$

Collecting these two cases with the understanding the minimum wage is binding only when

$$\omega^M e < \overline{w}$$

the lemma is proven. ■

The result is intuitively clear. Given the labor pool for collusion, the monopsony wage is just minimum wage for lower productivity workers until the monopsony efficiency unit wage $\omega^M e$ takes over. Note also that

$$\omega^M < \omega^*$$

The monopsony wage schedule is composed of two parts. For worker with lower productivity, the per capita wage rate is just the minimum wage. For those workers $\omega^M e \geq \overline{w}$, per efficiency unit wage schedule is applied. This efficiency wage is flatter than the competitive equilibrium.

The collusion equilibrium given by (E4a)~(E4c) presupposes that collusion, if successful, generate super normal profit. I.e., it must be the case that their joint profit is larger than what they would have obtained by sticking to the competitive wage schedule ω^*. Collusive wage is certainly the better choice against a subset of high productivity workers to whom $\omega^M e \geq \overline{w}$ as the collusion wage rate per efficiency unit is smaller than the competitive one. For workers closer to e_c,however, the minimum wage is paid and the implied efficiency unit wage is higher than ω^M. If the portion of workers paid minimum wage is too large, the collusion may not be tenable. The implication of this cautionary note is that, given the demarcation productivity, e_c, the minimum wage must be low enough to ensure the profitability of collusion.

The second main result is the impact of a change in minimum wage. If we assume that the collusion among complying firms continues after the increase for the labor pool of the workers with productivity above e_c, we can log differentiate the monopsony equilibrium conditions and obtain

$$\begin{aligned}
\boldsymbol{\eta}_{\omega^M} &= -\frac{s_M \epsilon_\lambda}{\epsilon_\lambda(1-s_M)+\epsilon_D} < 0, \\
\boldsymbol{\eta}_{D^M} &= -\epsilon_D \boldsymbol{\eta}_{\omega^M} = \frac{s_M \epsilon_\lambda \epsilon_D}{\epsilon_\lambda(1-s_M)+\epsilon_D} > 0, \\
s_M &\equiv \frac{\int_{e_c}^{\frac{\overline{w}}{\omega^M}} \lambda\left(\frac{\overline{w}}{e}\right) n(e) de}{D^M}
\end{aligned}$$

To see this, as far as the collusive employers jointly comply with the new minimum wage, they need to increase their wage for workers with lower productivity to a higher minimum wage, which obviously increase the supply from these workers. The marginal

condition (E4b) then dictates that the efficiency unit wage rate ω^M should decline. Note also that as far as the demarcation value e_c remain unchanged, the non-complying sector of the market is totally insulated from the change in minimum wage. In that case, the gap between the minimum wage and the highest wage at non-complying sector widens and exceeds c.

Lemma 4 *Under tacit collusion, an increase in minimum wage results in expansion of employment among colluding firms, whereas the efficiency unit wage rate for above minimum wage workers declines as far as the colluding firms continue to honor the minimum wage.*

3.5 Finite substitution among heterogenous labor

The base line model of this section can be extended to cases wherein different labors are imperfect substitute. We report only the main results and relegate the analysis to Appendix 1. Here we assume that different labors are imperfect substitute such that the demand is a CES type given by

$$m(e) = \left(\frac{\omega(e)}{\Omega}\right)^{-\epsilon_L} D$$

wherein D stands for the demand for composite labor, Ω is corresponding wage index, and ϵ_L is the elasticity of substitution. The demand for composite labor is determined by

$$Q'(D) = \Omega.$$

Applying Dixit-Stiglitz model to heterogenous labor, we show that the main results shown above continue to apply in the case of finite substitution among labors when we impose two additional conditions[21]. Namely, with endogenous compliance decision, the employment expands (shrinks) for workers paid above (below) minimum wage. Tacit collusion model continue to predict the employment expansion and wage compression after an increase in minimum wage.

3.6 Summary

In this section, we build a model of a simple labor market that can capture two crucial aspects of the conditions in which minimum wage law is placed in many (including

[21] The conditions are (1) the minimum wage binds only for lower subset of workers, and (2) the elasticity of substitution within labor is smaller than the elasticity for the composite labor. The condition (1) is given by

$$\frac{en'(e)}{n(e)} < \epsilon_L + \epsilon_\lambda \tag{A3}$$

whereas the condition (2) is

$$\epsilon_L > \epsilon_D$$

wherein ϵ_D is the elasticity of the demand for composite labor with respect to wage index Ω.

Thailand) developing economies. First, we have a model in which compliance decision by employers are based upon the cost incurred by non-compliance, rather than the expected probability of monitoring and penalty by regulatory agency. Second, we explicitly incorporate labor heterogeneity so that we make explicit who are influence (more) by the minimum wage. Such a model predicts that employment at below minimum wage shrinks, whereas the employment above minimum wage expands. Both of these are along labor supply schedule. When we adds a collusion among employers who comply the minimum wage, the model delivers a few key results that can be matched against the empirical evidence. First of all, the model predicts overall positive impact of minimum wage on employment, due to the expansion of employment by complying sector. Second result is that the complying employers shed their wage schedule such that marginal efficiency unit wage is smaller than what should prevail under the competitive labor market. Thus the model predicts that wages at complying firms are compressed.

4 Main Results

In the last section, we presented a simple model of labor market incorporating endogenous compliance decision. In the analysis, the crucial ingredient is the cost of non-compliance, which induce a wedge between above and below minimum wage rate. Our first agenda for the empirical analysis is to estimate the model wherein the choice between compliance and noncompliance is jointly determined with the wage schedules for both above and below minimum wage. For this purpose, we employ switching regression and obtain the estimate of treatment effect. The second issue is how the (employer) compliance decision in turn influence the labor market participation decision. We estimate two versions of the participation decision. In the first, we use probit model over employed and non-employed, with the latter including both self employment and non-participation. In the second, we use multinomial probit model over non-participation, self employment, and employed.

4.1 Switching regressions and average treatment effects

4.1.1 Estimation model for the cost of non-compliance

As we do not have detailed employers data, the compliance decision at the individual employer level are generally unobservable. Luckily, however, in the first 3 months of 2013, Labor Force Survey did ask several key questions on the effect of the increase in minimum wage during 2012~2013. Among others, LFS asks if each of the surveyed employer raised the wage to or above 300thb, and several other questions. We use the answer to this question for a probit regression on compliance with the minimum wage after the change in January 2013. Our agenda here is to connect this probit regression result to the choices by sample workers over different job opportunities. Denote by $\widehat{\gamma}(i, s, p)$ as the predicted compliance probability of employers in industry i, employer size s, located in province p.

Individuals in each province decides whether or not to work, and, if work, where, the decision of which is influenced by whether not the potential employers (in their areas of residence, and the chosen industry and firm size) offers wage above or below minimum wage, which we represent by the predicted compliance profile $\widehat{\gamma}(i,s,p)$[22]. We posit that the decision by individual worker whether or not to work at wage above or below minimum wage is given by

$$U^j(i,s,p) = \beta_1 Z_t^j + \beta_2 \widehat{\gamma}(i,s,p) + u_t^j > 0$$

As the choice depends evidently upon the availability of two types of jobs, we use $\widehat{\gamma}(i,s,p)$ as a proxy representing relative job availability with wage above or below minimum wage. Depending upon the choice, each individual faces distinct wage schedules. Thus the switching regression model is comprised of the following equations.

$$\begin{aligned}
\log(w_t^j) &= I^j \log(w_t^{jC}) + (1 - I^j)\log(w_t^{jN}), \\
\log(w_t^{jM}) &= \alpha^M X_t^j + u_t^M, M = C, N \\
I^j &= 1, \\
& \quad iff \\
U^j(i,s,p) &= \beta_1 Z_t^j + \beta_2 \widehat{\gamma}(i,s,p) + u_t^j > 0
\end{aligned}$$

wherein I^j is an indicator variable for employment at a job above (below if $I^j = 0$) the minimum wage. The average treatment effect c is given by

$$\widehat{c} = E\left((\alpha^C - \alpha^N)X\right)$$

Most parsimonious interpretation of the estimated treatment effect is the wage gap induced by treatment (non-compliance). In Section 3, we built a model in which a cost c is imposed upon noncomplying employers. The estimated wage gap should coincide with this cost.

Table 3 shows our estimates of average treatment effects (ATE) based upon switching regression for the sample of daily and monthly wage earners[23]. Estimated switching regressions are reported below. We estimated the model using entire samples after 2001 (data prior to 2001 are quarterly and we drop the samples in the earlier period), and in the second set of estimations, we used samples in 2012-2013. The upper half of the table reports the results for samples of daily wage, and the bottom half are for the sample of monthly wages.

Starting from the sample of daily wages, the estimated treatment effects are robust and do not markedly differ across samples or AT or AT on treated (ATET). On the other hand, treatment effects differ markedly across the employer size(measured in the number of employees)[24]: the treatment effects are larger for smaller employers. The bottom half of Table 3 shows the results for monthly wage. Except for the estimates using the small size employers, none of the estimated average treatment effect for this

[22] See Appendix Table A4 for the background probit regression.

[23] Table A5 reports ATE and ATET employing propensity score matching. Results are quite similar.

[24] Small firms:~19 employees, medium: 20~99, large: 100 or more.

Table 3 Average treatment effect

daily wage								
	Average Treatment				Average Treatment on the Treated			
sample period	2001~2013		2012~2013		2001~2013		2012~2013	
	mean	s.dev	mean	s.dev	mean	s.dev	mean	s.dev
all sample	-0.448	0.134	-0.445	0.082	-0.453	0.141	-0.456	0.083
small size	-0.572	0.098	-0.499	0.080	-0.598	0.100	-0.529	0.080
medium size	-0.470	0.100	-0.455	0.061	-0.501	0.103	-0.478	0.062
large size	0.131	0.087	-0.364	0.037	0.097	0.084	-0.244	0.034
monthly wage								
	Average Treatment				Average Treatment on the Treated			
sample period	2001~2013		2012~2013		2001~2013		2012~2013	
all sample	0.082	0.097	0.234	0.238	0.120	0.098	-0.067	0.226
small size	0.080	0.083	-0.730	0.133	0.065	0.086	-0.764	0.129
medium size	0.047	0.110	0.134	0.069	0.141	0.099	0.163	0.066
large size	0.014	0.216	0.054	0.164	0.081	0.283	0.139	0.222

Table shows the average treatment effects of non-compliance, based upon the estimation results of the switching regressions.

sample is statistically significant. As a matter of fact, the point estimates of ATE and ATET are slightly positive for all the cases except for small size employers.

This is consistent with our finding earlier on the contrast between daily and monthly wage distribution. The impact on daily wages by minimum wage change appears large and concentrated heavily around the minimum wage, whereas for monthly wages, the overall impact is much smaller and found no strong evidence that the impact are concentrated around the minimum wage. The estimated treatment effects show that the minimum wage constrains structure of daily wages, but not monthly wage.

Our finding that the treatment effect is inversely related to the employer size[25] is *not supported by* the prediction of the model in Section 3, at least the one derived from competitive equilibrium: the model predicts that the cost incurred by non compliance should encourage compliance. Hence the compliance rate and estimated treatment cost should be positively correlated, whereas our results in Table 3 show that treatment effect is smaller at larger firms which tend to have higher compliance rate. As we indicated at the end of 3.4, one possible interpretation is that collusive firms can effectively reduce wage as the minimum wage declines so that the gap between complying and non-complying sector is narrowed down. It is also possible that with a large chunk of observation at exactly minimum wage, the log wage regressions fit poorly and produces downward bias on the ATE at large firms [26].

Table 4 (daily wage samples) and Table A3 (monthly wage samples) in Appendix

[25] The inverse relation between ATE and employer size is robust over the choice of sample period and other specifications. See Table A5 in Appendix for the ATE estimations using propensity score matching, instead of switching regressions. We tried other estimations methods such as endogenous treatments effect model yet this reverse relation is robust.

[26] Another interpretation is the Aschenfelter-Smith model of penalty cum monitoring. Perhaps, larger firms are more visible and more likely to be inspected, which might increase the expected cost of penalty.

Table 4 Switching Regression part 1 Logwage regressions: Daily wage *																
	Treated (less than minimum wage) samples								Control (more than or equal to minimum wage) samples							
sample	all		small		medium		large		all		small		medium		large	
period	2001~201	2012~13	2001~20	2012~13	001~201	2012~13	001~201	2012~13	2001~201	2012~13	2001~20	2012~13	001~201	2012~13	2001~2013	2012~13
	*All the regressions reported in the table includes dummy variables for year, region, industry (two digit 23 ISIC classifications), and area (urban or municipal), aside from the firm size dummies reported above															
years of schooling	0.0123	0.0091	0.0142	0.0107	0.0142	0.0100	0.0153	0.0043	0.0060	0.0065	0.0087	0.0082	0.0033	0.0082	0.0111	0.0028
	(0.001)***	(0.002)***	(0.001)***	(0.002)***	(0.001)***	(0.003)***	(0.005)***	(0.009)	(0.001)***	(0.001)***	(0.001)***	0.002)**	(0.001)**	(0.003)***	(0.004)***	(0.001)***
years of schooling2	-0.0005	-0.0004	-0.0007	-0.0004	-0.0008	-0.0005	-0.0003	-0.0003	-0.0003	-0.0001	-0.0003	-0.0003	0.0001	-0.0001	-0.0002	0.0000
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)	(0.000)	(0.000)***	(0.000)**	(0.000)***	(0.000)**	(0.000)	(0.000)	(0.000)	(0.000)
e-6-years of school	-0.0005	-0.0004	-0.0009	-0.0004	-0.0002	-0.0001	0.0037	0.0002	0.0018	0.0018	0.0019	0.0014	0.0029	0.0024	0.0035	0.0019
	(0.000)***	(0.000)**	(0.000)***	(0.000)*	(0.000)	(0.000)	(0.006)	(0.001)	(0.000)***	(0.000)***	(0.000)***	(0.000)**	(0.000)***	(0.000)***	(0.001)***	(0.000)***
SD2(<5 employees	-0.1534	-0.1029	-0.0564	-0.0403					0.0782	0.0833	0.0010	-0.0011				
	(0.006)***	(0.018)***	(0.002)***	(0.004)***					(0.002)***	(0.008)***	(0.002)	(0.004)				
SD3(5~9 employees)	-0.0876	-0.0613							0.1044	0.0829						
	(0.006)***	(0.018)***							(0.002)***	(0.008)***						
SD4 (10~19 employees)	-0.0621	-0.0487			-0.0217	-0.0144			0.0962	0.0873			0.0140	0.0173		
	(0.006)***	(0.017)***			0.002)***	(0.007)**			(0.002)***	(0.007)***			(0.002)***	(0.006)***		
SD5 (20~49 employees)	-0.0416	-0.0300							0.0920	0.0664						
	(0.006)***	(0.017)*							(0.002)***	(0.008)***						
SD6 (50~99 employees)	-0.0168	-0.0043							0.0505	0.0524						
	(0.006)***	(0.014)							(0.002)***	(0.006)***						
SD7 (100~199 employees)	-0.0483	-0.0022							0.0184	0.0094						
	(0.006)***	(0.014)							(0.002)***	(0.005)**						
Constant	0.8825	0.9808	0.7986	0.6942	0.7815	0.7662	1.1666	0.7358	1.1068	0.9228	1.2257	1.2876	1.3035	1.1698	1.0343	1.1391
	(0.055)***	(0.053)***	(0.070)***	(0.037)***	(0.048)***	(0.067)***	(0.427)***	(0.327)**	(0.035)***	(0.052)***	(0.039)***	0.039)***	(0.043)***	(0.035)***	(0.183)***	(0.011)***
ρ(with selection equation residual)	0.3537	0.3737	0.2863	0.3335	0.2345	0.3951	-0.9961	0.5511	0.2418	0.3289	0.3348	0.4380	0.3836	0.4254	-0.9992	0.0935
	(.035)***	(.103)***	(.028)***	(.081)***	(.086)***	(.216)*	-0.076	-0.941	(.017)***	(.082)***	(.030)***	(.098)***	(.042)***	(.155)***	(.084)***	-0.119
Observations	501,656	63,535	230,662	31,166	112,959	12,853	158,035	19,516	501,656	63,535	230,662	31,166	112,959	12,853	158,035	19,516
Robust standard errors in parentheses			*** p<0.01, ** p<0.05, * p<0.1													

report the estimated model of switching regressions. In each table we report eight estimation results. The first two are estimation results using the entire sample, the second pair estimated for samples employed at small size employers (less than 20 employees), the third pair for samples employed at medium size (20~99 employees), and the last pair for samples employed at large (100~employees) firms. In each pair, the first result uses samples in 2001~2013, whereas the second uses only samples in 2012~13. We start the discussion with Table 4 for daily workers. In both tables, we only display estimated coefficients for several key variables. In Table 4 part 1 reports log wage regressions conditional upon 'treated'(non-compliance) [left half] and 'non-treated' (compliance) [right half]. One difference between the two wage regressions is that the effect of general experience. It is negative for the 'treated' (less than minimum wage), whereas it is positive and both are highly significant.

More important for the subsequent analysis are the coefficient for firm size dummies. In treated (less than minimum wage) samples, they show that the employer size has positive impact of log wage, a standard result in most of wage regressions of this type, whereas in controlled samples, the employer scale has negative impact on log wage. We come back to this somewhat anomalous result later on.

Table 4 part 2 reports probit regressions for selection into 'treated' and 'non-treated'. The most important covariate is $\widehat{\gamma}(i, s, p)$ which is used as the proxy representing the relative availability of jobs paying more than (or equal to) minimum wage. This variable is constructed as cell means of predicted value for the probability that an employer

Table 4 Switching Regression part 2 Probit regressions for treatmeant: Daily Wage

sample	all		small		medium		large	
period	2001~2013	2012~13	2001~2013	2012~13	2001~2013	2012~13	2001~2013	2012~13
γ(i,s,p)	-1.1330	-0.9321	-0.3403	-0.1037	-0.4992	-0.8184	-0.0953	-3.3571
	(0.107)***	(0.374)**	(0.153)**	(0.376)	(0.145)***	(0.377)**	(4.811)	(1.372)**
female	0.6385	0.4895	0.7044	0.6210	0.6730	0.5875	-0.0021	0.0739
	(0.005)***	(0.014)***	(0.007)***	(0.017)***	(0.009)***	(0.025)***	(0.027)	(0.030)**
married	-0.2967	-0.2287	-0.3562	-0.3332	-0.2380	-0.2103	-0.0021	-0.0261
	(0.005)***	(0.012)***	(0.006)***	(0.016)***	(0.009)***	(0.026)***	(0.356)	(0.023)
years of schooling	-0.0963	-0.0540	-0.0744	-0.0396	-0.1054	-0.0552	-0.0596	-0.0577
	(0.002)***	(0.005)***	(0.003)***	(0.008)***	(0.004)***	(0.010)***	(0.025)**	(0.009)***
years of schooling2	0.0031	0.0010	0.0024	0.0005	0.0029	0.0007	0.0010	0.0013
	(0.000)***	(0.000)***	(0.000)***	(0.001)	(0.000)***	(0.001)	(0.003)	(0.001)**
age-6-years of schooling	-0.0099	-0.0070	-0.0066	-0.0067	-0.0111	-0.0079	-0.0180	-0.0065
	(0.000)***	(0.001)***	(0.000)***	(0.001)***	(0.000)***	(0.001)***	(0.021)	(0.001)***
SD2(<5 employees)	0.5583	0.6435	0.1284	0.0775				
	(0.050)***	(0.182)***	(0.009)***	(0.024)***				
SD3(5~9 employees)	0.4499	0.6152						
	(0.047)***	(0.167)***						
SD4 (10~19 employees)	0.4183	0.5641			-0.0437	0.0231		
	(0.042)***	(0.148)***			(0.021)**	(0.056)		
SD5 (20~49 employees)	0.5449	0.5496						
	(0.033)***	(0.116)***						
SD6 (50~99 employees)	0.6196	0.5314						
	(0.017)***	(0.053)***						
SD7 (100~199 employees)	0.3952	0.3436						
	(0.012)***	(0.035)***						
Constant	0.4401	0.0797	0.7125	0.1144	0.8439	0.0464	0.1186	1.9268
	(0.182)**	(0.442)	(0.193)***	(0.186)	(0.173)***	(0.251)	(1.991)	(1.083)*
Observations	501,656	63,535	230,662	31,166	112,959	12,853	158,035	19,516

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

adjusted minimum wage after the minimum wage increase in 2012~2013. See Appendix A4 for the probit regression used to construct the variable. As expected, the variable carries negative and statistically significant effect on selection into jobs with less than minimum wage. Naturally, employer scale has negative effect on the probability that the worker selects jobs paying less than minimum wage.

Table A3 part 1 and 2 (in Appendix) report switching regression models for the sample of monthly wage earners. As they show qualitatively similar results with Table 4 for daily wage earners, we only note major differences. Unlike daily wage earners, the general work experience generally have positive impact on log wage in controlled samples for monthly wage earners. Even in the treated samples., its coefficients are mostly positive (but insignificant). Employer size dummies in log wage regressions show that the employer size exerts positive impact both in treated and controlled samples. Most important difference is in the coefficient of $\widehat{\gamma}(i, s, p)$: unlike daily wage earners, the selection into treated or controlled samples is not significantly influenced by this variable for monthly wage earners.

All in all, the contrast between daily and monthly wage earners is strong and robust. As we have shown in Table 3, the wage gap estimated as ATE is sizable and statistically significant for daily wage, whereas except for the small size firms, none of the estimated ATE are statistically significant for monthly wage. Regressions on log wages also exhibit sharp contrast between two types. In the case of daily wages, the demarcation line drawn by the minimum wage does show up in the differences in the determinants of respective wages, whereas in the case of monthly wage, no such sharp distinction emerge.

4.2 Participation decision and compliance rate

The switching regression results above indicates that the probability of finding a job offering above minimum wage is enhanced by employer's compliance rate in the case of daily wage earners, but not among workers paid monthly wages.

In this subsection, we estimate (multinomial) probit model for participation decision. From a view point of individual worker, it is unclear if the increase in compliance rate increases the employment. In the textbook model of minimum wage, as the binding minimum wage is increased, the employment demand shrinks. As a result more workers are rationed out of jobs. In this textbook case, the impact must be negative. As we have seen above, compliance is far from perfect so that it is not obvious that an increase in compliance rate results in disemployment. It is possible that higher wage rate due to increase in minimum wage can induce higher participation rate. In that case, the impact must be positive. On the other hand, the analysis in section 3 predicts positive impact on employment from compliance decision.

We have two main results. Table 6 reports the first set of results of probit regression on the probability of employed. We use those aged between 15 and 59 and not in education as the potential labor force. The dependent variable, employed, is unity if and only if a sample individual is employed. This excludes those self employed, as well as those listed as unpaid family worker. Our key variables are two: $mwadjust(a, p, t)$ is the share of sample workers who receive less than minimum wage. This variable is

Table 5 Probit Employed/Work

dependent variable	Employed						Work					
education	all		middle school or less		college or more		all		middle school or less		college or more	
sample periods	2001~2013	2012~2013	2001~2013	2012~2013	2001~2013	2012~2013	2001~2013	2012~2013	2001~2013	2012~2013	2001~2013	2012~2013
	regressors include regional dummies, age group (5yrs.) dummies, and areatype dummy											
mmwadjust	0.3805	0.5179	0.3825	0.5186	-0.0919	-0.0179	0.1817	0.2506	0.1317	0.1994	-0.0742	-0.0135
	(0.005)***	(0.014)***	(0.006)***	(0.018)***	(0.015)***	(0.040)	(0.005)***	(0.014)***	(0.006)***	(0.018)***	(0.017)***	(0.046)
rminwage	0.0040	0.0029	0.0357	0.0118	-0.0820	-0.0308	-0.0255	-0.0090	-0.0288	-0.0098	-0.0422	-0.0264
	(0.002)**	(0.004)	(0.002)***	(0.005)**	(0.006)***	(0.011)***	(0.002)***	(0.004)**	(0.002)***	(0.005)**	(0.006)***	(0.013)**
percapitagdp	0.0005	0.0004	0.0005	0.0005	-0.0000	0.0001	0.0004	0.0004	0.0004	0.0004	0.0001	0.0001
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)	(0.000)	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)**
female	-0.3216	-0.3171	-0.4181	-0.4062	0.1232	0.0983	-0.7586	-0.7453	-0.9043	-0.8770	-0.2591	-0.2740
	(0.001)***	(0.003)***	(0.001)***	(0.004)***	(0.003)***	(0.008)***	(0.001)***	(0.003)***	(0.001)***	(0.004)***	(0.004)***	(0.010)***
married	-0.0012	-0.0376	-0.1019	-0.1093	-0.0068	-0.0367	0.0583	0.0315	-0.0223	-0.0233	-0.0336	-0.0622
	(0.001)	(0.004)***	(0.002)***	(0.005)***	(0.003)**	(0.009)***	(0.001)***	(0.004)***	(0.002)***	(0.005)***	(0.004)***	(0.011)***
years of schooling	-0.0938	-0.1245	-0.0186	-0.0491	1.3610	1.0961	-0.0317	-0.0555	0.0642	0.0335	0.9549	0.3841
	(0.001)***	(0.001)***	(0.001)***	(0.003)***	(0.072)***	(0.196)***	(0.001)***	(0.001)***	(0.001)***	(0.003)***	(0.093)***	(0.293)
years of schooling2	0.0080	0.0093	0.0008	0.0021	-0.0337	-0.0249	0.0037	0.0050	-0.0054	-0.0033	-0.0233	-0.0059
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.002)***	(0.006)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.003)***	(0.009)
Constant	-0.9034	-0.8706	-0.7729	-0.8469	-13.3312	-10.9911	-0.7607	-0.8227	-0.5939	-0.7842	-9.1924	-4.1072
	(0.006)***	(0.016)***	(0.008)***	(0.020)***	(0.626)***	(1.710)***	(0.006)***	(0.017)***	(0.008)***	(0.020)***	(0.803)***	(2.527)
Observations	6,714,792	846,534	4,536,039	568,857	786,104	105,693	6,714,792	846,534	4,536,039	568,857	786,104	105,693

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

constructed for each province (p) and area type (a, municipal or rural) for every months (t) starting from January 2001[27].

The results are quite clear that higher the share of local employers paying at least minimum wage, sample workers are more likely to be employed. This is as expected from our earlier analysis in section 3 of employment and compliance rate changes after changes in minimum wage. Overall, the results support strongly the idea that the observed positive correlation between compliance rate and employment are predominantly supply response to better employment opportunity. On the right hand half, Table 6 reports similar probit regressions for *work* that includes self employment as well as being employed. The positive impact of *mwadjust* continue to apply for this case.

In both employment and work probit regressions, we have results estimated for sub samples, divided according to their education attainments. In both employment and work decisions, the impact of *mwadjust* is positive and significant in the first two columns, whereas the impact of *mwadjust* is either insignificant or negative if we limit samples to those with college education, as shown in the last column in each Table. When real minimum wage is added to these probit regressions, the impact are positive for employed, but negative for work, indicating that the self employment (the difference between work and employment variable) is negatively influenced by real minimum wage. The exception is again the sub-sample of college graduates: the impact on their employment probability is negatively affected by real minimum wage.

The second set of results on participation decision are multinomial probit model

[27] Note that $\widehat{\gamma}(i, s, p)$, the minimum wage compliance probability that we used above, cannot be employed in this analysis as the sample individuals are entire labor force. Thus no industry or employer scale affiliations can be used to match each individual to $\widehat{\gamma}(i, s, p)$.

Table 6 Multinomial Probit model

	Self employed						Employed					
education	all		middle school or less		college or more		all		middle school or less		college or more	
sample periods	2001~2013	2012~2013	2001~2013	2012~2013	2001~2013	2012~2013	2001~2013	2012~2013	2001~2013	2012~2013	2001~2013	2012~2013
	regressors include regional dummies, age group (5yrs.) dummies, and areatype dummy											
mmwadjust	-0.4095	-0.4558	-0.1363	-0.0804	0.0490	-0.0380	1.0558	1.6259	236.4027	166.9995	-0.0561	-0.0361
	(0.008)***	(0.023)***	(0.011)***	(0.032)**	(0.025)**	(0.065)	(0.020)***	(0.185)***	(34.148)***	(19.128)***	(0.009)***	(0.051)
rminwage	-0.0479	-0.0186	-0.0816	-0.0286	0.1048	0.0220	0.0097	0.0080	22.3012	3.7831	-0.0495	-0.0380
	(0.003)***	(0.006)***	(0.004)***	(0.008)***	(0.009)***	(0.018)	(0.005)*	(0.012)	(3.545)***	(1.596)**	(0.004)***	(0.015)**
female	-0.7211	-0.8035	-1.5170	-1.4417	-0.6743	-0.6205	-0.9229	-1.1127	-264.3189	-133.8124	0.0702	0.1211
	(0.002)***	(0.013)***	(0.002)***	(0.007)***	(0.005)***	(0.014)***	(0.013)***	(0.116)***	(37.811)***	(14.592)***	(0.004)***	(0.022)***
married	0.0798	0.0709	-0.0692	-0.0730	0.0400	0.0591	0.1531	-0.0038	-69.8004	-38.5566	0.0035	-0.0308
	(0.002)***	(0.006)***	(0.003)***	(0.008)***	(0.006)***	(0.015)***	(0.004)***	(0.012)	(10.071)***	(4.472)***	(0.002)*	(0.013)**
years of schooling	0.1431	0.1575	0.1483	0.1318	-1.6818	-1.5924	-0.2718	-0.3904	-12.0511	-16.0507	0.8119	1.3737
	(0.001)***	(0.003)***	(0.002)***	(0.005)***	(0.112)***	(0.304)***	(0.004)***	(0.043)***	(1.848)***	(1.964)***	(0.008)***	(0.055)***
years of schooling2	-0.0101	-0.0096	-0.0106	-0.0085	0.0420	0.0382	0.0230	0.0293	0.5312	0.6918	-0.0201	-0.0311
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.003)***	(0.009)***	(0.000)***	(0.003)***	(0.095)***	(0.110)***	(0.000)***	(0.003)***
per capita gdp	-0.0003	-0.0002	0.0002	0.0003	0.0001	0.0001	0.0013	0.0013	0.3149	0.1487	-0.0000	0.0001
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)	(0.000)***	(0.000)***	(0.046)***	(0.018)***	(0.000)	(0.000)*
Constant	-3.1591	-3.3429	-2.4452	-2.7179	14.3374	14.1089	-2.5032	-2.6756	-476.2444	-271.8593	-7.9279	-13.8228
	(0.011)***	(0.030)***	(0.017)***	(0.048)***	(0.980)***	(2.702)***	(0.039)***	(0.299)***	(68.502)***	(30.417)***	(0.000)	(0.000)
Observations	6,714,792	846,534	4,536,039	568,857	786,104	105,693	6,714,792	846,534	4,536,039	568,857	786,104	105,693
ρ23	-0.9302	-0.7641	0.3660	0.3811	-0.9986	-0.9983	-0.9302	-0.7641	0.3660	0.3811	-0.9986	-0.9983
	(0.0019)***	(0.013)***	(0.0087)***	(0.026)***	(0.001)***	(0.002)***	(0.0019)***	(0.013)***	(0.0087)***	(0.026)***	(0.001)***	(0.002)***
Standard errors in parentheses		*** p<0.01, ** p<0.05, * p<0.1										

reported in Table 6. Here we estimate choices over non-employment [use as the default choice], self employment, and employed.

The results shown in Table 6 show clearly that those living in province with higher share of minimum wage compliance ($mwadjust$) tend to be employed, rather than self-employed. Similarly, higher real wage has positive impact on employment, but the effect is negative for self employment. Results are the opposite if we limit the samples to those with college education. Given that most of college workers are paid monthly wages if they are employed, these contrasting impacts of wage compliance shares and real minimum wage conform well with our earlier results. Clearly, these m-probit results support the view that we are tracing changes in employment along the supply schedule for the daily wage workers.

5 Tacit collusion facilitated by the minimum wage

Then, a natural question that follows is why do large size firms tend to comply with the minimum wage, yet, after the change, overall employment expands?

Our preferred interpretation is that the daily wage at large firms are well below their marginal products. We believe the employment growth after major increase in the minimum wage strongly suggest that higher wages induce positive supply response,

Figure 9: In each graph, '>=mw' indicates subsamples complying minimum wage, and '<mw' indicates subsamples with less than minimum wage.

which in turn implies that the wage rate before the minimum wage hikes in 2012-13 was too low and suppressed the employment. This can be explicable if we assume tacit collusion among major employers using the minimum wage as their focal price (wage) in wage setting. We rely on insights from the tacit collusion model developed in Section 3 as we collect evidence supportive of the hypothesis.

5.1 Wage distributions

5.1.1 Wages across employer size

In upper panel of Figure 9, we find that across employer size, average non-complying log daily wage are higher at larger employers, whereas we find no such tendency for wages above minimum wage. As a matter of fact, mean log wage is slightly lower at largest size firms. We find no such reversal for monthly wages as shown in the bottom panel of Figure 9: both above and below minimum wage, monthly log wages are consistently higher at larger employers. This discrepancy might be a simple reflection of the fact that those paid above minimum wage at large scale employers are of lower quality.

To see if this is the case, Figure 10 shows the distributions of the residuals of Mincerian wage regression for daily wages. Naturally, residuals are negative for wages

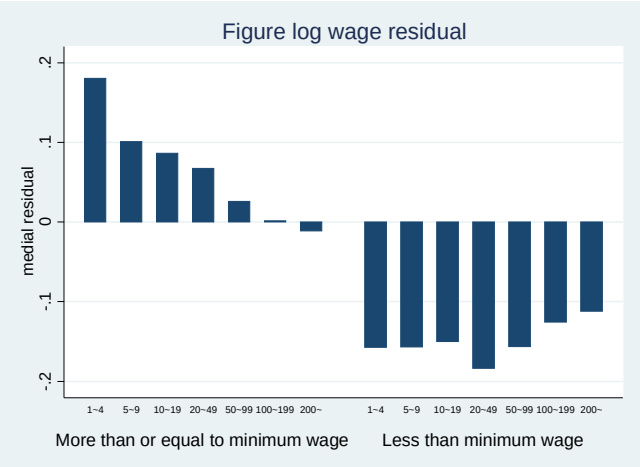

Figure 10: Each bar shows the difference between the log wage and its fitted values from Mincerian log wage regression.

less than minimum wage and positive for above minimum wage, but, the deviations are negatively correlated with employer size for above minimum wage. It appears as if, — relatively speaking–, daily wage workers are paid less than what Mincerian wage regressions indicate. The mean residual differences are quite large at small employers, around .2 for more than minimum wage, and -.2 for below minimum. At the largest employers (more than 200 employees), the mean residual is slightly negative for the wages above minimum. Thus the inverse relation found in Figure 9 for above minimum wages cannot be due to quality difference.

All in all, wage and regression residual distributions across employer size suggest an interpretation that workers at larger firms paid above minimum wage are actually paid less than what they could earn.

5.1.2 Higher moments of wages

Table 7 shows higher moments of log wage distributions before and after major minimum wage increases. The most surprising is the fourth moment (kurtosis). For normal distribution, the kurtosis (fourth moment divided by variance) is 3. Among daily wages, this moments all exceeds 3, and larger at larger employers. As the kurtosis shows the sharpness of the peak, Table 8 shows that the wage distribution has much sharper peaks than normal, which is what we expect from the effect of minimum wage. We also notice that the kurtosis declines after the minimum wage increase. But this is not the whole story. The kurtosis is order of magnitude smaller for monthly wages and there is no clear tendency that the kurtosis increases over employer size. This evidence is consistent with the tacit collusion in daily wage setting among larger employers: the daily wages are highly concentrated around the minimum wage. The collusive effect is somewhat attenuated after a major increase in minimum wage. Moreover, sharp contrast with monthly wage suggests further what we see for the daily wages is

Table 7 Higher Moments of Wage Distributions: before and after increases in minimum wage

	employer size			
	daily wage		monthly wage	
	before	after	before	after
employer siz	standard deviation			
1~4	0.387	0.368	0.554	0.540
5~9	0.336	0.314	0.527	0.525
10~19	0.331	0.308	0.566	0.561
20~49	0.346	0.311	0.578	0.580
50~99	0.311	0.273	0.573	0.576
100~199	0.234	0.205	0.588	0.586
200~	0.195	0.172	0.572	0.563
	kurtosis			
1~4	6.416	5.220	5.591	5.886
5~9	12.606	4.764	6.858	7.647
10~19	16.136	5.260	6.459	5.630
20~49	29.382	8.193	4.600	4.804
50~99	50.155	8.169	4.929	4.552
100~199	68.735	10.543	6.124	4.692
200~	90.696	32.101	5.467	4.886
	skewness			
1~4	-0.276	-0.369	-0.524	-0.292
5~9	0.605	0.003	0.003	0.282
10~19	0.801	0.131	0.174	0.380
20~49	2.178	0.519	0.487	0.393
50~99	3.676	0.596	0.479	0.663
100~199	3.666	0.230	0.639	0.800
200~	5.893	2.059	0.646	0.823

not solely due to minimum wage compliance. As a matter of fact, even the standard deviation is extremely small for largest employers for daily wages, whereas the standard deviations increase across employer size for monthly wages.

5.1.3 Truncated right tails

As a final piece of evidence in wage distribution, Figure 11 shows 6 histograms of wage to minimum wage ratio. In the upper row, we show results for daily wages and the bottom row histograms are for monthly wages. It is clear that in the case of daily wages, large employers stand out as having extremely concentrated distribution around the minimum wage. Although extremely thin left tail is a direct outcome of high compliance rate, the right hand tail is equally thin and there exists virtually no observation above 1.5[28].

Compared to these samples, smaller employers have much larger shares of wages above minimum wage (as well as wages below). This can be also contrasted against the histograms for monthly wages. Here, the largest employers have fattest right hand tail[29].

5.2 Positive correlation between compliance and wage distortion

Figure 12 shows scattered diagram of quality (measured as predicted values of Mincerian regression) gaps between daily wage workers paid above or below minium wage. Each

[28] See also Figure15 in Appendix.

[29] See Figures 13 and 14 in Appendix for overall wage distributions.

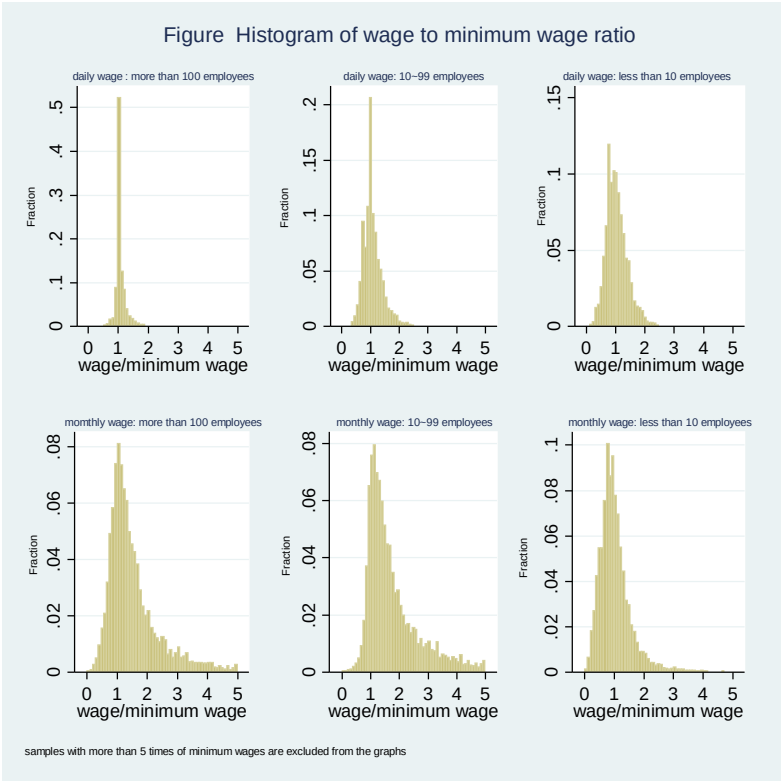

Figure 11: Wages exceeding 5 times of minimum wages are excluded from the graph. Vertical axis shows the fraction of samples represented by each bar.

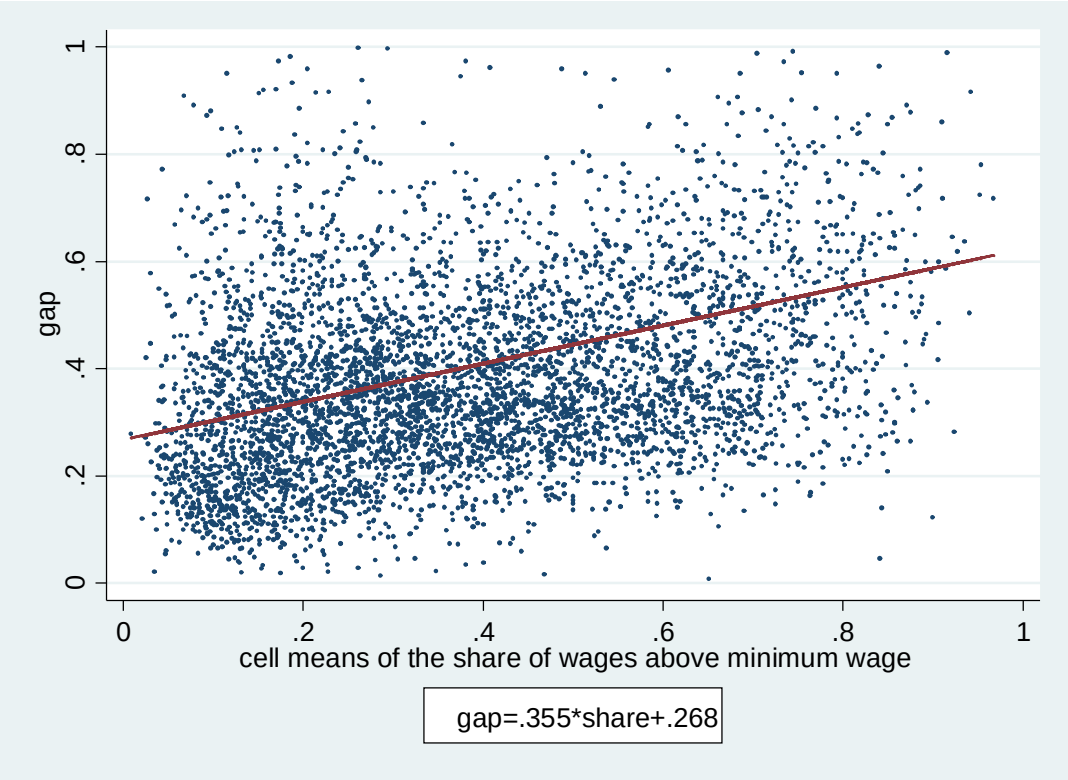

Figure 12: Each dot represent cell means constructed for combinations of (region, areatype, firm size, industry code, time)

dot is computed as cell means of the quality gap and the mean of compliance rate wherein each cell is demarcated by province, industry, employer size and year. Strong positive correlation between the two measures is unmistakable. Namely, there is strong tendency that those receiving above minimum wage are actually underpaid, relative to the prediction of Mincerian wage model.

5.3 Positive correlation between compliance and employment changes

We have shown already the robust tendency that the compliance rate and employment are positively correlated. To show that this is not a statistical fluke induced by some type of selectivity, we construct a pseudo panel of workers and see if cell means of the share of above minimum wage has significant impact on their employment level. Using 14 episodes of minimum wage increases[30], we constructed a panel of employment in each province before and after the change in minimum wage.

[30] See Table A6. Some episodes of small changes in minimum wages are excluded. See Table A2 for the full list of changes in the minimum wage.

Table 8 Panel Regressions on Employment Changes after increases in minimum wage

sample	daily wage earners									
weights	un-weighted					weighted				
sample episodes	all			after 2001	before 2001	all			after 2001	before 2001
estimation method		fixed effects					fixed effects			
dependent variable	changes in employment									
change in compliance rate	0.4925	0.6200	0.5537	0.4676	0.9206	0.4573	0.5720	0.5092	0.6354	0.6691
	(0.076)***	(0.088)***	(0.084)***	(0.074)***	(0.217)***	(0.095)***	(0.107)***	(0.101)***	(0.067)***	(0.258)***
Constant	1.0446	1.0283	1.0330	1.0588	0.9676	1.0496	1.0333	1.0374	0.9792	1.0879
	(0.015)***	(0.016)***	(0.027)***	(0.025)***	(0.106)***	(0.020)***	(0.020)***	(0.036)***	(0.024)***	(0.198)***
Regional Dummies		yes		yes		yes		yes		yes
Observations	1,014	1,014	1,014	642	372	1,014	1,014	1,014	642	372
R-squared		0.050					0.030			
Number of province	76	76	76	76	76	76	76	76	76	76

sample	monthly wage earners									
weights	un-weighted					weighted				
sample episodes	all			after 2001	before 2001	all			after 2001	before 2001
estimation method		fixed effects					fixed effects			
dependent variable	changes in employment									
change in compliance rate	-0.3546	-0.0877	-0.3643	-1.0705	-0.1378	-0.3470	-0.3030	-0.3430	0.0504	-0.4843
	(0.150)**	(0.052)*	(0.150)**	(0.253)***	(0.197)	(0.118)***	(0.125)**	(0.118)***	(0.161)	(0.169)***
			(0.020)	(0.023)	(0.033)			(0.024)	(0.022)	(0.044)
Constant	1.0369	1.0461	1.0491	1.0765	1.0314	1.0532	1.0519	1.0536	1.0250	1.0778
	(0.008)***	(0.011)***	(0.016)***	(0.019)***	(0.025)***	(0.009)***	(0.009)***	(0.018)***	(0.017)***	(0.032)***
Regional Dummies		yes		yes		yes		yes		yes
Observations	650	590	650	341	309	650	650	650	341	309
R-squared		0.006					0.010			
Number of province	76	76	76	76	74	76	76	76	76	74
Standard errors in parentheses		*** p<0.01, ** p<0.05, * p<0.1								

This panel is constructed separately for daily wage and monthly wage earners. We took a half year average (a quarter average before 2001) before and after the change. Our dependent variable is changes in employment and explanatory variable is the change in the compliance rate, i.e., share of workers paid more or equal to the minimum wage.

The results are shown in Table 8 which confirms our remarks made in section 2: among daily wage workers, employment expands more after the minimum wage increase if the compliance rate is higher. The relation is either insignificant or negative for monthly wage earners.

5.4 Industry and location proximity of large scale employers

Large scale employers in Thailand are predominantly manufacturing firms. In our sample of labor force survey in 2012 and 2013, 87% of daily wage workers employed at large firms (more than 100 employee) are in manufacturing establishments. They are also highly concentrated in Bangkok and neighboring provinces in central and eastern regions: 38% in Bangkok, 17% in Eastern provinces, and 13% in Central provinces. Thus, it is fair to say that the dominant share of large scale employers are located nearby and they are mostly manufacturing firms. Added to these, many of them are actually located in the same industrial park. These conditions are obviously amenable for tight information network and coordination among the employers.

5.5 Long run declines in real minimum wage and the reversal in 2012-2013

In this section, we assembled a variety of evidence in support of our hypothesis that the large scale firms tacitly colluded in setting daily wage, using the minimum wage as the focal point.

In this sub-section, we try to place our conclusion in a historical perspective of minimum wage and the labor market for the low skilled workers of the country.

The case for the suspected implicit collusion is supported by the long run decline in the real value of minimum wage. As we have noted already in Introduction, the real value of minimum wage declined continuously since late 1990's. Compared to 1996, the real value of minimum wage declined by 15% by March 2012, immediately before the major increase. The dwindling minimum wage seems to have exerted major impact on the real wages for daily wage workers, whereas the impact is not so visible for monthly wage.

There also exists a popular perception that the labor market has been in chronic shortage of workers, especially unskilled and semi-skilled workers. Bank of Thailand (2013) cites three syndrome of the chronic shortage and tight labor market, overall, but in particular in both ends of the quality spectrum: extremely low unemployment rate, brisk demand and increase in immigrant labor, and the skill mismatch[31]. Such a concern for mismatches and chronic labor shortage should come as no surprise if we look at the stagnant real wage of those unskilled and semiskilled workers. Compared to 1997, the peak year, 2011 median real daily wage increased only by 11.1%, whereas the median real monthly wage increased by 21.6%, and per capita real GDP rose by 52.3%. Especially noticeable even among the daily wage earners, for those employed at the employers with more than 100 employees, the real median daily wage actually *declined* by 8.5% between 1997 and 2011. There is little wonder that the stagnant real wage depressed the supply of low and semi skilled workers and the employers voiced chronic shortage of those workers.

Depression in real wage for unskilled and semiskilled workers is likely to be partially responsible for the surge in college enrollment during the last two decades. BOT(2013) also shows that actually the unemployment rate is significantly higher for college graduates, compared to those with high school diploma or less.

Thus the accommodation of 70% increase in minimum wage in 2012-2013 came, perhaps, if anything, with a silent sense of relief, especially by large scale employers. There is little wonder that they aggressively expanded employment of daily wage workers after the 70% minimum wage jump as they must have induced sizable increase in available workers in the market.

In retrospect, it seems clear that the minimum wage had been kept too low, and

[31] Bank of Thailand (BOT) (2013) cites a study by National Statistical Office conducted in 2008. This study used a survey of employers in which they estimate the size of shortage for semi-skilled (high school graduates) is as large as 60% of the current employment. BOT then goes on to argue that the low number of new entry of high school graduates, reflecting the strong aspiration of high school graduates to go to college, only exacerbates the problem.

it depressed the supply of low and middle skilled workers. The large scale employers probably earned extra profits as they collectively succeeded in depressing the daily wage, well below what could be considered as reasonable by any standard.

5.6 So, at the end of day,..

We have shown in this paper that the minimum wage increase in 2012-2013 brought about changes which are apparently at odds with conventional wisdom on the employment impact of minimum wage increase. As the wage increased after the change, employment also increased, especially among daily wage workers paid minimum wage or higher. We collect evidence pertaining to the impact distribution across region, industry and workers. In so doing, we also check if any of the findings shown below supports/contradicts tacit collusion hypothesis.

To begin with, there is little doubt that the wage increase benefitted more on low wage earners. Among daily wage samples, the ratio of 90%/10% wage tiles declined from 1.966 to 1.749, 12% decline. The wage inequality also declined substantially for monthly wage earners. The ratio of 90/10 wage tiles declined 5.96 to 5.02. Minimum wage indeed raised the lower tail of wage distribution and reduced inequality. But equally important factor responsible for the wage inequality is compliance decision. When we construct a two measures of wage inequality (10 vs 90% , and 25 vs. 75% tile wage ratios) for daily and monthly wages for each of 7 regions pseudo panel, we obtain

$$
\begin{aligned}
r_{dt}^{1090} &= -.087 * mean(lessthanmw)_{dt} + .156 * \log(rmwage), \\
r_{dt}^{2575} &= -.168 * mean(lessthanmw)_{dt} + .148 * \log(rmwage), \\
r_{st}^{1090} &= -.353 * mean(lessthanmw)_{st} + .145 * \log(rmwage), \\
r_{st}^{2575} &= -.232 * mean(lessthanmw)_{st} + .219 * \log(rmwage)
\end{aligned}
$$

wherein the first two are for daily wage and the next two regressions are for monthly wages. All the coefficients are significant at 1%. Thus, naturally, the provincial means of the share of workers receiving less than minimum wage carry highly significant and important positive impact on wage inequality. Thus, non-compliance attenuate the disemployment effects, but, at the same time, the minimum wage impact on wage inequality is curtailed.

The next question is: are the beneficial impact evenly distributed, or, do we find some clear winners and losers? Let us first look at regional variations. Table 9 collects changes between 2011 and 2013 across seven regions. The evidence indicates clear regional differences in the impact. Bangkok, Central, East and West on average benefitted more from the change than North and Northeast. The difference is particularly large in % changes in employed samples. In Bangkok, it rose more than 5%, compared to meager .3% in North and Northeast. In terms of average wage, daily wage workers were the major beneficiary as we have seen already. Even among the daily wage earners, it is interesting to note that Bangkok, Central and East regions registered higher increase.

Table 9 Changes between 2011 and 2013					
	log daily wage	log monthly wage	% share of employed	% share of work	% share of self employed
Bangkok	0.187	0.147	5.125	6.092	0.967
Central	0.216	0.092	1.189	2.094	0.905
East	0.185	0.164	3.284	4.360	1.076
West	0.167	0.082	1.309	2.120	0.811
North	0.179	0.040	0.324	0.993	0.669
Northeast	0.174	-0.002	-0.351	0.087	0.438
South	0.148	0.075	1.173	2.671	1.498
Total	0.165	0.075	0.820	1.801	0.981

These regional variations are certainly consistent with tacit collusion as we know that large scale employers are heavily concentrated in these industrialized areas.

Table 10 shows changes in log wages across industry. Generally speaking, industries typically found in urbanized/industrialized area fared much better than agriculture, construction, or education, all of which are located primarily in rural areas or evenly distributed. It should be noted also that agricultural workers are exempt from minimum wage law. In spite of this exemption, the increase is still substantial (and larger than 5 industries), supporting our claim that it is not penalty against minimum wage violation but the cost associated with offering below minimum wage that determines the compliance decision.

Table 11 compares wage changes across employer size. The winner is workers at large firms, especially for daily wage earners. This is exactly what we expect from the tacit collusion hypothesis. It is primarily the large manufacturing firms that honor (and benefit most from) the increase in the minimum wage. Note that the increase in monthly salary do not differ markedly across employer size, which again support our hypothesis.

Our analysis in section 3 predicts that minimum wage reduces employment at below minimum wage but it expands above minimum wage. The implication is that higher productivity workers tend to benefit from the increase but lower productivity workers benefit less or possibly lose. Lacking the direct measure of worker productivity, we cannot test the prediction directly. Still, available data suggests that higher productivity workers benefitted more. If we take years of schooling as a proxy and use only daily wage earners as our sample, those with those with only or some of elementary education have their real daily wage increased by 17.5%, compared to 22.3% with 9 years of education, 18.7 % with 12 years of education, and whopping 36.6% with 16 years of education. On the other hand, we do not see such tendency for monthly wage earners. Respective numbers are:10.3%, 10.6%, 10.2%, and 5.7%. Strong correlation between productivity and wage increase is found only among daily wages, not among monthly wages, which is exactly what we should expect from the fact that only daily

Table 10 Log changes in average wage across industry		
	daily wage	monthly wage
A 101 - Agriculture, forestry and fishing	0.134	0.123
B 102 Mining and quarrying	0.227	0.065
C 103 Manufacturing	0.268	0.179
D 104 Electricity, gas, steam and air conditioning supply	0.324	-0.025
E 105 Water supply; sewerage, waste management and remedi	0.143	0.051
F 106 Construction	0.109	0.149
G 107 Wholesale and retail trade; repair of motor vehicles and m	0.175	0.170
H 108 Transportation and storage	0.149	0.079
I 109 Accommodation and food service activities	0.154	0.200
J 110 Information and communication	0.197	0.120
K 111 Financial and insurance activities	0.268	0.053
L 112 Real estate activities	0.128	0.068
M 113 Professional, scientific and technical activities	0.339	0.055
N 114 Administrative and support service activities	0.248	0.139
O 115 Public administration and defence	0.153	0.015
P 116 education	0.061	0.022
Q 117 Human health and social work activities	0.102	0.028
R 118 Arts, entertainment and recreation	0.158	0.139
S 119 Other service activities	0.119	0.065
T 120 Activities of households as employers	0.159	0.098
U 121 Activities of extraterritorial organizations and bodies	0.351	0.164
Total	0.179	0.077

Table 11 Wage changes across employer size: 2011-2013		
employer size	daily wage	monthly wage
~5 employees	0.146	0.118
5~9	0.127	0.138
10~19	0.151	0.135
20~49	0.163	0.106
50~99	0.215	0.161
100~199	0.287	0.186
200 and more	0.302	0.161
total	0.180	0.165

wages are directly influenced by the minimum wage.

6 Conclusion

In this paper, we investigated the impact of the recent major increases in minimum wage in Thailand. We found that non-compliance is widespread, especially in daily wages. Our estimation show that non-compliance is more common among smaller firms, in rural provinces, and the probability of working for less than minimum wage is higher among the less skilled, less educated, and female. As they are less likely to be active in the labor market, we take this as a strong evidence that the minimum wage before the increase in 2012 depressed employment.

The estimated treatment effect (wage gap) due to the minimum wage is sizable: our best estimate for the daily wage ranges between .24~.45 in log points. Using 300 bahts minimum wage, these estimates correspond to 64 to 109 bahts as the estimated cost of non-compliance. Our estimations also show that there is no strong evidence that the minimum wage had significant direct impact on monthly wage.

Employing probit and multinomial probit, our estimations consistently show that the employers' compliance decision induce workers to be employed, rather than remain inactive or self employed. We therefore conclude that the minimum wage increase in 2012~2013 produced north-eastward shift of the equilibrium along the labor supply schedule.

We found that the large scale firms mostly comply with minimum wage, and increased employment after minimum wage increase. Taken together with the fact that their daily wages are highly concentrated within a narrow margin around the minimum wage, we suspect tacit collusion to use the minimum wage as the focal point, and they succeeded suppressing the daily wage before the 2012 increase in minimum wage. Hence, as the minimum wage increases, these employers easily meet the regulation, and expand the employment. These outcomes match predictions of the model of tacit collusion in Section 3. On the other hand, our model prediction fails to capture the inverse relation between the estimated treatment effect and firm scale. This is an agenda for the future research[32].

Even if the evidence is only circumstantial and may not be conclusive on the wage collusion, it is difficult to deny the fact that the minimum wage had been kept too low for the last two decades in Thailand, until the major increases in 2012 and 2013. Viewed from this historical perspective, the minimum wage change had been long overdue, and there perhaps remains little mystery why 70% increase in minimum wage did not produce any major adversely effect on employment. Instead, if anything, the impact on employment of low paid workers was positive, minimum wage increases benefitted sizable population of workers who are paid minimum wage, without any visible adversely effect on overall employment of low skilled workers.

[32] In Appendix 1, we extend the model into imperfect substitutions between labors, wherein the 'wage gap' can depend also on substitution elasticity and other parameters.

It goes without saying that the preceding analysis should be viewed in a proper perspective. Absence of any major adverse effect on employment is conditioned by a set of circumstances and pre-conditions which are rather unique to the case we have analyzed. Even for Thailand, there is no guarantee that the future increase in minimum wage will be equally beneficial. As a matter of fact, after 70% increase in 2012-13, it seems even likely that another sizable increase in minimum wage generate a major case of disemployment.

On the other hand, the case for the need to incorporate the compliance decision in the analysis seems more widely applicable and not limited to Thailand, or not even to developing countries.

The effect of minimum wage depends crucially on compliance decision. Our analysis has shown that compliance decision has important and perhaps far more complex interactions with the labor market institutions, characteristics of local labor markets, not to mention how tightly the regulation is imposed. Our analysis in section 3 and Appendix also indicate that the exclusive attention on labor demand is inadequate, if not misplaced.

We are fortunate to have access to the data that includes information on compliance by individual employer, which enabled us to incorporate such a decision in the empirical analysis. At the same time, it is clear we need to go beyond what we have done in this paper. Individual employment and wage we observe in the data is a joint outcome of compliance decision (by employer) and the choice of employment (by workers). Unless minimum wage compliance decision is totally exogenous, changes in minimum wage induces changes in both sides. A full analysis of minimum wage calls for a full model that incorporate decisions made by both sides.

7 References

References

[1] Ashenfelter, O. and R.S. Smith (1979), 'Compliance with the minimum wage law,' *Journal of Political Economy*, 87(2): 333–50.

[2] Alatas, V. and L.A. Cameron (2003), 'The Impact of Minimum Wages on Employment in a Low Income Country: An Evaluation Using the Difference-in-Differences Approach,' *World Bank Policy Research Working Paper* No. 2985. Available at SSRN: http://ssrn.com/abstract=636347

[3] Basu, A.K., N. H. Chau and R. Kanbur (2010), 'Turning a blind eye: Costly enforcement, credible commitment and minimum wage laws,' *The Economic Journal*, 120: 244–269

[4] Bank of Thailand (2013), ' Thai labor market and its roles in strengthening the Thai economy,' BOT Discussion Paper, 2013 #1.

[5] Bird, K., and C. Manning (2008), Minimum Wages and Poverty in a Developing Country: Simulations from Indonesia's Household Survey,' *World Development* 36(5): 916–933

[6] Boeri, T. and Garibaldi, P. (2005) "Shadow Sorting" *NBER Macroeconomics Annual 2005.*

[7] Boeri, T., Garibaldi, P., and e Ribeiro, M. (2011), 'The Lighthouse Effect and Beyond,' *the Review of Income and Wealth*, series 57, pp. 54-78.

[8] Chang, Y.-M., and I. Ehrlich (1985), 'On the economics of compliance with the minimum wage law,' *Journal of Political Economy* 93(1): 84–91.

[9] Del Carpio et al. (2014), 'Minimum Wage: Does It Improve Welfare in Thailand?' *IZA DP* 7911

[10] Lathapipat, D.(2009), 'Changes in the Thai Wage Structure before and after the 1997 Economic Crisis'

[11] Lathapipat, D.(2010), 'The Absorption of Immigrants and its Effects on the Thai Wage Structure'

[12] Leckcivilize, A. (2013), *Essays on Labor Economics,* unpublished Ph.D. Thesis (LSE)

[13] Lemos, S. (2009), 'Minimum wage effects in a developing country,' *Labour Economics* 16 (2), 224-237.

[14] Meghir, C., R. Narita and J-M. Robin (2012), 'Wage and informality in developing countries,' *NBER Working Paper* 18347

[15] Rama, M. (2001), 'The Consequences of doubling the minimum wage: the case of Indonesia,' *Industrial and Labor Relations Review* 54 (4), 864{881.

[16] Rani,U., P. Belser, M. Oelz and S. Ranjbar (2013), 'Minimum wage coverage and compliance in developing countries,' International Labour Review, 152 (3–4): 381-410

[17] Weil, D.(2005), 'Public enforcement/private monitoring: evaluating a new approach to regulating the minimum wage,' *Industrial and Labor Relations Review*, 58(2)

[18] Worldbank (2008), Minimum wages in developing countries: helping or hurting workers?' *Worldbank Employment Policy Primer*, 20

[19] Yaniv. G. (2006), 'On the employment effect of noncompliance with the minimum wage law,' *International Review of Law and Economics* 26: 557–564

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9 Appendix 1 Extending the model into finite substitution cases

9.1 A variant of Dixit-Stiglitz model

Here, we extend the model in the main text into cases with finite substitutions among heterogenous labors. To ease the analysis, we adopt a Dixit Stiglitz model of infinite variety for the labor heterogeneity that we specified in the main text. To fix the idea, assume the production technology:

$$\begin{aligned} y &= Q(D), Q' > 0, Q" < 0 \\ D &= \left(\int_{e_0}^{e_1} \tau \left[m(e) \right]^{\rho} de \right)^{\frac{1}{\rho}}, \\ \tau &\equiv \frac{1}{e_1 - e_0} \end{aligned}$$

Namely, the production function Q, uses composite labor D as the only input, is increasing and strictly concave in D. The composite labor, D, in turn, follows CES function over the continuum of heterogenous labor.

To derive the demand for labor, solve the following problem:

$$\max Q(D) - \int_{e_0}^{e_1} \omega(e) m(e) de$$

subject to

$$D = \left(\int_{e_0}^{e_1} \tau \left[m(e) \right]^{\rho} de \right)^{\frac{1}{\rho}}$$

wherein the price of output is used as numeraire. The Lagranigian for this problem is given by

$$\begin{aligned} \mathcal{L} &\equiv Q(D) - \int_{e_0}^{e_1} \omega(e) m(e) de \\ &\quad + \Omega \left[\left(\int_{e_0}^{e_1} \tau \left[m(e) \right]^{\rho} de \right)^{\frac{1}{\rho}} - D \right] \end{aligned}$$

The system can be readily solved to obtain the system of the demand function for D :

$$
\begin{aligned}
m(e) &= \left(\frac{\widetilde{\omega}(e)}{\Omega}\right)^{-\epsilon_L} D, \\
\widetilde{\omega}(e) &\equiv \frac{\omega(e)}{\tau}, \\
Q'(D) &= w, \\
\Omega &\equiv \left(\int_{e_0}^{e_1} \tau \widetilde{\omega}(e)^{1-\epsilon_L} de\right)^{\frac{1}{1-\epsilon_L}}, \\
\epsilon_L &= 1-\rho
\end{aligned}
\tag{A1}
$$

Namely, the demand for the heterogenous labor is proportional to D and its elasticity with respect to the relative wage, $\frac{\widetilde{\omega}(e)}{w}$, is constant at ϵ_L.

The equilibrium condition of a typical market for type e labor is

$$
\left(\frac{\widetilde{\omega}(e)}{\Omega}\right)^{-\epsilon_L} D = n(e)\lambda(\tau\widetilde{\omega}(e)), \tag{A2}
$$

which can be used to obtain the equilibrium wage rate, $\omega^*(e)$.

9.2 Binding minimum wage

In the case of the binding minimum wage with perfect compliance, rationing occurs for some of workers. But, unlike the textbook case, unless different labors are perfect substitute, the disemployment effect is attenuated by substitution among heterogenous labors. The demand for workers whose wage rate is constrained by the minimum wage is given by

$$
m(e) = \left(\frac{\overline{w}}{\tau e \Omega}\right)^{-\epsilon_L} D \leq n(e)\lambda\left(\frac{\overline{w}}{e}\right)
$$

wherein the efficiency unit wage with the binding minimum wage is given by

$$
\omega(e) = \frac{\overline{w}}{e}
$$

Using

$$
\widetilde{\omega}(e) \equiv \frac{w(e)}{\tau e}
$$

We continue to have

$$
\left(\frac{\widetilde{\omega}(e)}{\Omega}\right)^{-\epsilon_L} D = n(e)\lambda(\tau\widetilde{\omega}(e)), \tag{A2}
$$

for those above minimum wage threshold. The threshold productivity, e_c, is given by

$$
e_c = \frac{\overline{w}}{\tau\widetilde{\omega}(e_c)}
$$

Without further restrictions on distribution $n(e)$ of workers, the way in which minimum wage binds is no longer obvious: it is possible that the minimum wage binds only in some subset strictly interior in the worker distribution as there is no guarantee that $e\omega(e)$ is monotonically increasing in e. Setting aside theoretical curiosity, it is perhaps not very interesting to consider cases wherein only high productivity workers are rationed, or the lowest productivity workers are not rationed. Log differentiation of (A2) yields

$$\frac{en'(e)}{n(e)} < \epsilon_L + \epsilon_\lambda \tag{A3}$$

as the condition that guarantees that the per person wage rate is monotonically increasing in e.

Then the wage index is

$$\Omega_B \equiv \left(\int_{e_0}^{e_1} \tau \left(\frac{\omega(e)}{\tau} \right)^{1-\epsilon_L} de \right)^{\frac{1}{1--\epsilon_L}} = \left(\int_{e_0}^{e_c} \tau \left(\frac{\overline{w}}{\tau e} \right)^{1-\epsilon_L} de + \int_{e_c}^{e_1} \tau \widetilde{\omega}(e)^{1-\epsilon_L} de \right)^{\frac{1}{1-\epsilon_L}} \tag{A1b}$$

The aggregate demand for labor satisfies

$$Q'(D) = \Omega_B$$

Recall in the main text we denote by $\boldsymbol{\eta}_x$ % change of variable x when minimum wage changes by 1%.

$$\boldsymbol{\eta}_x \equiv \frac{d\log(x)}{d\log(\overline{w})}$$

We have

$$\boldsymbol{\eta}_D \equiv -\epsilon_D \boldsymbol{\eta}_{\Omega_B} \tag{A4}$$

wherein ϵ_D is the elasticity of demand for composite labor with respect to wage index w, as defined above. Log differentiation of (A2) yields

$$\boldsymbol{\eta}_{\widetilde{\omega}} = \frac{(\epsilon_\lambda - \epsilon_D)\boldsymbol{\eta}_{\Omega_B}}{\epsilon_L + \epsilon_\lambda} \tag{A5}$$

Take log derivative of (A1b) and substituting (A4) for $\eta_{\widetilde{\omega}}$, we obtain the following

$$\boldsymbol{\eta}_{\Omega_B} = \frac{s_B(\epsilon_L + \epsilon_\lambda)}{s_B\epsilon_L + \epsilon_\lambda + (1 - s_B)\epsilon_D}, \tag{A6}$$

$$\boldsymbol{\eta}_{\widetilde{\omega}} = \frac{s_B\left(\epsilon_L - \epsilon_D\right)}{s_B\epsilon_L + \epsilon_\lambda + (1 - s_B)\epsilon_D}. \tag{A7}$$

as the elasticities of wage index (w) and wage rate for above minimum wage ($\widetilde{\omega}$), wherein

$$s_B \equiv \frac{\int_{e_0}^{e_c} \tau \left(\frac{\overline{w}}{\tau e}\right)^{1-\epsilon_L} de}{\Omega_B^{1-\epsilon_L}}$$

Hence we obtain

$$\boldsymbol{\eta}_D = -\epsilon_D \boldsymbol{\eta}_{\Omega_B} = -\frac{s_B(\epsilon_L + \epsilon_\lambda)\epsilon_D}{s_B\epsilon_L + \epsilon_\lambda + (1 - s_B)\epsilon_D} < 0, \tag{A8}$$

$$\boldsymbol{\eta}_{D_x} = \epsilon_\lambda \boldsymbol{\eta}_{\widetilde{\omega}} = \frac{s_B\left(\epsilon_L - \epsilon_D\right)\epsilon_\lambda}{s_B\epsilon_L + \epsilon_\lambda + (1 - s_B)\epsilon_D} \tag{A9}$$

These results generalize the one we obtained for the case of perfect substitute that we analyzed in the main text. Namely, overall employment always decreases after an increase in minimum wage, whereas the employment above minimum wage increases if $\epsilon_L > \epsilon_D$, namely the elasticity of substitution among heterogenous labor exceeds the demand for aggregate labor. Therefore, if the different labors are very poor substitute each other, and also if the MPL is sufficiently insensitive to the labor input (large value of ϵ_D), it is possible that an increase in minimum wage has general disemployment effect. Otherwise, an increase in minimum wage reduces the overall employment but the employment above minimum wage expands.

As the wage index rises as those with binding minimum wages are higher, there will be substitution away from the composite labor. Thus employment at above minimum wage are depressed to the extent that S declines. The severity of the rationing depends crucially upon the elasticity of substitution among labor. If they are perfect substitute, as in our main text model, we obtain complete rationing as there will be no demand for low productivity workers. If elasticity is smaller, only some of workers will be rationed.

Now the crucial question is whether or not $\widehat{\omega}$ is higher than the equilibrium wage rate, ω^* without minimum wage. In the case of perfect substitute, there is no supply of labor below threshold, so that the wage rate should increase to induce higher labor supply from above minimum wage sector, although the rise in wage should be attenuated somewhat by the substitution away from the composite labor. If the elasticity of substitution is sufficiently low ($\epsilon_L < \epsilon_D$), the rationing of labor supply below threshold is small. Thus, the wage rate $\widehat{\omega}$ should decline somewhat to accommodate lower demand due to higher composite wage.

9.3 Endogenous compliance decision

Consider now the compliance decision. If per person wage rate is below the minimum, the worker receives

$$w(e) = e\omega(e) - c$$

so that per efficiency wage rate that a worker receives is given by

$$\frac{w(e)}{e} = \omega(e) - \frac{c}{e}$$

Then, in such a market, the equilibrium condition is

$$\left(\frac{\widetilde{\omega}^b(e)}{\Omega}\right)^{-\epsilon_L} D = n(e)\lambda\left(\tau\widetilde{\omega}^b(e) - \frac{c}{e}\right), \tag{A10}$$

$$if \quad \tau e\widetilde{\omega}^b(e) > \overline{w},$$

whereas we continue to have

$$\begin{aligned} \left(\frac{\widetilde{\omega}^a(e)}{\Omega}\right)^{-\epsilon_L} D &= n(e)\lambda(\tau\widetilde{\omega}^a(e)), \\ if\ \tau e\widetilde{\omega}^a(e) &> \overline{w} \end{aligned} \tag{A2}$$

To proceed, let us assume, for the time being, that per person wage rate in both cases are monotonically increasing in e. Suppose further that the minimum wage is binding for some subset of productivity workers. By continuity, it is evident that there exists threshold value of e_a such that

$$\left(\frac{\overline{w}}{\tau e_a \Omega}\right)^{-\epsilon_L} D = n(e_a)\lambda\left(\frac{\overline{w}}{e_a}\right)$$

i.e., the minimum wage just binds the market for type e_a worker. Assuming the minimum wage has enough bite, there also exists another threshold, e_b such that

$$\left(\frac{\overline{w}}{\tau e_b \Omega}\right)^{-\epsilon_L} D = n(e_b)\lambda\left(\frac{\overline{w}}{e_b} - \frac{c}{e_b}\right)$$

i.e., at the market for type e_b worker, the market just clears at the efficiency unit wage rate $\frac{\overline{w}}{e_b} - \frac{c}{e_b}$. Thus for workers of productivity type below e_b, equilibrium per person wage rate is strictly less than the minimum wage. By construction, we have $e_b < e_a$. Hence the equilibrium efficiency wage rate is given simply by

$$\begin{aligned} \omega(e) &= \frac{\overline{w}}{e}, \\ if\ e_b &< e \leq e_a \end{aligned} \tag{A11}$$

Thus there exists spike at $w(e) = \overline{w}$ in the equilibrium distribution of (per person) wage rate.

To sum up: (A2) holds if $e > e_a$, the minimum wage binds if $e_b < e \leq e_a$, and (A10) holds for $e < e_b$. To guarantee that these configuration apply, we take log differentiations of the equilibrium conditions (A2) and (A10) with respect to e. Both differentiations yield

$$\frac{en'(e)}{n(e)} < \epsilon_L + \epsilon_\lambda \tag{A3}$$

as the sufficient condition for

$$\frac{d(e\omega^b(e))}{de} > 0$$

To solve for the impact of an increase in minimum wage, first, we rewrite (A1) employing (A2), (A9), and (A11):

$$\begin{aligned} \mathbf{\Omega}_C^{1-\epsilon_L} &\equiv \int_{e_0}^{e_1} \tau \left(\frac{\omega(e)}{\tau}\right)^{1-\epsilon_L} de \\ &= \int_{e_0}^{e_a} \tau \left(\widetilde{\omega}^b(e)\right)^{1-\epsilon_L} de + \int_{e_a}^{e_b} \tau \left(\frac{\overline{w}}{\tau e}\right)^{1-\epsilon_L} de + \int_{e_b}^{e_1} \tau \left(\widetilde{\omega}^a(e)\right)^{1-\epsilon_L} \\ ,\tau &= \frac{1}{e_1 - e_0}, \end{aligned} \tag{A1c}$$

After log differentiations of (A2) and (A10), we obtain

$$\boldsymbol{\eta}_{\omega^a} = \frac{\epsilon_L \boldsymbol{\eta}_{\Omega_C} + \boldsymbol{\eta}_S}{(\epsilon_L + \epsilon_\lambda)}, \tag{A12}$$

$$\boldsymbol{\eta}_{\omega^b(e)} = \frac{\epsilon_L \boldsymbol{\eta}_{\Omega_C} + \boldsymbol{\eta}_S}{\left[\epsilon_L + \epsilon_\lambda \left(\frac{\omega^b(e)}{\omega^b(e) - \frac{c}{e}}\right)\right]} \tag{A13}$$

We also have

$$\boldsymbol{\eta}_D = -\epsilon_D \boldsymbol{\eta}_{\Omega_C} \tag{A4'}$$

Then, log differentiating (A1c) and using (A12), (A13) and (A4'), we obtain

$$\begin{aligned}
\boldsymbol{\eta}_{\Omega_C} &= s_{C1} E(\boldsymbol{\eta}_{\omega^b(e)} | e_0 \leq e \leq e_b) + s_{C2} + (1 - s_{C1} - s_{C2}) \boldsymbol{\eta}_{\omega^a}, \\
s_{C1} &\equiv \frac{\int_{e_0}^{e_a} \tau \left(\frac{\omega^b(e)}{\tau}\right)^{1-\epsilon_L} de}{\boldsymbol{\Omega}_C^{1-\epsilon_L}}, \\
s_{C2} &\equiv \frac{\int_{e_a}^{e_b} \tau \left(\frac{\overline{w}}{\tau e}\right)^{1-\epsilon_L} de}{\boldsymbol{\Omega}_C^{1-\epsilon_L}}
\end{aligned}$$

Let us rewrite this further using

$$\begin{aligned}
\tau(e_a - e_0) \int_{e_0}^{e_a} \left(\frac{(\epsilon_L - \epsilon_D) \boldsymbol{\eta}_w}{\left[\epsilon_L + \epsilon_\lambda \left(\frac{\omega^b(e)}{\omega^b(e) - \frac{c}{e}}\right)\right]} \right) de &\equiv \frac{\gamma(\epsilon_L - \epsilon_D) \boldsymbol{\eta}_{\Omega_C}}{\epsilon_L + \epsilon_\lambda} \\
, \gamma &< 1
\end{aligned}$$

Then we have

$$\boldsymbol{\eta}_{\Omega_C} = s_{C1} \frac{\gamma(\epsilon_L - \epsilon_D) \boldsymbol{\eta}_{\Omega_C}}{\epsilon_L + \epsilon_\lambda} + s_{C2} + (1 - s_{C1} - s_{C2}) \frac{(\epsilon_L - \epsilon_D) \boldsymbol{\eta}_{\Omega_C}}{(\epsilon_L + \epsilon_\lambda)}, \tag{A14}$$

Solve (A14) and substituting in (A12), we obtain

$$\boldsymbol{\eta}_{\Omega_C} = \frac{(\epsilon_L + \epsilon_\lambda) s_{C2}}{((1-\gamma) s_{C1} + s_{C2}) \epsilon_L + (1 - (1-\gamma) s_{C1} - s_{C2}) \epsilon_D + \epsilon_\lambda}, \tag{A15}$$

$$\boldsymbol{\eta}_{\omega^a} = \frac{(\epsilon_L - \epsilon_D)(\epsilon_\lambda + \epsilon_D) s_{C2}}{((1-\gamma) s_{C1} + s_{C2}) \epsilon_L + (1 - (1-\gamma) s_{C1} - s_{C2}) \epsilon_D + \epsilon_\lambda} \tag{A16}$$

Then these can be used to compute the impact on employment

$$\begin{aligned}
\boldsymbol{\eta}_D &= -\epsilon_D \eta_{\Omega_C} \\
&= -\frac{(\epsilon_L + \epsilon_\lambda) s_{C2} \epsilon_D}{((1-\gamma) s_{C1} + s_{C2}) \epsilon_L + (1 - (1-\gamma) s_{C1} - s_{C2}) \epsilon_D + \epsilon_\lambda} < 0 \qquad \text{(A17)} \\
\boldsymbol{\eta}_{Da} &= \epsilon_\lambda \boldsymbol{\eta}_{\omega^a} = \frac{(\epsilon_L - \epsilon_D) s_{C2} \epsilon_\lambda}{((1-\gamma) s_{C1} + s_{C2}) \epsilon_L + (1 - (1-\gamma) s_{C1} - s_{C2}) \epsilon_D + \epsilon_\lambda} \qquad \text{(A18)}
\end{aligned}$$

Compared to the perfect compliance ((A8) and (A9)), the impact of minimum wage increase on average wage is smaller as below minimum wage equilibrate the demand and supply in sub markets. Overall disemployment effect is therefore attenuated by non-compliance. At the same time, the substitution effect continue to work to expand employment at sub markets offering above minimum wage. Again, this expansion effect is also attenuated by the non-compliance.

Qualitatively, the difference between the two cases lies in the fact that with endogenous compliance decision, the effects are through the shift in the labor supply as the cost of non compliance depresses the below minimum wage. In general, this negative effect is milder than the (supply) rationing in the case of binding minimum wage. The difference between the two cases is larger when the substitution elasticity is large among different workers.

9.3.1 Size of spike at $w = \overline{w}$

Crucial to the impact of minimum wage change on average wage is the relative size of the spike of wage distribution at $w = \overline{w}$.

$$\left(\frac{\overline{w}}{\tau\Omega_C e_a}\right)^{-\epsilon_L} D = n(e_a)\lambda\left(\frac{\overline{w}}{e_a}\right)$$

$$\left(\frac{\overline{w}}{\tau\Omega_C e_b}\right)^{-\epsilon_L} D = n(e_b)\lambda\left(\frac{\overline{w}}{e_b} - \frac{c}{e_b}\right)$$

Taking log of the two equations, we have

$$\begin{aligned}
\epsilon_L(\log(e_a) - \log(e_b)) &= \delta + \epsilon_\lambda\left(-\log(e_a) - \log(1-\beta) + \log(e_b)\right), \\
\beta &\equiv \frac{c}{\overline{w}}, \\
\delta &\equiv \log\left(\frac{n(e_a)}{n(e_b)}\right),
\end{aligned}$$

Arranging terms, we get

$$\log\left(\frac{e_a}{e_b}\right) = \delta + \frac{\epsilon_\lambda}{\epsilon_L + \epsilon_\lambda}\log\left(\frac{1}{1-\beta}\right)$$

For example, if we use ATE estimate in Table 4, $\log\left(\frac{1}{1-\beta}\right) = .445$, and assuming δ is small relative to the second term, $\log\left(\frac{e_a}{e_b}\right)$ is going to be a fraction of .445. For example, if ϵ_L is 4 times larger than ϵ_λ, $\log\left(\frac{e_a}{e_b}\right)$ is around .08, i.e., $e_a \simeq 1.08 e_b$.

9.3.2 Disemployment effect of non-compliance

In the case of perfect substitute, the cost of non-compliance is paid entirely by the worker and their per person wage is lower exactly by c. When labors are imperfect

substitute, part of the non-compliance cost is born by employers. To see this, take the log ratios of the two equilibrium conditions to get

$$\begin{aligned}\log(\omega^b(e)) - \log(\omega(e)) &\simeq \frac{\epsilon_\lambda t}{\epsilon_L + \epsilon_\lambda}, \\ t &= \frac{c/e}{\omega^b(e)}\end{aligned}$$

For example, suppose ϵ_L is 4 times larger than ϵ_λ. Then, $\omega^b(e)$ is roughly $.2t$ log point higher than the efficiency unit wage rate without non-compliance cost. In other words, the $\omega^b(e) - c/e$ is pushed down by $\frac{\epsilon_L t}{\epsilon_L+\epsilon_\lambda} = .8t$ log point by non-compliance cost, which in turn lower the labor supply by $\frac{\epsilon_\lambda \epsilon_L t}{\epsilon_L+\epsilon_\lambda}$. Take, for example, workers near the threshold e_b: their wage rate is roughly $\frac{\overline{w}}{e_b} - \frac{c}{e_b}$. If we use our base line estimate that this is below the minimum wage by .445 log points, $t = .36$. If we continue to assume $\epsilon_L = 4\epsilon_\lambda$, the disemployment effect is in the order of $.288\epsilon_\lambda$, i.e., the effect is in the order of magnitude of 28.8% increase in income tax, which can be substantial.

9.4 Tacit collusion

There is one modelling detail that we need to patch up before we proceed. In the main text, we assumed that a set of firms collude in employing workers above minimum wage threshold. This entails these firms employ only those above threshold productivity, whereas the rest of firms employ below the threshold. In order to allow this specialization possible, we need to allow the production technology using only subset of workers. Thus we assume

$$\begin{aligned}y^M &= Q(D^M), \\ D^M &= \left(\int_{e_i}^{e_1} \tau' m(e)^\rho de\right)^{\frac{1}{\rho}}, \\ \tau' &= \frac{1}{e_j - e_i}\end{aligned}$$

for any (e_j, e_i) that jointly satisfy

$$e_0 \leq e_i < e_j \leq e_1$$

With this assumption, any continuous subset of employers can be used to build a composite labor input employing workers of type between e_c and e_1 as we assume in the main text . Then, the joint profit of the employers under tacit collusion is given by

$$
\begin{aligned}
\max \mathcal{L} &\equiv Q(D^M) - \int_{e_c}^{e_1} \lambda(\omega(e))\omega(e)n(e)de \\
&\quad +\Omega_M \left[\left(\int_{e_c}^{e_M} \tau' \left(\lambda(\frac{\overline{w}}{e})n(e) \right)^{\frac{\epsilon_L - 1}{\epsilon_L}} de + \int_{e_M}^{e_1} \tau' \left(\lambda(\omega(e))n(e) \right)^{\frac{\epsilon_L - 1}{\epsilon_L}} de \right)^{\frac{\epsilon_L}{\epsilon_L - 1}} - D^M \right], \\
\epsilon_L &\equiv \frac{1}{1-\rho}
\end{aligned}
$$

$$
\left(1 + \frac{1}{\epsilon_\lambda}\right) \omega^M(e) = \tau' \Omega_M \left(\frac{\tau' \lambda(\omega^M(e))n(e)}{D^M} \right)^{-\frac{1}{\epsilon_L}} \tag{A19}
$$

that uniquely determines the monopsonistic wage rate. (A19) is finite substitution version of the monopsonistic wage (E4b) in the main text. We can rewrite the above as

$$
\tau' \lambda(\omega^M(e))n(e) = D^M \left(\frac{\left(1 + \frac{1}{\epsilon_\lambda}\right) \omega^M(e)}{\tau' \Omega_M} \right)^{-\epsilon_L},
$$

And we continue to have first order condition for the composite labor.

$$
Q'(D^M) = \Omega_M
$$

Threshold value of e_c is given by

$$
\left(1 + \frac{1}{\epsilon_\lambda}\right) \frac{\overline{w}}{e_c} = \tau' \Omega_M \left(\frac{\tau' \lambda(\frac{\overline{w}}{e_c})n(e_c)}{D^M} \right)^{-\frac{1}{\epsilon_L}}
$$

Define

$$
\begin{aligned}
D_D^M &\equiv \int_{e_c}^{e_M} \tau' \left(\lambda(\frac{\overline{w}}{e})n(e) \right)^{\frac{\epsilon_L - 1}{\epsilon_L}}, \\
s_M &\equiv \frac{D_D^M}{(D^M)^{\frac{\epsilon_L - 1}{\epsilon_L}}}.
\end{aligned}
$$

Using this, we have

$$
\boldsymbol{\eta}_{D_D^M} = \frac{(\epsilon_L - 1)\epsilon_\lambda}{\epsilon_L},
$$

and

$$
(D^M)^{\frac{\epsilon_L - 1}{\epsilon_L}} = D_D^M + \int_{e_M}^{e_1} \tau' (D^M)^{\frac{\epsilon_L - 1}{\epsilon_L}} \left(\frac{\left(1 + \frac{1}{\epsilon_\lambda}\right) \omega^M}{\tau' \Omega_M} \right)^{1-\epsilon_L} de
$$

We can solve out for the elasticities in a manner similar to the above. The results are:

$$\boldsymbol{\eta}_{\Omega_M} = \frac{-s_M\epsilon_\lambda(\epsilon_L+\epsilon_\lambda)}{s_M\epsilon_D(\epsilon_L+\epsilon_\lambda)+(1-s_M)(\epsilon_D+\epsilon_\lambda)} < 0, \tag{A20}$$

$$\boldsymbol{\eta}_{D^M} = -\epsilon_D\eta_{\Omega_M} = \frac{s_M\epsilon_D\epsilon_\lambda(\epsilon_L+\epsilon_\lambda)}{s_M\epsilon_D(\epsilon_L+\epsilon_\lambda)+(1-s_M)(\epsilon_D+\epsilon_\lambda)} > 0 \tag{A21}$$

$$\boldsymbol{\eta}_{\omega(e)} = \frac{-s_M\epsilon_\lambda(\epsilon_L-\epsilon_D)}{s_M\epsilon_D(\epsilon_L+\epsilon_\lambda)+(1-s_M)(\epsilon_D+\epsilon_\lambda)} \tag{A22}$$

Hence, the total labor input expands as a result of increase in minimum wage. The efficiency unit wage rate, $\omega(e)$, for above minimum wage will decline as in the perfect substitute case provided that $\epsilon_L - \epsilon_D > 0$.

9.4.1 Expansionary effect on employment

As an illustrative example of the magnitude of expansionary effect of the increase in minimum wage, we use (A21) and suppose $\epsilon_L = 2, \epsilon_\lambda = \epsilon_D = .5, s_M = .3$.Then, $\boldsymbol{\eta}_{S^M} = .088$. i.e., the elasticity of employment at collusive sector with respect to changes in minimum wage is .088. Hence if we use the 70% increase in the minimum wage during 2012-2013, the employment at collusive sector should have increased by roughly 6.2%. This is comparable to 7.6% increase of the daily wage employment at large firms (more than 200 employees) from 2011 to 2013.

This can be compared with the overall negative impact of minimum wage increase in the case of competitive equilibrium with endogenous compliance. If we employ the same values for common parameters, setting $\gamma = .5$, and use figures in Table 1 of the main text to set $s_{C1} = .222, s_{C2} = .395$, the elasticity of overall employment with respect to minimum wage change is .095, which in turn translates into 6.7% decline of employment by 70% increase in minimum wage.

10 Appendix 2 Data construction

10.1 Wage

The micro data is taken from Labor Force Survey of Thailand and is made available through data center at Research Institute for Policy Evaluation and Design, University of Thai Chamber of Commerce. The data is monthly from January 2001 til June 2013. Prior to 2001, quarterly data from August 1985 til November 2000 are also available but the use of these quarterly data are mostly limited to the analysis in Section 2.

Throughout this paper, I use only the wage data for daily and monthly wage. Wage data for other types, such as hourly or weekly wages are not used primarily because of the difficulty to convert them in the way comparable to minimum daily wage. Among daily and monthly wage, I used samples whose reported working hours in the survey

Table A1 Working hours per week

wage type	daily wage		monthly wage	
work hours per week	% share	cumulative % share	% share	cumulative % share
less than 10 hours		1.25		0.89
less than 20 hours		3.35		1.68
less than 30 hours		8.51		5.10
less than 35 hours		13.04		6.75
equal to 35 hours	2.41	15.46	25.29	32.04
less than 40 hours		16.51		32.53
equal to 40 hours	8.25	24.76	17.12	49.65
equal to 42 hours	2.41	27.18	2.10	51.76
equal to 45 hours	1.23	28.48	1.19	53.14
euqal to 48 hours	29.54	58.10	23.22	76.45
less than 50 hours	0.87	60.87	1.15	77.60
equal or less than 60 hours	3.00	89.79	2.60	91.52

week is 35 hours or longer. Table A1 shows the distribution of work hours during the survey week. 35 hours per week has now the highest share among the monthly wage earners, whereas among daily wage earners, 48 hours per week is the norm, comprising roughly 30%.

To obtain daily wage equivalent of monthly wages, I divide sample monthly wages by 22.5. This conversion rate is based upon 5.5 working days per week and 16 national holidays per year. After dropping samples below age 15 and over 60 (see below), and screening away wages in excess of 4 standard deviations from means, we have 981,709 daily wage and 1,887,720 monthly wage observations.

10.2 Weights

The data includes frequency weights. Unfortunately, the weight data is somewhat contaminated. As being a frequency weights, the grand sum of the frequency weights is equal to the population: to be exact, the grand sum is equal to one third of population, in order to retain the compatibility of the weights prior to 2001 when the survey was conducted quarterly. Indeed, the grand sums of weights in all but 4 periods indeed closely match one third of the population of the country. Grand sum of weights in April, May and June 2004 survey data is, however, 2 to 3 times larger than one third of the population. There are also sporadic (685) samples whose weights are smaller than one in 7 surveys (the latest is November 2011). Because of these apparent anomalies, I have no choice but avoid using weights in regression analysis unless otherwise noted. I however ventured to use weighted data in some of tabulations by dividing weights in 4 periods by the average of neighboring months. Fortunately, the results differ little when I use both weighted and unweighted samples.

Table A2 Incidence of Minimum Wage Change 1989~2013

Month/Year	mean minimum wage	% change	mean increase (in	Notes
Jan. 1989	64.7			
Apr. 1989	66.7	3.0	1.9	all provinces raised minimum wage
Apr. 1990*	76.0	14.0	9.3	all provinces raised minimum wage
Apr. 1991*	84.3	10.9	8.3	all provinces raised minimum wage
Apr. 1992*	96.6	14.7	12.4	all provinces raised minimum wage
Apr. 1993*	104.8	8.4	8.1	all provinces raised minimum wage
Apr. 1994*	110.8	5.8	6.1	all provinces raised minimum wage
Oct. 1994	112.9	1.9	2.1	all provinces raised minimum wage
Jul. 1995*	121.1	7.2	8.2	all provinces raised minimum wage
Oct. 1996*	131.4	8.5	10.3	all provinces raised minimum wage
Jan. 1998	133.7	1.8	2.4	all provinces raised minimum wage
Jan. 2001	136.7	2.2	3.0	all provinces raised minimum wage
Jul. 2001	137.0	0.2	0.3	12 provinces raised
Jan. 2002	136.7	-0.2	-0.3	7 provinces lowered
Jan. 2003	138.8	1.5	2.1	12 provinces no change
Aug 2003	138.6	-0.2	-0.2	17 provinces lowered
Jan. 2004	139.4	0.6	0.8	27 provinces raised
Jan. 2005*	143.5	3.0	4.2	all but 1 provinces raised
Aug. 2005*	148.0	3.1	4.5	all but 1 provinces raised
Jan. 2006	149.3	0.9	1.3	36 provinces raised
Jan. 2007*	154.0	3.1	4.7	57 provinces raised
Jan. 2008	155.9	1.2	1.9	all provinces raised minimum wage
Jun. 2008*	162.0	3.9	6.1	all except for 4 provinces raised.
Jan. 2010	165.2	2.0	3.3	all provinces raised minimum wage
Jan. 2011*	175.8	6.4	10.6	all provinces raised minimum wage
Apr. 2012*	245.1	39.4	69.3	all provinces raised minimum wage
Jan. 2013*	300.0	22.4	54.9	all except for 7 provinces where minimum wage was raised to 300thb on April 2012

* included as major changes in minimum wage in Figure 3

10.3 Minimum wage

Table A2 collects information on minimum wage changes since 1989. As shown below, some of changes involve downward adjustments and many increases in this century up to 2010 are small. Consequently, we chose only major changes (indicated by asterisk in table) in the analysis of the impact of minimum wage increases.

10.4 Labor force and work status

Unless otherwise noted, I use sample individuals aged between 15 and 59 as the labor force. The cutoff at age 59 is used as age 60 is the most common mandatory retirement age. If we use 2013 samples, the share of the employed peaks at age 35 at 50.8%. The share remains above 30% until age 50, but then drops sharply after age 50, to 20.4% at age 59, and only 13.8% are employed at age 60. By age 65, only 6.7% are employed.

10.5 Industry and Occupation Classification

The Labor Force Survey data include industry classification of employers using 6-digit TSIC, Thailand Standard Industry Classification. Fortunately, this is conformable at two digit level to ISIC, International Standard Industry Classification. I converted and

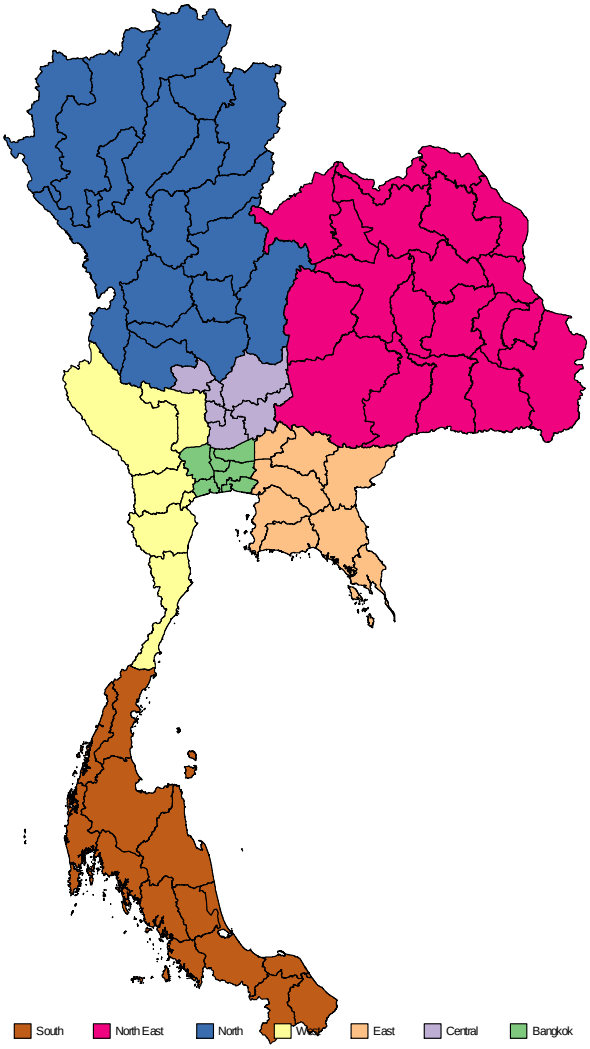

Figure 13: 7 regions of Thailand

aggregated 6-digit TSIC into 21 two digit ISIC. Individual samples are also equipped with occupation classifications, which comes in 6-digit ISCO, International Standard Classification of Occupation, compiled by ILO. I converted and aggregated this 6 digit classifications into single digit 9 occupations category.

10.6 Province and regions

Thailand currently has 76 provinces and Bangkok metropolitan district as the base units of local administration. These provinces are commonly divided into 5 or 7 regions. I opted to use 7 regions: Bangkok and vicinity (6), Central (6), East (8), West (6), North (17), Northeast (20), and South (14).

11 Appendix 3 Additional results

11.1 Excluding Exempt workers

The minimum wage law in Thailand stipulates that the following workers are exempt from the law: (1) employees of central, local governments and government enterprises, (2) agricultural workers, and (3) part time workers. In the analysis of the paper, we do not distinguish these exempt workers except that we use only samples with 35 hours or more working hours[33]. In the spirit of the model analysis in this paper, there is no strong reason to treat separately these exempt workers in that below minimum wage either at exempt or non-exempt sector incurs type of additional recruiting cost as we argued in the main text.

We did some robustness checks, however. We ran switching regressions using only subset of the samples who are not exempt from the minimum wage. The main result (average treatment effect) are in Appendix Table A8 where we confirm that the main findings are not materially influenced by this change. The estimated treatment effect (cost of setting below minimum wage) are of similar magnitudes and the ATE are larger at larger firms for daily wages, whereas as in the main results, the ATE are statistically insignificant and small, and point estimates are often positive.

11.2 Flood in 2011

In late 2011, Thailand sustained a major damage from the flood of Chao Phraya river. Bangkok and Ayutthaya were hit hardest. Hence, our measurement of the employment change before and after the 2012~2013 hike of the minimum wage can overestimate the impact of minimum wage change as the employment before the increase includes major negative effect of the flood in the last months of 2011.

To remove the impact of the flood, we excluded two hardest hit provinces from the data and repeated regressions reported in Table 8 . The main finding (results not show here but available upon request) is that although the modifications do alter the estimated coefficients somewhat, the changes are relatively minor and our main findings are not affected. We also changed the benchmark period for the 2012-2013 minimum wage changes from July 2011~December 2011 to January~June 2011 and recomputed changes in employment and repeated regressions reported in Table 8. Again, we found no major changes.

11.3 Mobility across wage types

In this paper, we exploited the differences in two major types of wage payments, daily versus monthly wages. In particular, we found the apparent downward bias of the wage

[33] The law defines 8 hours per day as the condition for the statutory minimum (daily) wage to apply. At the same time, the law also states that workers less than 8 hours per day are also entitled to receive hourly minimum wage which is equal to the daily minimum wage divided by 8 hours. As we stated in the main text, we define full time workers as those with 35 hours or more of the work hours during the survey period. See Table A1

paid at the large scale firms only among daily wage workers, not among those paid monthly wages. Although available evidence indicates the sharp distinction between the two types apply not only to the type of works, but also to the types of workers, it is certainly possible that a worker may move from a job paying daily wage to another paying monthly wage. For example, it seems possible that a worker is promoted within a firm from a job that pays daily wage, to another job that pays monthly wage. If this practice of promoting better workers from daily wage jobs to monthly wage jobs are common only among large firms, the apparent downward bias of daily wage maybe an artifact produced by this promotion ladder[34].

Although it is impossible to ascertain the quantitative significance of the possible mobility across wage types within a firm, it should be noted that the tacit collusion hypothesis is far more relevant to the wages for the newly hired workers, than to those with long term tenure at the current employers.

11.4 Additional Figures and Tables

Table A3 part 1 and part 2 are results for monthly wage samples on which we obtained the estimates of wage gap shown in Table 4.

Table A4 below are used to construct $\widehat{\gamma}(i, s, p)$ used in the results shown in Table 4 part 2 and Table A3 part 2 above. The dependent dummy variable is equal to unity if a sampled employer said that the employer adjusted the wage in line with the increased minimum wage as of the first three months of 2013. The probit model is then used to construct cell means of the predicted value over regions (76) , area type (urban or rural), firm size (7 categories), and ISIC industry classifications (23 industries).

Table A5 is ATE estimates employing propensity score matching and they are comparable to those in Table 4 of the main text.

Table A6 list the episodes of the minimum wage increases which are used to construct provincial panel data used in regressions reported in Table 8.

Table A7 replicates Table 1 using non-exempt samples only.

Table A8 re-estimates ATE using only non-exempt samples (excluding part time workers, workers in government and governmental enterprises, and agricultural workers).

[34] I attempted to collect some anecdotal evidence indicating whether or not such a practice (from a job paid daily wage to another paying monthly wage) is common. In one correspondence with a former HR head of a firm in Samut Sakon province (located west of Bangkok), she flatly denied such possibility: ' At our firm, those at supervisor and up are paid monthly wages, and the rest are paid daily wages. Supervisors are recruited externally, and never promoted from within. They need minimum a high school diploma, preferably a 2 year college diploma ' This seems to be a norm among large Thai manufacturing firms: paying daily wages for workers on the shop floor, including regular workers, team leaders, and up to foreman. Supervisors and higher are paid monthly wages and they are recruited differently. On the other hand, several field survey reports that Japanese manufacturing firms or their subsidiaries in Thailand start conversion to monthly wages at lower level, typically from team leaders and up, and most of them are promoted from within.

Table A3 Switching Regression part 1 Logwage regressions : Monthly wage

	treated (<minimum wage) samples								controlled (>= minimum wage) samples							
sample	all		small		medium		large		all		small		medium		large	
period	2001~2013	2012~13	2001~2013	2012~13	2001~2013	2012~13	2001~2013	2012~13	2001~2013	2012~13	2001~201	2012~13	2001~2013	2012~13	2001~2013	2012~13
years of schooling	-0.0008	0.0271	0.0220	0.0193	0.0104	0.0227	0.0401	0.0157	-0.0085	-0.0668	0.0174	-0.0179	0.0049	0.0032	-0.0645	-0.0751
	(0.077)	(0.002)***	(0.026)	(0.003)***	(0.028)	(0.027)	(0.256)	(1.503)	(0.066)	(0.003)***	(0.178)	(0.004)***	(0.106)	(0.010)	(0.202)	(0.118)
years of schooling2	0.0033	-0.0008	0.0013	-0.0004	0.0027	0.0018	0.0008	0.0020	0.0040	0.0051	0.0015	0.0016	0.0034	0.0031	0.0063	0.0062
	(0.007)	(0.000)***	(0.003)	(0.000)**	(0.006)	(0.004)	(0.042)	(0.124)	(0.003)	(0.000)***	(0.005)	(0.000)***	(0.003)	(0.000)***	(0.002)***	(0.011)
age-6-years of schooling	0.0140	-0.0001	0.0073	-0.0011	0.0152	0.0115	0.0117	0.0118	0.0169	0.0131	0.0081	0.0049	0.0186	0.0150	0.0247	0.0201
	(0.020)	(0.000)	(0.011)	(0.000)***	(0.039)	(0.013)	(0.138)	(0.267)	(0.010)	(0.000)***	(0.007)	(0.001)***	(0.007)***	(0.002)***	(0.038)	(0.077)
SD2(<5 employees)	-0.3499	-0.1507	-0.1320	-0.0480					-0.3263	-0.0477	-0.1179	-0.0117				
	(0.127)***	(0.012)***	(0.023)***	(0.008)***					(0.189)*	(0.009)***	(0.283)	(0.010)				
SD3(5~9 employees)	-0.2306	-0.0957							-0.2111	-0.0587						
	(0.126)*	(0.011)***							(0.100)**	(0.008)***						
SD4 (10~19 employees)	-0.1553	-0.0790			-0.0479	-0.0575			-0.1413	-0.0590			-0.0536	-0.0698		
	(0.133)	(0.010)***			(0.423)	(0.028)**			(0.148)	(0.008)***			(0.050)	(0.009)***		
SD5 (20~49 employees)	-0.1309	-0.0653							-0.1106	-0.0328						
	(0.093)	(0.010)***							(0.132)	(0.007)***						
SD6 (50~99 employees)	-0.0900	-0.0440							-0.0732	-0.0088						
	(0.131)	(0.014)***							(0.083)	(0.008)						
SD7 (100~199 employees)	-0.0660	-0.0165							-0.0615	-0.0271						
	(0.015)***	(0.011)							(0.051)	(0.007)***						
Constant	0.9933	0.7399	0.7675	0.7004	0.6868	0.7596	0.7000	0.8175	0.6758	1.4969	0.6469	1.4686	0.4490	0.5858	0.9022	1.1096
	(0.744)	(0.058)***	(0.855)	(0.038)***	(1.198)	(0.160)***	(2.573)	(7.103)	(0.309)**	(0.087)***	(0.789)	(0.055)***	(0.069)***	(0.180)***	(4.584)	(7.156)
ρ(with selection equation residual)	-0.9958	0.0223	-0.9946	0.1469918	-0.9960	-0.9970	-0.9990	-0.9966	-0.9994	0.6011	-0.9998	0.4670	-0.9996	-0.9763	0.4142	0.4428
	(.033)***	(0.054)	(.029)***	(.073)**	(.074)***	(.083)***	(.196)***	(.337)***	(.083)***	(.021)***	(.120)***	(.068)***	(.146)***	(.040)***	(11.78)	(20.52)
Observations	490,737	61,761	158,361	17,194	146,986	16,881	185,390	27,686	490,737	61,761	158,361	17,194	146,986	16,881	185,390	27,686

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A3 Switching Regression Part 2 Probit regressions for treatmeant : Monthly Wage

sample	all		small		medium		large	
period	2001~2013	2012~13	2001~2013	2012~13	2001~2013	2012~13	2001~2013	2012~13
γ(i,s,p)	-0.0025	-0.3307	0.0303	-0.5922	0.0266	0.0698	-0.0547	-0.0496
	(0.079)	(0.200)*	(2.261)	(0.316)*	(2.028)	(0.058)	(0.338)	(36.478)
years of schooling	0.0151	-0.0926	-0.0421	-0.0496	-0.0126	-0.0241	-0.0869	-0.0339
	(0.203)	(0.007)***	(0.089)	(0.010)***	(0.128)	(0.011)**	(0.884)	(1.793)
years of schooling2	-0.0085	0.0007	-0.0035	-0.0016	-0.0076	-0.0054	-0.0021	-0.0041
	(0.017)	(0.000)**	(0.008)	(0.001)***	(0.014)	(0.001)***	(0.080)	(0.160)
age-6-years of schooling	-0.0365	-0.0118	-0.0189	-0.0086	-0.0406	-0.0270	-0.0275	-0.0250
	(0.052)	(0.001)***	(0.030)	(0.001)***	(0.091)	(0.009)***	(0.119)	(0.182)
female	0.0009	0.3391	0.0011	0.3159	0.0021	-0.0113	0.0317	0.0180
	(0.092)	(0.013)***	(0.418)	(0.024)***	(0.111)	(0.015)	(2.793)	(5.953)
married	-0.0021	-0.1968	-0.0009	-0.2913	-0.0043	-0.0013	0.0019	-0.0007
	(0.056)	(0.012)***	(0.467)	(0.022)***	(0.389)	(0.009)	(0.845)	(2.153)
SD2(<5 employees)	0.7175	0.5920	0.2827	0.1575				
	(0.238)***	(0.098)***	(0.209)	(0.030)***				
SD3(5~9 employees)	0.4610	0.4098						
	(0.256)*	(0.086)***						
SD4 (10~19 employees)	0.3077	0.3169			0.1079	0.1352		
	(0.238)	(0.077)***			(0.855)	(0.024)***		
SD5 (20~49 employees)	0.2537	0.2541						
	(0.312)	(0.062)***						
SD6 (50~99 employees)	0.1692	0.1917						
	(0.382)	(0.036)***						
SD7 (100~199 employees)	0.1360	0.1670						
	(0.020)***	(0.027)***						
Constant	0.5291	0.9202	0.9302	0.9933	1.2910	0.7912	0.9971	0.6614
	(2.211)	(0.246)***	(1.372)	(0.165)***	(4.216)	(0.603)	(0.965)	(30.786)
Observations	490,737	61,761	158,361	17,194	146,986	16,881	185,390	27,686

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A4 Probit regression for adjusting the wage to meet the minimum wage regulation

	Coef.	Std. Err.	z	P>z	[95% Conf	Interval]
SD2	-1.1771	0.0254	-46.3100	0.0000	-1.2270	-1.1273
SD3	-0.9870	0.0261	-37.8400	0.0000	-1.0382	-0.9359
SD4	-0.8168	0.0276	-29.5500	0.0000	-0.8709	-0.7626
SD5	-0.5984	0.0292	-20.5000	0.0000	-0.6556	-0.5412
SD6	-0.3524	0.0345	-10.2000	0.0000	-0.4201	-0.2847
SD7	-0.1615	0.0328	-4.9200	0.0000	-0.2259	-0.0971
ID1	-0.4832	0.2186	-2.2100	0.0270	-0.9116	-0.0548
ID2	0.0586	0.2428	0.2400	0.8090	-0.4173	0.5345
ID3	0.3038	0.2177	1.4000	0.1630	-0.1229	0.7304
ID4	-0.2722	0.3305	-0.8200	0.4100	-0.9199	0.3755
ID5	-0.1914	0.2874	-0.6700	0.5050	-0.7548	0.3720
ID6	0.3272	0.2181	1.5000	0.1340	-0.1004	0.7547
ID7	0.1872	0.2179	0.8600	0.3900	-0.2399	0.6142
ID8	0.0572	0.2216	0.2600	0.7960	-0.3772	0.4915
ID9	0.0114	0.2191	0.0500	0.9590	-0.4180	0.4407
ID10	0.0524	0.2333	0.2200	0.8220	-0.4048	0.5096
ID11	-0.1365	0.2222	-0.6100	0.5390	-0.5720	0.2990
ID12	-0.0041	0.2377	-0.0200	0.9860	-0.4700	0.4619
ID13	0.1146	0.2302	0.5000	0.6190	-0.3367	0.5658
ID14	0.0701	0.2226	0.3100	0.7530	-0.3663	0.5065
ID15	-0.2033	0.3081	-0.6600	0.5090	-0.8072	0.4006
ID16	-0.0576	0.2243	-0.2600	0.7970	-0.4972	0.3820
ID17	-0.1239	0.2316	-0.5300	0.5930	-0.5779	0.3301
ID18	-0.2948	0.2305	-1.2800	0.2010	-0.7466	0.1570
ID19	-0.1807	0.2263	-0.8000	0.4250	-0.6242	0.2628
ID20	-0.2519	0.2259	-1.1100	0.2650	-0.6947	0.1910
AD1	0.0185	0.0152	1.2200	0.2220	-0.0112	0.0482
RD1	0.9022	0.0254	35.5000	0.0000	0.8524	0.9520
RD2	0.5161	0.0307	16.8100	0.0000	0.4559	0.5763
RD3	0.1883	0.0282	6.6800	0.0000	0.1331	0.2436
RD4	0.2071	0.0298	6.9500	0.0000	0.1487	0.2656
RD5	0.0885	0.0255	3.4700	0.0010	0.0385	0.1384
RD6	0.1685	0.0252	6.7000	0.0000	0.1192	0.2178
cons	0.0114	0.2191	0.0500	0.9580	-0.4181	0.4409

SD: employer size dummies (in ascending order), ID: ISIC industry classification dummies, AD1: dummy for municipal area, RD: regional dummies. The dependent variable: employer survey in 2013

Table A5 Average treatment effect : propensity score matching estimations

sample employer size		all	small	medium	large
ATE	less than vs. more than minimum wage	-0.3055	-0.3538	-0.3150	-0.2072
		(0.002)***	(0.003)***	(0.004)***	(0.004)***
	Observations	63,535	31,166	12,853	19,516

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A6 Changes in Employment afte major increases in minimum wage							
minimum wage changes in	number of workers				labor force status		
	daily wage		monthly wage		work	employed	self employed
	unweighted	weighted	unweighted	weighted	unweighted	unweighted	unweighted
Apr. 1990	1.012	0.894	1.130	0.989	0.957	0.940	0.977
Apr. 1991	0.860	0.901	1.020	1.044	0.988	0.959	1.031
Apr. 1992	0.817	0.845	1.020	0.991	0.932	0.890	0.999
Apr. 1993	0.921	0.913	1.025	0.992	0.954	0.910	1.024
Apr. and Oct. 1994	0.851	0.885	1.003	0.957	0.934	0.897	0.990
Jul. 1995	1.316	1.183	1.010	0.986	1.026	1.087	0.943
Jan. 2005	0.985	1.321	1.090	1.331	1.332	1.371	1.278
Jan. 2007	1.006	1.000	1.023	1.058	1.022	1.034	1.004
Jan. 2008	1.046	1.007	1.021	1.005	0.997	1.008	0.982
Jun. 2008	0.911	0.936	0.997	1.010	0.998	0.975	1.035
Jan. 2010	1.065	1.047	1.017	1.018	1.006	1.033	0.968
Jan. 2011	1.054	1.211	1.022	1.203	1.188	1.208	1.160
Apr. 2012 and Jan. 2013	1.077	1.082	0.980	0.962	1.007	1.018	0.999

Figures in the table are ratios of respective figures before and after the change in minimum wage. For episodes prior to 2001 , we use quarterly data immediately before and after the change, whereas for episodes after 2001, we use 6months averages for before and after figures. See Table A1 for the details

Table A7 Minimum wage compliance (non-exempt workers only						
	daily wage			monthly wage/22.5		
	compared to minimum wage					
	less than	equal to	more than	less than	equal to	more than
Bangkok	0.134	0.594	0.272	0.046	0.000	0.942
Central	0.262	0.248	0.490	0.065	0.001	0.933
East	0.245	0.225	0.530	0.078	0.000	0.918
West	0.333	0.232	0.434	0.119	0.001	0.877
North	0.434	0.170	0.397	0.182	0.000	0.813
Northeast	0.413	0.176	0.411	0.222	0.000	0.776
South	0.364	0.167	0.468	0.141	0.000	0.857
Total	0.318	0.268	0.414	0.108	0.000	0.886

Figures in each cell is the share of wage samples that are less than, equal to, or more than minimum wage. Full time workers (35 hours per week or more) only

Table A8 Average treatment effect (non-exempt samples only)

daily wage								
	Average Treatment				Average Treatment on the Treated			
sample period	2001~2013		2012~2013		2001~2013		2012~2013	
	mean	s.dev	mean	s.dev	mean	s.dev	mean	s.dev
all sample	-0.418	0.129	-0.463	0.064	-0.427	0.134	-0.431	0.077
small size	-0.558	0.096	-0.477	0.078	-0.569	0.101	-0.485	0.081
medium size	-0.435	0.105	-0.438	0.056	-0.489	0.103	-0.443	0.060
large size	-0.229	0.081	-0.346	0.044	-0.257	0.053	-0.272	0.055
monthly wage								
	Average Treatment				Average Treatment on the Treated			
sample period	2001~2013		2012~2013		2001~2013		2012~2013	
all sample	-0.100	0.370	-0.093	0.329	-0.106	0.329	-0.097	0.303
small size	-0.092	0.262	-0.076	0.212	-0.101	0.238	-0.085	0.204
medium size	0.362	0.122	0.706	0.281	-0.035	0.071	-0.104	0.081
large size	0.114	0.397	0.104	0.350	-0.156	0.071	-0.117	0.070

Table shows the average treatment effects of non-compliance, based upon the estimation results of the switching regressions.

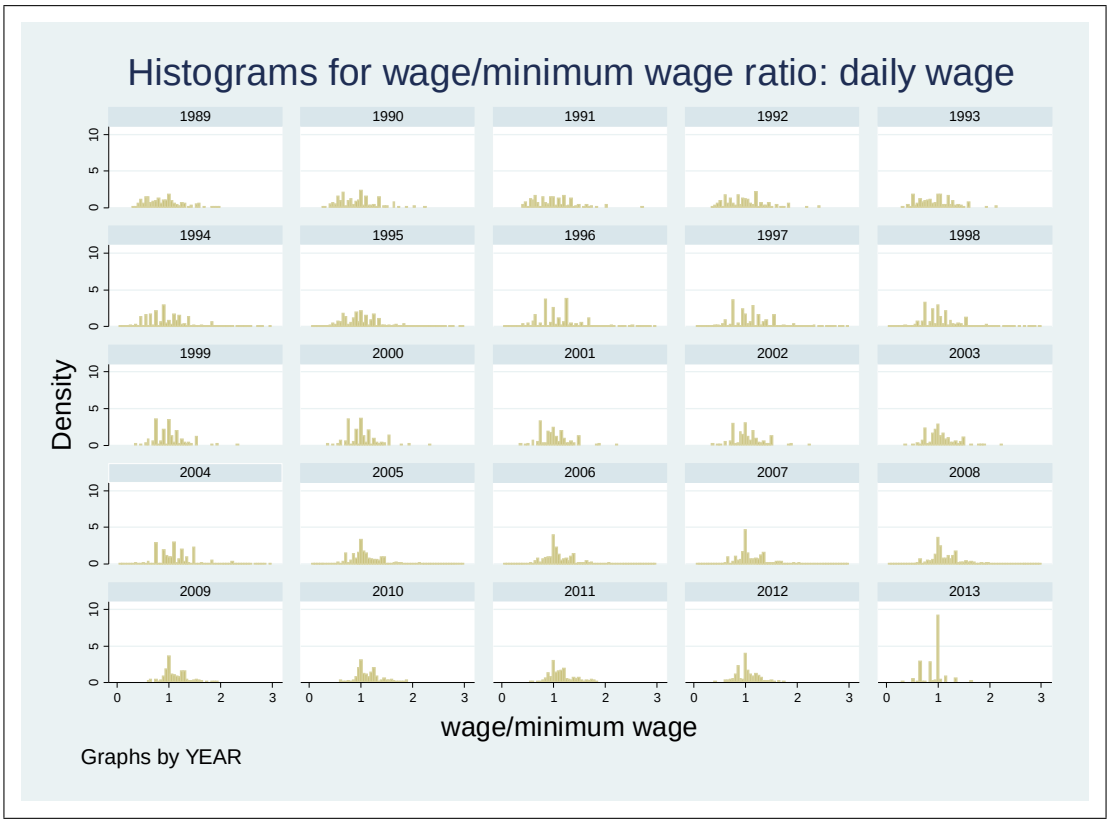

Figure 14: Each graph shows distribution of the ratio of daliy wage to minimum wage. The y-axis shows the local density.

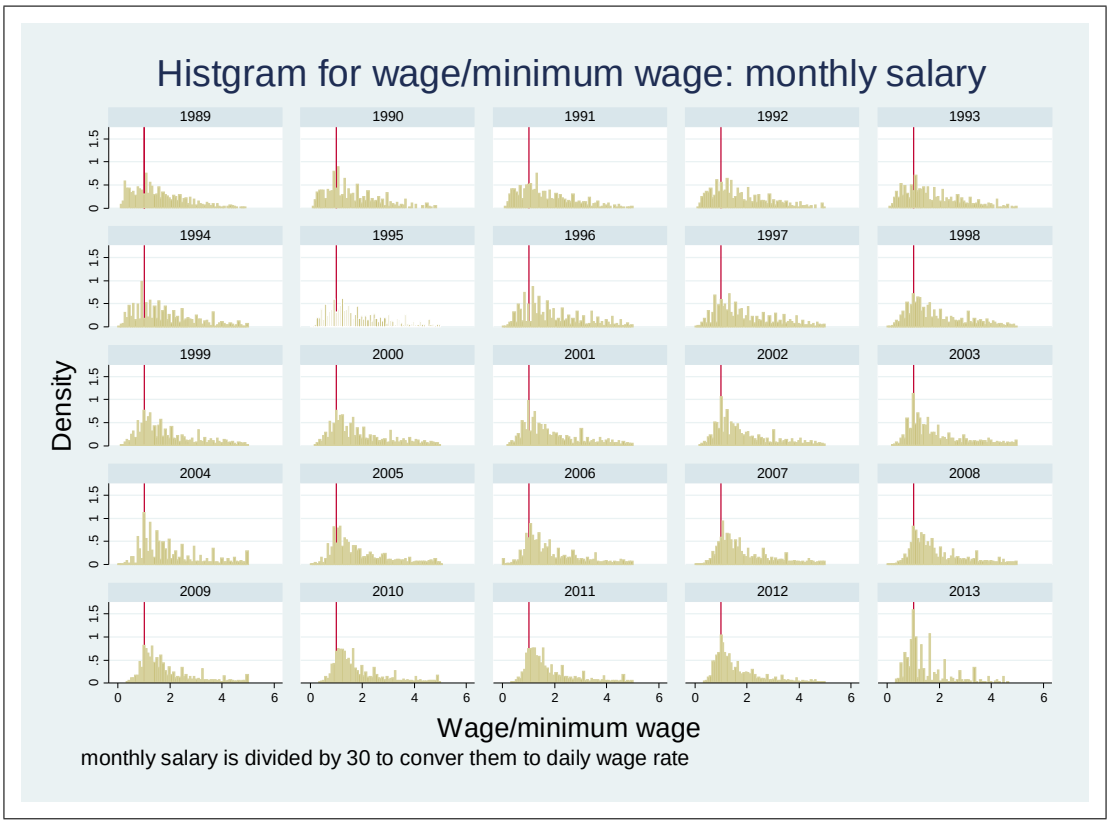

Figure 15: Each graph shows distribution of the ratio of monthly wage/30 to minimum wage. The y-axis shows the local density.

Figure 16: Daily wage distribution for different sizes of employers.

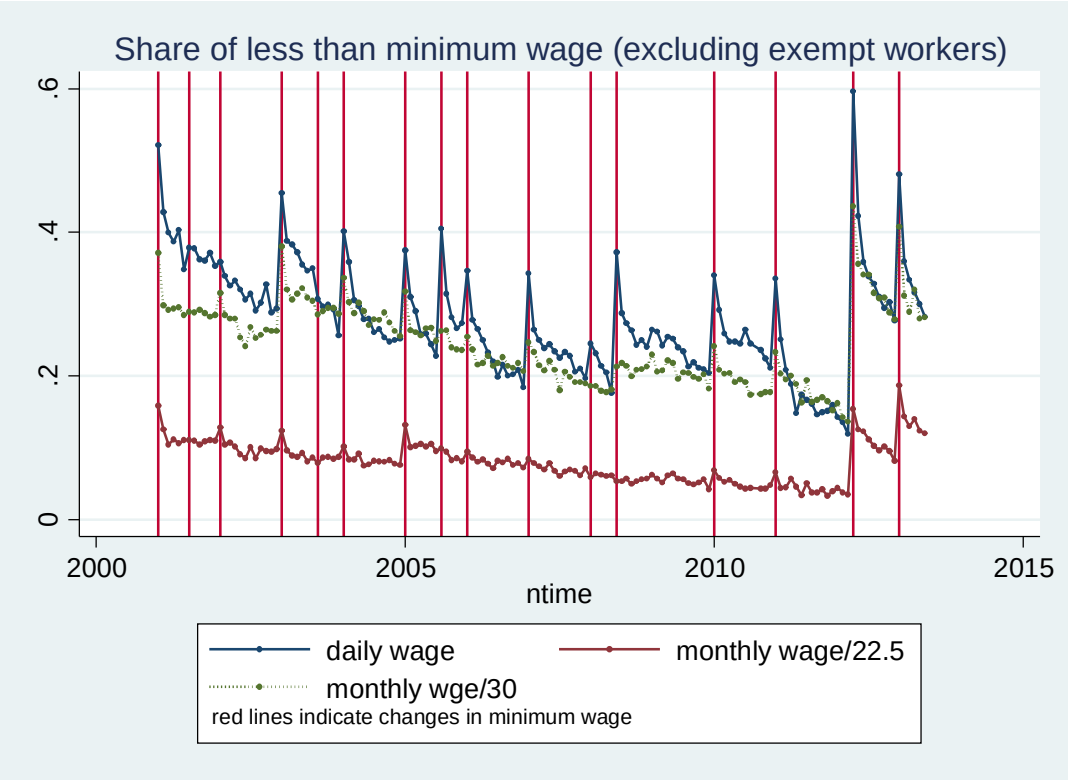

Figure 17: The share of wage samples with less than minimum wage when exempt workers and sectors are excluded from the sample

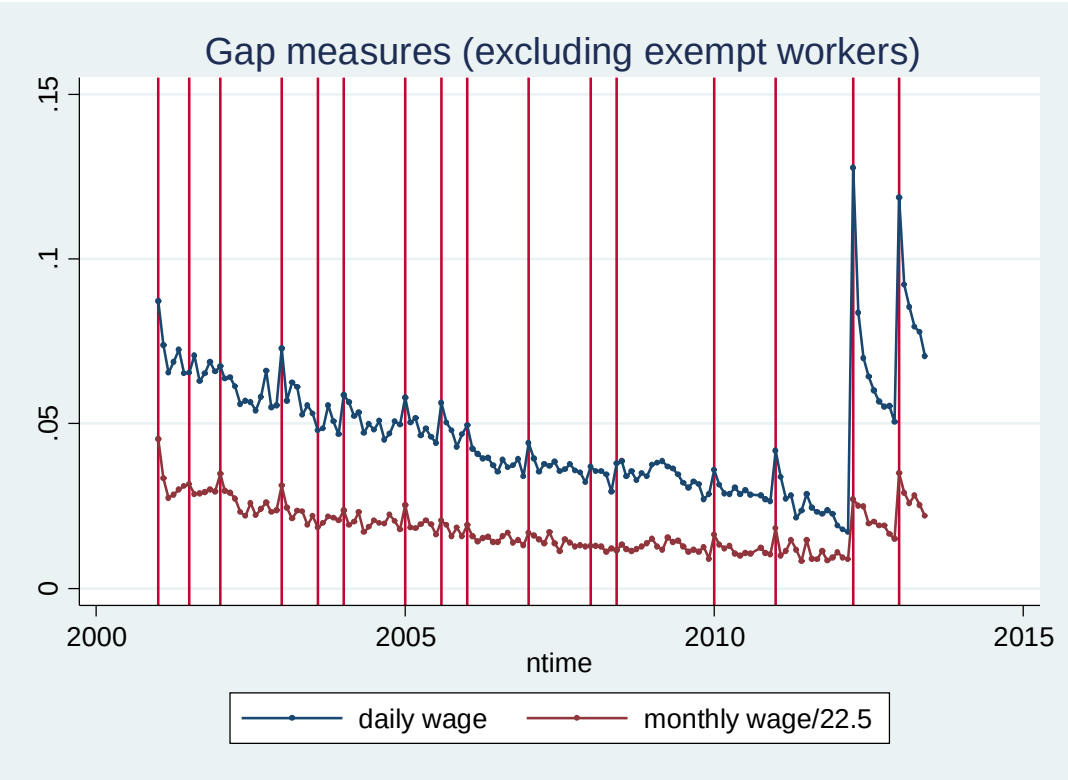

Figure 18: Gap measures recomputed using only non-exempt samples.