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ABSTRACT

A holistic assessment of the labor market effects of minimum wage regulation requires understanding employer compliance. We investigate how minimum wage increases and the strength of enforcement regimes affect the prevalence of subminimum wage payment. Using the Current Population Survey (CPS), we find strong evidence that higher minimum wages lead to a greater prevalence of subminimum wage payment. We estimate that increases in measured underpayment following minimum wage increases average between 14 and 22 percent of realized wage gains. Furthermore, we provide evidence that these estimates are unlikely to be driven by measurement error in the CPS's wage data, which are self-reported. Taken together, we interpret these findings as evidence that minimum wage noncompliance is an important reality in the low-wage labor market. We find some evidence that enforcement regimes mediate both baseline rates of subminimum wage payment and the response of subminimum wage payment to increases in minimum wages.

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Section I: Introduction

An understanding of employers' compliance with minimum wage regulation is crucial for developing a holistic assessment of its labor market effects. Despite its importance, compliance has been understudied by economists. In this paper, we investigate two key issues regarding the magnitude and determinants of subminimum wage payment, which can indicate noncompliance. First, we estimate the extent of "subminimum wage payment on the margin." That is, we estimate the increase in subminimum wage payment that occurred in response to recent increases in minimum wages. Second, we investigate whether changes in the prevalence of subminimum wage payment were shaped by enforcement provisions in state labor laws.

We find strong evidence that higher minimum wages increase the prevalence of workers who report being paid wage rates below the minimum wage. We consistently find that increases in self-reported subminimum wage payment average between 14 and 22 percent of the wage gains realized following minimum wage increases. These findings suggest that compliance with minimum wage laws is the norm, but that subminimum wage payment occurs with nontrivial frequency. We also find evidence that enforcement regimes mediate compliance patterns.

Economic models of compliance extend at least as far back as Becker's (1968) classic analysis of the economics of crime. A familiar application of the Becker (1968) framework to financial misdeeds involves purposeful tax evasion, as in the model of Allingham and Sandmo (1972).[2] In the tax context, the classic model suggests that the decision to evade will be a function primarily of the gains from successful evasion, the probability of detection, and the penalties associated with being caught. A similar dynamic may be at work with firms' decisions

[2] Additional papers in this spirit include Yitzhaki (1974), Slemrod and Yitzhaki (2002), and Slemrod (2007).

to pay subminimum wages.[3] Analyses by Ashenfelter and Smith (1979), Grenier (1982), Chang and Ehrlich (1985), and Yaniv (1994) have brought related insights to the minimum wage literature.

Empirical research on the determinants of minimum wage noncompliance has been limited. In the U.S. context, analyses have found that violation rates are correlated with several of the factors that arise in classic models. Both Weil (2005) and Bernhardt, Spiller, and Theodore (2013), for example, find high violation rates in industries in which firms have a limited ability to pass labor costs on to consumers.[4] Bernhardt, Spiller, and Theodore (2013) find that firms' management structures shape compliance behavior. Goraus-Tanska and Lewandowski (2016) find that subminimum wage payment is most prevalent when countries' minimum wage rates are high relative to their average wage rates. Caliendo, Schröder, and Wittbrodt (2019) discuss evidence from several recent papers on compliance in the context of Germany's recent introduction of a statutory minimum wage. The evidence suggests moderately high rates of noncompliance in the short run (Caliendo et al., 2017; Bruttel, Baumann, and Dütsch, 2018).

Several papers assess the role of minimum wage enforcement institutions. Weil (2005) finds evidence that noncompliance tends to be high when the value of workers' skills is low and when enforcement technologies are weak. Bhorat, Kanbur, and Mayet (2012) find no evidence of

[3] Agan and Makowsky (2018) apply the lens of the Becker model to understand the effects of the minimum wage on recidivism.

[4] These empirical findings are typically connected to insights from an earlier theoretical literature (Ashenfelter and Smith, 1979; Grenier, 1982; Chang and Ehrlich, 1985) that applies the theoretical lens of Becker's (1968) economic analysis of crime to the issue of minimum wage compliance. This literature finds that evasion and avoidance behavior will tend to be increasing in such factors as the degree to which the minimum wage exceeds the market wage, the magnitude of the elasticity of demand for a firm's output, the resources devoted to identifying violations, and the severity of the penalties associated with violation. Subsequent theoretical work has brought insights related to partial compliance (Yaniv 2001) and optimal enforcement strategies.

a relationship between evasion and the number of inspectors employed to detect violations. Galvin (2016), on whose documentation of enforcement institutions we draw, finds that strict enforcement and penalty regimes reduce the prevalence of subminimum wage payment.

Our analysis advances the literature on subminimum wage payment along two key dimensions. First, in the U.S. context there is very little existing analysis of the prevalence of subminimum wage payment on the margin. That is, little evidence reveals how the prevalence of subminimum wage payment responds to changes in the wage floor. Second, the economics literature has done little to develop evidence on the empirical relevance of enforcement institutions.

Our empirical analysis focuses on recent minimum wage changes, enacted from January 1, 2011 to December 31, 2018. After a lull in the years following the Great Recession, many states have legislated and implemented substantial minimum wage increases. This policy environment offers an opportunity to conduct transparent labor market analyses using standard empirical methods, as we discuss in greater detail below.

We begin our analysis with an investigation of whether the prevalence of subminimum wage payment rises as the minimum wage rises.[5] We find strong evidence that it does. In our analysis of un-tipped hourly workers ages 16 to 25, for example, we find that each dollar of minimum wage increase predicts, on average, a wage gain of roughly 27 cents and a 3.8 cent increase in underpayment. A consistent finding across analysis samples is that increases in

[5] We focus on the population ages 16 to 25, which is a group more likely to be on the margin of making at or near the minimum wage than are populations with greater labor force experience.

measured underpayment average between 14 and 22 percent of realized wage gains. This suggests that compliance is the norm, but that avoidance and evasion are nontrivial.

The limitations of self-reported wage data present hurdles to analyses of subminimum wage payment in the U.S. labor market. Our analysis thus considers the potential relevance of several margins along which data limitations might be roadblocks to interpreting our estimates as evidence of underpayment on the margin. These margins include legal exemptions for tipped workers, workers who receive overtime or commissions, workers who live in states with substate minimum wage rates, and workers in occupations that may exempt them from the minimum wage. Additional relevant margins include measurement error for salaried workers relative to wage earners and wage imputation made necessary by survey item nonresponse.

The key assumption we must make is that the effect of these margins on workers' propensity to report subminimum wage payments has not changed differentially in ways that are correlated with minimum wage changes. Although these margins pose difficulties for estimating the overall prevalence of subminimum wage payment, it is not obvious that they present first-order concerns for estimating subminimum payment on the margin. While we can provide some evidence on our key assumption's plausibility, however, the evidence is not dispositive.

Our analysis of the relevance of data limitations takes three steps. We first investigate whether minimum wage increases predict changes along the margins discussed above. We find that they do not. We next investigate whether our estimates are affected by imposing sample restrictions that eliminate the relevance of these margins. This includes dropping states with substate minimum wage regimes from the sample, as well as workers who are potentially exempt due to their occupation. Reassuringly, our estimates across samples of varying degrees of

restrictiveness have similar implications for our estimates of aggregate noncompliance on the margin. Finally, we investigate whether a measurement error model proposed by Autor, Manning, and Smith (2016) can explain the patterns we observe in the data. We show that this measurement error model substantially misses two key features of the under-payment patterns we observe, and thus does not provide a plausible alternative interpretation of the data.

Our preferred calculation of the aggregate implications of subminimum wage payment uses estimates from our restricted samples of hourly wage workers who do not receive tips, commissions or overtime pay and who do not have imputed wage rates. Survey weights imply that this sample represented 36.6 million individuals ages 16 to 65 in January 2011.[6] Between January 2011 and December 2018, we estimate that, on average across the country, each dollar of minimum wage increase generated an increase in subminimum wage payment of roughly $1.3 billion and realized wage gains, among the employed, of roughly $6.1 billion. The increase in subminimum wage payment was thus roughly 21 percent of the value of the realized wage gains.

A key feature of U.S. minimum wage enforcement is that the process is largely driven by worker complaints (Weil and Pyles, 2005).[7] As observed in the literature (Weil and Pyles, 2005; Gideon, 1994), complaint-based processes have important implications for both patterns of evasion and patterns of realized enforcement actions. Most relevant to our analysis, these papers highlight that a worker's incentive to complain depends in part on the complaint's implications for their employment status. The theoretical framework presented in Section II highlights the empirical implications of this key consideration.

[6] There were an estimated 59.7 million un-tipped hourly wage workers ages 16 to 65 in January 2011. The observations representing the remaining 23.1 million (59.7 minus 36.6) have imputed wage rates.
[7] Complaint-driven inspections have accounted for roughly half of inspections in recent years, and more previously.

Our empirical analysis finds patterns of subminimum wage payment consistent with important roles for the forces emphasized by our conceptual framework. We harness measures of enforcement institutions and penalty regimes developed by Galvin (2016) in a recent contribution to the literature on labor law. In a cross-sectional analysis similar to Galvin's, we find that subminimum wage payment is most common when minimum wage rates are high and when enforcement provisions are weak.

We conclude by exploring whether enforcement regimes mediate the extent to which minimum wage hikes increase the prevalence of subminimum wage payment. We find that increases in subminimum wage payment are largest in states with relatively *strong* enforcement regimes. This is what our model predicts as the minimum wage begins to bind on the value of what workers produce. As the minimum wage crosses this threshold, workers may cease to desire its enforcement. Increases in avoidance and evasion can be large under strong enforcement regimes because evasion is more prevalent under weak enforcement regimes to begin with.

Our paper proceeds as follows. Section II presents a straightforward theory of minimum wage evasion and avoidance. Section III describes recent changes in states' minimum wage policy regimes. Section IV describes the data we analyze. Section V presents our empirical methodology. Sections VI and VII present our empirical analysis. Section VIII concludes.

Section II: Illustrative Framework

In this section we develop a simple framework that generates predictions for the relationship between the level of the minimum wage, the stringency of wage enforcement

provisions, and the prevalence of subminimum wage payment. The framework focuses on two sets of decisions—namely, firms' choices whether to comply with minimum wage laws and workers' choices whether to report noncomplying firms.

Before describing those choices, we present our approach to describing wage and employment determination. We rely on the framework we have deployed in complementary work on the employment effects of recent minimum wage changes (Clemens and Strain, 2017; 2018a).[8] Let the value of individual i's output to firms be a_i per hour, which represents the product of the quantity and market price of his or her output. Suppose that bargaining frictions, represented by θ_i, generate the possibility that firms pay workers wage rates that may be less than the value of their output ($\theta \leq 1$). We assume that firms employ all individuals they can hire at wage rates less than or equal to a_i, and that firms offer individual i a wage of $\theta_i a_i$ when they are unconstrained by the minimum wage.

The existence of subminimum wages implies that not all firms comply with minimum wage laws. In a complementary theoretical paper on minimum wage compliance, Yaniv (1994) breaks with earlier theoretical studies by emphasizing the complaint-driven nature of minimum wage enforcement. As Weil and Pyles (2005) report, roughly 78 percent of inspections conducted in 2004 by the Wage and Hour Division of the U.S. Department of Labor initiated from worker complaints. While this share has decreased in recent years, roughly half of all investigations originated from complaints in 2018 (DOL WHD, 2019). Like the framework we

[8] Our framework is also similar to that in Kreiner, Reck, and Skov (forthcoming), which studies the effect of youth minimum wages on youth employment in Denmark. A large discontinuity in Danish minimum wage regulation results in an average increase in hourly wage rates of 40 percent for workers when they turn 18 years old. Kreiner, Reck, and Skov find that this reduces employment (along the extensive margin) by one-third, driven by 18-year-olds losing their jobs.

develop here, Yaniv's framework allows an important role for the possibility that a worker would lose her job as their firm alters its employment decisions in response to minimum wage enforcement. In addition to complaint-driven inspections, random inspections have become an increasingly important enforcement mechanism. Our framework allows for both random and complaint-driven inspections.

For simplicity, assume that each firm employs one worker. If the minimum wage (w_{min}) binds and firms comply with minimum wage laws, a firm will continue to employ individual *i* so long as $a_i \geq w_{min}$. Assuming compliance, minimum wage rates between $\theta_i a_i$ and a_i will improve the worker's earnings. Over the region $\theta_i a_i < w_{min} < a_i$, the worker thus has an interest in ensuring compliance. A worker paid less than the minimum wage, but whose productivity exceeds the minimum wage, stands to gain from filing a complaint.[9]

Suppose, by contrast, that the minimum wage exceeds the value of the worker's output. The worker's decision to report a wage violation must account for the fact that the employer would no longer hire him or her if forced to pay the minimum wage. In this case, it may be in both the firm's and worker's interest to evade the law, because following the law would end the mutually beneficial employment relationship into which they had entered.

[9] We have simplified the problem by assuming each firm employs one worker, so that each worker's decision is equivalent to the decision of the firm's entire workforce. Allowing for multiple workers introduces a number of additional considerations. First, the complaint process could be modeled as a set of individual decisions or as a collective decision on the part of workers. Worker interactions must be taken into account. High-skilled workers might discourage low-skilled workers from complaining, for example, if a complaint would force the firm to shut down either permanently or temporarily. Whether the decision is taken collectively or individually, a single complaint would result in a firm-wide inspection. If the decision is individual, a large firm with many similarly underpaid workers will face a higher risk of complaint than a small firm if there is heterogeneity in workers' costs of filing a complaint (or in their intrinsic desire to call out wrongdoing as a whistle-blower). This would generate the empirically validated prediction that large firms will be more likely to comply with minimum wages than small firms (Garnero, 2018).

To further develop this framework, we make several simplifying assumptions regarding the information environment and the nature of employment relationships. First, we assume that firms and workers both know each worker's productivity. Second, we assume that all employment arrangements last for one period. Third, we assume that individuals will be unable to find employment, and know this, if their productivity is less than the minimum wage and they report an employer for a wage violation. Fourth, we assume that firms choose between offering an individual a wage of w_{min} or a wage of $\theta_i a_i$. In other words, we assume that firms do not partially comply with a binding minimum wage by adjusting the offered wage rate from the initial $\theta_i a_i$ to any value other than the minimum wage.[10]

Beyond the issues discussed above, there are several factors that might affect a worker's decision to report his or her employer for violating minimum wage laws. From the perspective of the worker, the decision may be affected by the costs of the reporting process, the generosity of financial rewards (or back-wage payment plus damages), and an intrinsic motivation to report lawbreaking. We summarize these factors with the parameter c_i.

In this environment, the worker would report his or her employer if the expected outcome resulting from enforcement is superior to receiving the wage of $\theta_i a_i$ for a period of employment. When compliance would not lead the worker to lose employment, the condition is whether $\theta_i a_i < w_{min} - c_i$. When compliance would lead the worker to lose employment, the condition is whether $\theta_i a_i < -c_i$. When compliance would result in the worker losing his or her job, he or she will only

[10] We could implicitly allow for partial compliance by allowing θ_i to vary over time, as well as across individuals and circumstances. For example, a change in the strength of the enforcement regime could, for some workers, increase the value of θ_i such that it is greater than the previous period's value but still less than one. This change in bargaining power could be thought of as partial compliance. Importantly, the basic intuition of the predictions of our illustrative framework are not dependent on assuming away partial compliance.

report underpayment if the financial rewards and intrinsic motivation for reporting are sufficiently large to compensate for lost wages from lost employment. The relevant conditions are summarized by: $\theta_i a_i < w_{min} \times 1\{a_i \geq w_{min}\} - c_i$.[11]

A complying firm's profit from employing individual i at the minimum wage is $a_i - w_{min}$. An evading firm's profit is $a_i - \theta_i a_i$ when evasion is successful. When caught, the firm pays a penalty of F and no production or wage payment takes place. We assume also that firm manager j has an intrinsic utility loss valued at I_j dollars from violating the law. Suppose for simplicity that violations are caught in 100 percent of cases in which the worker reports, and that violations are caught in fraction E of cases, due to random inspections, when no report is made. If fraction p of workers would report violations, where p is a function of individual-specific productivity and individual-specific costs and benefits of reporting violations, then the probability of the firm getting caught is $z = p + (1–p)E$. The expected value of evading is thus $(1 - z)[a_i - \theta_i a_i] - zF - I_j$, and the decision to evade rests on whether: $[a_i - w_{min}] < (1 - z)[a_i - \theta_i a_i] - zF - I_j$.

The implications of enforcement for the relationship between violation rates and minimum wage increases depend primarily on how increases in the minimum wage affect the above expression's left-hand side and p, the probability that the worker reports a violation, which in turn affects z. As the minimum wage rises, the profits earned through compliance decline, so the left-hand side is always decreasing in the minimum wage. Over an initial range, increases in the minimum wage increase the returns to the worker from reporting a violation, which increases

[11] Looking ahead, this expression provides insight into the potential role of the partial compliance behavior we have implicitly de-emphasized. Firms can use partial compliance to deter enforcement. Because they do not know each individual's cost of reporting, which includes an individual-specific preference component, partial compliance would be set to balance between the costs of higher wage payments and the benefit of reduced reporting, which will depend in turn on the local density of the distribution of the reporting cost term, c_i.

z. Because this decreases the right-hand side, the relationship between minimum wage increases and evasion rates is ambiguous over this range. Over a subsequent range, an increase in the minimum wage reduces the probability of the worker reporting because it would eliminate employment. Over this range, increases in the minimum wage thus lead unambiguously to increases in the violation rate.

Note that if penalties (F) and the random inspection rate (E) are trivial, it becomes more likely that evasion will be profitable for firms. If penalties and the random inspection rate are in a "moderate" range, then shifts in the probability of a worker reporting violations will be decisive. Consequently, the observed violation rate will tend to rise substantially when enforcement provisions are moderately strong and the minimum wage rises to become strongly binding, raising the likelihood that firms and workers will arrive at an understanding that subminimum wage payment is essential in order for employment to be sustained.[12]

The average degree of underpayment (conditional on a violation occurring) depends on the densities of the distributions of the productivity and bargaining parameters across all individuals for whom underpayment occurs. Further, it depends on patterns of partial compliance by firms, from which our analysis has largely abstracted. Our framework thus has weak predictions for underpayment's average severity.

[12] It is sometimes assumed that F, the penalty a firm pays when caught violating minimum wage regulation, is not large relative to the financial benefits from underpaying workers. Lott and Roberts (1995) find that F is larger than is typically thought. This is consistent with our finding that compliance with minimum wage regulation is more common than avoidance and evasion.

Section III: Background on Recent State Minimum Wage Changes

As we have noted in previous work (Clemens and Strain 2017, 2018a, 2018b), there was a pause in both state and federal efforts to increase minimum wages during the years immediately following the Great Recession. Since that pause, states' minimum wage policies have diverged. Many states have kept their minimum wage rates at the $7.25 federal minimum, while others have enacted increases ranging from less than $1 to in excess of $3. This policy environment provides an opportunity to conduct relatively transparent analyses of the extent to which firms have evaded these minimum wage changes.

We take two approaches to analyzing recent minimum wage variation. The first makes straightforward use of the level of each state's minimum wage on a monthly frequency. Our second approach divides states into qualitatively distinct policy regimes. We consider two alternative groupings, for which the full divisions of states are presented in main Table 1 and Appendix Table A1. The purpose, in both cases, is to allow estimates to vary with two dimensions of minimum wage policy that are of strong potential interest. The first dimension is whether the minimum wage increases were forecastable, as is the case when minimum wage changes are driven by inflation-indexing provisions. The second dimension involves a fuzzier distinction between "large" and "small" increases. We view these approaches as complementary.

Section IV: Data Sources

In this section we discuss the data sources and variables used in the analysis, including wage data, subminimum wage variables, macroeconomic data, and enforcement measures. The

latter comes from outside of the economics literature and may thus be less familiar to economists. We conclude the section with a brief discussion of summary statistics.

Wage data and other variables in the CPS MORG

We analyze data from several sources. Our wage data come from the Current Population Survey (CPS). We use several wage-related variables that are asked of individuals in two out of the eight interviews in which they participate in the CPS. The relevant interviews, during which respondents are asked supplemental questions about their earnings, take place at the end of each of two four-month waves of a respondent's participation. These interviews are collectively known as the Merged Outgoing Rotation Groups (MORG).

Several variables are relevant for estimating an individual's wage rate and for gauging the quality of the underlying data. The first key piece of information is an indicator for whether the respondents are paid on an hourly basis. When they are, the respondents are asked for their hourly wage rate. When they are not, hourly wage rates can be inferred by dividing the individual's usual weekly earnings by his or her usual weekly hours. While all the relevant information is subject to respondent reporting error, the potential for error will be greater when the hourly wage must be inferred from earnings and hours data because the hourly wage itself is not reported directly. Further, a nontrivial fraction of respondents elects not to report their earnings information when asked. The wage rates for these individuals are therefore imputed.

Our analysis tracks the relevance of several margins along which data limitations have the potential to inhibit our identification of wage underpayment. The first is the margin of whether the individual is an hourly worker. The second is the margin of whether the individual

has actually responded to the questions required to estimate their wage rates without imputation. The third is whether the individual receives tips or commissions, as tipped workers are typically exempt from states' general minimum wage. The fourth is whether the individual is in an occupation that may, for other reasons, be exempt from the Fair Labor Standards Act. The fifth is whether the individual lives in a state in which substate governments have enacted their own minimum wage rates.

Effective minimum wage rates

Our data on states' effective minimum wage rates draw on many sources. These include the comprehensive state-by-month minimum wage rates compiled in Clemens, Hobbs, and Strain (2018). These minimum wage rates have been checked against the complementary database of Vaghul and Zipperer (2019). Both databases draw on sources including the U.S. Department of Labor, the National Conference on State Legislatures, and myriad news articles, reports from state labor departments, and legislative texts.

Further, our analysis accounts for the fact that some workers may be exempt due to their occupation (under a duties test) or to their earnings. We obtain data on these exemptions from the Wage and Hour Division of the Department of Labor. We also account for the fact that substate minimum wage rates have become increasingly common in recent years. Our basic approach is to investigate whether our full-sample estimates are substantively altered by excluding observations that are potentially affected by these occupational exemptions or substate minimum wage rates.

Subminimum wages

For our analysis of subminimum wage payment, we follow Goraus-Tanska and Lewandowski (2016) in describing subminimum wage payment using two variables. The first is a simple indicator for subminimum wage payment. To avoid overstating the pervasiveness of subminimum wage payment due to modest reporting error, our primary measure is an indicator for whether the individual's self-reported wage is more than 25 cents less than the minimum wage effective in his or her state of residence during the relevant month.[13] The second is a continuous measure of the extent to which wage rates fall short of the legislated minimum. The first measure thus captures the extensive margin of subminimum wage payment, while the second measure incorporates both the intensive and extensive margins.

Macroeconomic variables

Our analysis incorporates data on macroeconomic covariates that may be relevant as control variables. Specifically, we assess whether macroeconomic conditions are biasing our estimates by tracking indicators of the performance of state-level housing markets, state aggregate income, and labor markets. We proxy for variations in housing markets using a statewide median house price index from the Federal Housing Finance Agency (FHFA). We proxy for aggregate economic performance using data on aggregate state income per capita from

[13] When the individual is an hourly worker, the relevant wage is his or her self-reported wage. When the individual is not an hourly worker, we calculate the wage as the individual's usual weekly earnings divided by his or her usual weekly hours. Because the inferred wage rates of non-hourly workers are more prone to reporting error, one of our key robustness checks involves restricting the analysis sample to hourly workers.

the Bureau of Economic Analysis (BEA). Finally, we proxy for variations in broader labor market developments using employment among skill groups that are not directly affected by the minimum wage. As shown in Clemens and Strain (2018b), it has tended to be the case that minimum wage increases have been enacted by states that have experienced relatively strong economic recoveries over the time period under analysis.

Enforcement measures

To analyze the relevance of states' minimum wage enforcement regimes, we make use of data presented and analyzed by Galvin (2016). Galvin presents information on a broad set of characteristics associated with minimum wage enforcement regimes. He then aggregates these characteristics into two indices, constructed to take values from 0 to 1. The first of these is based exclusively on the aspects of states' regimes that have bearing on the penalties faced by violators who are caught.[14] The second is Galvin's broadest enforcement index, which incorporates information on the authority and operation of state enforcement agencies, enforcement mechanisms, and the size of the penalties associated with minimum wage violations.[15] These indices are calculated based on states' regimes as of December, 31, 2013, which falls just before

[14] Galvin's penalty index includes information on the maximum value of damages, civil penalties, and administrative fees public agencies or private arbitration can order an employer to pay, as well as whether an offender can face civil and criminal charges because of a wage violation. The index also details which party carries the burden of proof: whether the employer must always prove their actions were not in retaliation for complaints regarding wages or working conditions, whether the state agency or private arbiter has discretion, or whether the employer must be found a willful or repeat offender.

[15] Galvin's broader enforcement index includes the measures in the penalties index and details regarding how state enforcement agencies operate. They include whether state administrative agencies have subpoena power, whether agencies must exhaust administrative processes before bringing a civil suit, whether they can issue wage orders or binding interpretations of regulations, whether they have power to issue final determinations, and whether states can seek remedies in civil court on behalf of an employee. The index also incorporates information on the duration of statutes of limitations, and the payment of attorney's fees.

the wave of minimum wage legislation around which we have built our analysis. The maps in Figures 2A and 2B illustrate how Galvin's enforcement indices vary across states.

Summary statistics

Table 2 presents summary statistics on our primary analysis samples. The data illustrate several key features of the samples we analyze and the environment in which we analyze them. Columns 1, 3, 5, and 7 present data from 2011 to 2013 — namely, the baseline period during which few minimum wage changes took place — while Columns 2, 4, 6, and 8 present data from 2016 to 2018. Data on house prices, employment, and aggregate income growth are indicative of the economic recovery that took place over this time period. Columns 1 and 2 present data on the full population ages 16 to 25, while Columns 3 and 4 restrict to the employed. Columns 5 and 6 restrict to individuals who were employed as hourly workers, who are not tipped workers, and who responded to questions related to their wage rates so that their wage rates are not imputed. Columns 7 and 8 drop individuals who live in states with substate, city-specific minimum wage rates,[16] along with workers who might be exempt from the minimum wage due to their occupation.[17]

[16] The states dropped are Arizona, California, Illinois, Iowa, Maine, Maryland, Minnesota, Nevada, New Mexico, New York, Oregon, Pennsylvania, and Washington.

[17] Department of Labor regulations exempt employees in certain "white collar" occupations from minimum wage requirements. To be considered exempt, employees must meet minimum requirements related to their primary job duties and, in most instances, must be salaried and must earn more than a minimum amount. DOL has assigned probabilities to occupations for whether employees in that occupation would pass the duties test and be exempted from minimum wage requirements, provided the employees also pass the salary and earnings requirements. We drop workers in any occupation who have a nonzero probability of being exempt, provided that the workers also were not paid by the hour and earned at least $455 per week.

Section V: Estimation Frameworks

This section walks through the empirical models we estimate. The initial analysis we present can be described as a difference-in-differences estimator that uses the policy groupings described in Section III and presented in detail in tables 1 and A1. The basic specification is presented in equation (1) below:

$$S_{i,s,t} = \sum_{p(t)\neq 0} \beta_{p(t)} Policy_s \times Post_{p(t)} + \alpha_{1s} State_s + \alpha_{2t} Time_t + X_{i,s,t}\,\gamma + \varepsilon_{i,s,t}, \qquad (1)$$

where $S_{i,s,t}$ is a binary indicator of whether individual *i*, living in state *s*, in time period *t* is working at a wage that is below his or her state's effective minimum wage rate. We use equation (1) to analyze additional outcomes including indicators as to whether an individual reports being employed, earning tips, working hourly, and whether the wage rate is imputed.

Like any standard difference-in-differences specification, equation (1) controls for sets of state and time fixed effects. The vector *X* contains sets of control variables that vary across the specifications we estimate. In our most-controlled specification, it contains the median house price index, the log of aggregate personal income per capita, employment rates among individuals more skilled than those in the analysis sample, and individual-level demographic characteristics.

We use $Policy_s$ to represent binary indicators for whether a state fits into a given policy group. As discussed above, we differentiate among states that increased their minimum wage rates due to inflation-indexing provisions, states that enacted large statutory increases, and states that enacted small statutory increases. The coefficients of interest, $\beta_{p(t)}$, describe whether the incidence of subminimum wage payment rose more, less, or roughly the same in the active

policy regimes relative to states in which no minimum wage increases occurred. Comparisons of the point estimates associated with different policy groups (e.g., the inflation-indexing group vs. the group that enacted large new statutory increases) provide evidence on whether states that enacted alternative forms of minimum wage increases had different experiences.

The estimates of interest will be biased if the policy groups experienced differential shocks in factors that exert independent influence on subminimum wage payment. We thus investigate whether our estimates are robust to controlling for macroeconomic and demographic covariates. To capture the "medium-run" relationship between minimum wage increases and the incidence of subminimum wage payment, we exclude data from 2014 and 2015 from the samples on which we estimate equation (1). We thus estimate differential changes from a baseline period consisting of 2011–2013 to an end line consisting of 2016–2018.

We next implement a specification that harnesses all continuous variation in state minimum wage rates. The specification is in equation (2) below:

$$S_{i,s,t} = \beta_1 MW_{s,t} + \alpha_{1s}\, State_s + \alpha_{2t}\, Time_t + X_{i,s,t}\,\gamma + \varepsilon_{i,s,t}. \qquad (2)$$

The dependent variable in equation (2) is a binary indicator of whether individual *i*, living in state *s*, in year *t* is working at a wage that is below his or her state's effective minimum wage rate. The key difference between β_1 and $\beta_{p(t)}$ from equation (1) is that the minimum wage variable $MW_{s,t}$ is continuous and contemporaneous. We use data for all years from 2011 through 2018 to estimate this equation. The effects captured by equation (2) are thus "contemporaneous" and are "per dollar of minimum wage increase." We also use equation (2) to analyze effects on hourly wages.

After using equations (1) and (2) to estimate the overall pervasiveness of subminimum wage payment in response to recent minimum wage changes, we estimate two equations that focus on our conceptual framework's predictions for the role of minimum wage enforcement regimes. For this analysis, we first estimate a baseline relationship to generate descriptive facts regarding the prevalence of subminimum wage payment and its correlation with both the level of the minimum wage and the stringency of states' enforcement regimes. That is, we estimate

$$S_{i,s,t} = \beta_1 MW_s + \beta_2 Enforcement\ Index_s + X_{i,s,t}\,\gamma + \alpha_t\, Time_t + \varepsilon_{i,s,t}. \qquad (3)$$

We estimate equation (3) on data extending from 2011 to 2013. We describe β_1 and β_2 as capturing cross-sectional relationships between our policy variables and subminimum wage payment. From 2011 to 2013, variation in the minimum wage and the enforcement index is cross-sectional with the exception of several inflation-indexed minimum wage changes.

Finally, we investigate whether states' enforcement regimes mediate the extent of subminimum wage payment on the margin. To do so we interact the enforcement index with the contemporaneous minimum wage and estimate:

$$S_{i,s,t} = \beta_1 MW_{s,t} + \beta_2 Enforcement\ Index_s \times MW_{s,t} + \alpha_{1s}\, State_s + \alpha_{2t}\, Time_t + X_{i,s,t}\,\gamma + \varepsilon_{i,s,t}. \qquad (4)$$

The estimate of β_2 provides evidence on whether the strength of the relationship between minimum wage increases and subminimum wage payment varies across enforcement regimes.

Section VI: Analysis of Subminimum Wage Payment on the Margin

In this section we present results from the analyses described above. We begin by presenting simple time series variation in rates of subminimum wage payment. We then present regression estimates of equations (1) through (4).

Initial evidence on the evolution of subminimum wage payment across minimum wage regimes

Figures 3 and 4 provide a graphical look at the data underlying our analysis. The figures report time series separately for the groups we categorize as "no changers," "small changers," "large changers," and "indexers" in Table 1. Table 3 supplements the time series in Figures 3 and 4 with tabulations and calculations of changes from a baseline period including 2011–2013 to an end line period including 2016–2018. The tabulations in Column 4 of Table 3 are unadjusted difference-in-differences estimates of the effects of this period's minimum wage changes.

Figure 3 presents data on the fraction of individuals who report working for wage rates that are at least 25 cents less than their respective states' effective minimum wage rates. Panels A through D present data on several subsamples of the CPS MORG files. The "full sample" in Panel A consists of all employed individuals ages 16 to 25. The sample in Panel B is restricted to 16- to 25-year-olds who were employed and who report working on an un-tipped hourly wage basis (rather than on salary). The sample in Panel C is restricted to workers who, in addition to being paid hourly, responded to the survey's wage questions such that no imputations were required. Finally the sample in Panel D is restricted to workers who additionally did not live in a

state with substate minimum wage rates and did not work in an occupation exempt from the federal minimum wage according to the Fair Labor Standards Act.

Two consistent patterns emerge across the panels of Figure 3. First, states that enacted minimum wage increases through new legislation experienced substantial increases in the incidence of subminimum wage payment across all the samples we analyze. The consistency of this result across samples is important because it ensures that this finding is not driven by a tendency for the BLS's imputation procedures to erroneously assign wage rates that are above the federal minimum wage but below the minimum wage applicable in the state in which an individual is employed. Our restrictions also ensure that the changes we observe are not driven by shifts across the margin between hourly wage arrangements and salaried work or by shifts into or out of tipped arrangements.

Second, we find that states that index their minimum wage rates for inflation have experienced no increase in the incidence of subminimum wage payment. Indeed, the prevalence of subminimum wage payment may have modestly decreased in these states, even as their minimum wage rates have risen. Both the high baseline and the lack of increase in subminimum wage payment in states that index their minimum wage rates for inflation are consistent with forward-looking behavior on the part of firms, which expect an indexed increase to be "permanent," and not eroded over time by price inflation (Brummund and Strain, forthcoming).

Figure 4 presents similarly constructed series that describe the average size of the distance between an individual's wage and the effective minimum wage. These series thus augment those in the previous figure in that they account for the severity of subminimum wage payment. The patterns visible in Figure 4 are broadly similar to those observed in Figure 3. That

is, the patterns we observe along the extensive margin of subminimum wage payment (Figure 3) are quite similar to the patterns we observe for the intensive and extensive margins combined (Figure 4). Appendix Figures A1 and A2 show that the patterns we observe in Figures 3 and 4 are little changed by shifting to the categorization of states presented in appendix Table A1. This reveals that the qualitative patterns we observe are not substantially altered by modest differences in the timing of various states' minimum wage increases.

Regression estimates of the pervasiveness of subminimum wage payment on the margin

This section presents estimates of equations (1) and (2). These regression models allow us to estimate the extent to which the incidence of subminimum wage payment expands as the minimum wage rises and to place confidence bands on our estimates. Further, they provide a framework for investigating whether our estimates are sensitive to controlling for variations in states' macroeconomic conditions, for the individual-level demographic characteristics of the individuals in each sample, and, importantly in this setting, for margins that may contribute to measurement error.

Our initial regression analysis closely tracks the presentation of the data in Figures 3 and 4. Specifically, Tables 4 and 5 present estimates of equation (1). As in Figures 3 and 4, we allow the estimates to differ across the states we categorize in Table 1 as "indexers," "small statutory increasers," and "large statutory increasers." The estimates show that subminimum wage payment rose substantially in states that increased their minimum wage rates through new legislation relative to those that did not increase their minimum wage rates. There was no relative

increase in the prevalence of subminimum wage payment in states that increased their minimum wage rates through inflation-indexing provisions.

The distinction between inflation-indexed minimum wage changes and new statutory minimum wage increases has important economic content. Inflation-indexation provisions enable firms and workers to forecast modest minimum wage increases well in advance. Under these conditions, the wage data reveal that firms and workers largely avoid increases in the number of instances in which workers receive subminimum wage payment. Instead, we find that they coordinate around the minimum wage itself. Appendix Table A2 reveals directly, for example, that each dollar of minimum wage increase due to inflation-indexation provisions generates a far larger increase in the fraction of workers who report making exactly the minimum wage. As discussed in more detail below, this is a key feature of the data that is at odds with leading models of measurement error.

The columns of Table 4 show the qualitative robustness of our results across two key margins. First, comparing Columns 1 and 2 reveals that the estimates are little affected by including either a detailed set of demographic control variables or by controlling for proxies for developments in states' labor markets, housing markets, and general macroeconomic conditions. Second, the remaining columns present evidence on the relevance of margins that complicate the measurement of subminimum wage payment. Moving from Columns 1 and 2 to Columns 3 and 4, we restrict the sample to individuals who report being un-tipped hourly wage earners rather than salaried employees. The estimates rise moderately, reflecting that minimum and near-minimum wage payment is more common among hourly wage earners than among salaried workers. In Columns 5 and 6 we remove all individuals with imputed wage values. The point

estimates decline moderately, likely because a moderate amount of reported subminimum wage payment stems from imputation-driven measurement error. Finally, in Columns 7 and 8, we remove all individuals living in states with substate minimum wage rates, as well as workers who may be exempt from the federal minimum wage due to their occupation. Relative to Columns 5 and 6, some estimates of interest decline in magnitude while others rise. These final restrictions thus have little net effect on the implied relationship between minimum wage increases and the prevalence of subminimum wage payment.

On the most restricted sample, we estimate a 7.2 percentage point increase (averaged across the specifications in Columns 7 and 8) in the probability that an individual reports earning a subminimum wage in states that enacted large minimum wage increases relative to states that enacted no minimum wage increases. Across all subsamples, the relationship between statutory minimum wage increases and subminimum wage payment is strongly positive, while inflation-indexed minimum wage changes have no detectable effect on subminimum wage payment.

Table 5 presents evidence on whether the selection margins explored above were, themselves, responsive to this period's minimum wage changes. The table reports several findings of interest. First, neither indexed minimum wage increases nor small minimum wage increases had statistically significant relationships with employment, employment in tipped or otherwise exempt occupations, employment as hourly rather than salaried workers, nonresponse to the CPS's wage questions, or residence in states with substate, city-specific minimum wage rates. Second, large minimum wage changes have no detectable relationship with probabilities of employment in tipped occupations, imputed wage rates, residence in a state with substate minimum wage, or working in an occupation that is potentially exempt from the minimum wage.

Third, employment of individuals ages 16 to 25 is negatively correlated with large minimum wage increases in the specification that controls for variations in states' macroeconomic conditions, but has no relationship with minimum wage changes in the specification that includes no such controls. The same is true for estimates of the effect of large minimum wage changes on the probability of employment as an hourly wage worker.

Our employment estimates can be compared to those reported in our earlier work (Clemens and Strain 2018a) for samples consisting of individuals ages 16 to 21 on data that extend through 2016. The estimates' sensitivity to the inclusion of controls for states' overall economic conditions is quite similar to what we find in our earlier work. As shown in that work in greater detail, this reflects that overall economic growth, employment of high-skilled groups, and house price appreciation have been stronger in states that enacted large minimum wage changes than in those that enacted no minimum wage changes. Controlling for these factors thus generates more negative estimates. For interpreting results in the analysis presented here, the key point to bear in mind is that the increase in subminimum wage payment in states that enacted large minimum wage increases would likely, if anything, have been larger had there been no changes in low-skilled groups' employment. In our model, this reflects that the individuals who are prone to losing employment following a minimum wage increase will tend to be those who, under weaker enforcement regimes, could retain employment at a subminimum wage rate.

Table 6 presents estimates of equation (2), which differs from equation (1) in that we code minimum wage variation continuously rather than using categorical policy groupings. The samples for this analysis include all years from 2011 to 2018. The estimates describe the marginal "leakage" of intended wage gains due to subminimum wage payment.

Table 6 shows patterns in the evolution of subminimum wage payment that are quite similar to the patterns presented in Table 4. The relationship between subminimum wage payment and the level of the minimum wage is disproportionately concentrated among individuals paid as hourly workers. Estimates thus rise as we look from Columns 1 and 2 to Columns 3 and 4. Further, estimates will tend to be overstated when samples include individuals whose wage rates were imputed or individuals who may not be subject to the effective minimum wage because of their location or occupation. Estimates thus decline as we shift from Columns 3 and 4 to Columns 5 through 8. In our most restrictive samples, reported in Columns 7 and 8, we find that a one-dollar minimum wage increase predicts, on average, a 3.2 percentage point increase in the probability of earning a wage more than 25 cents below their state's effective minimum wage.

Table 7 presents estimates of equation (2), for which the dependent variable describes underpayment on a continuous basis. As with Table 6, the relationship between the amount of underpayment and minimum wage levels is strongest among hourly workers, as reported in Columns 3 and 4. The estimates attenuate when we exclude individuals with imputed wages, falling roughly in half. This suggests that the bias from imputations is relatively stronger for the continuous outcome. Interestingly, the relationship strengthens slightly when we remove individuals who are potentially exempt from the minimum wage due to their occupation or who are potentially subject to a substate minimum wage. In our most restrictive specification, presented in Column 8, we observe that a one-dollar minimum wage increase predicts an increase in underpayment of roughly 4 cents.

Further investigation of measurement error

We selected our baseline analysis sample with a goal of reducing the scope for measurement error to affect our estimates. Even so, measurement error remains a source of potential concern. A productive inquiry into measurement error's potential role requires placing structure on the measurement error one wishes to investigate. We proceed along these lines by investigating whether our results can be explained by the measurement error model proposed by Autor, Manning, and Smith (2016). Those authors (hereafter, AMS) propose a model of measurement error to investigate the question of whether measurement error can account for apparent positive spillovers in earnings from minimum wage increases.

In Appendix 2, we investigate whether the AMS measurement error model can reproduce key patterns in the underpayment we observe in the data. We show that the AMS measurement error model fails to match key patterns in the wage distributions we observe. First, it significantly understates the magnitude of measured underpayment relative to the magnitude of measured positive spillovers. Further, it cannot explain a striking difference we observe when comparing states that have indexed their minimum wage rates for inflation to states that enacted minimum wage changes through new legislation.

As shown in Table 4, we find substantial differences in self-reported underpayment in states that index their minimum wage rates for inflation relative to states that enacted higher minimum wage rates through new legislation. Pure measurement error in self-reported wage rates should not differ systematically between respondents in states that do and do not index minimum wage rates for inflation. Measurement error thus provides no rationale for the finding that firms and workers comply to a far greater degree with minimum wage increases that are

modest and forecastable than with minimum wage increases enacted through new legislation. An economic model in which firms and workers prefer to arrange their affairs to avoid breaking the law, however, can readily make sense of this difference.

In addition, the results in Appendix Table A2 reveal that wages in states with inflation indexation provisions are more likely than wages in states with new minimum wage legislation to coordinate around the minimum wage itself. This cuts directly against standard models of measurement error. Inflation-indexed minimum wage changes tend to take irregular values while new statutes tend to call for round numbers. The findings in Table A2 thus contrast with research on measurement error that shows survey respondents tend to be far more capable of recalling round numbers (Schwabish, 2007; Gideon, Helppie-McFall, and Hsu 2017). Measurement error would tend to imply less faithful tracking of wage rates to the minimum under inflation-indexing regimes. We observe the opposite.

Estimating the aggregate subminimum wage payment associated with recent minimum wage increases

In this section we extrapolate from our regression estimates to gauge the aggregate prevalence of subminimum wage payment as a response to recent minimum wage increases. That is, we attempt to estimate how much higher the national wage bill would have been under two conditions. The first condition is that subminimum wages be lifted to the effective minimum wage. The second condition is that the affected individuals continue to be employed.

While this might sound like a straightforward exercise, arriving at the desired estimates requires many assumptions. With regard to regression estimates, we conduct the following

exercise. We run regressions of the same form as those presented in the Table 7 alongside estimates of the minimum wage's effects on wage rates. A comparison of the resulting estimates allows us to compare the relative magnitudes of underpayment and realized wage gains.

Several additional aspects of the problem must be considered. First, how many individuals in the U.S. population would be affected? Answering this question requires applying sample weights. Importantly, we must consider whether we want our estimates to apply to individuals for whom wage rates had to be imputed. An "upper bound" estimate could incorporate these individuals, while a "lower bound" estimate would exclude them. Second, we must consider the robustness of the underlying estimates to the steps we have taken to control for variations in states' macroeconomic conditions. Third, to arrive at an annual wage bill estimate, we must estimate the average annual hours of work of individuals whose wage rates would be increased by full enforcement.

The regression estimates relevant to our extrapolation exercise can be found in Table 8. In this table, we present estimates of the dollar value of both the wage gains and increases in subminimum wage payment that were associated with each dollar of increase in the minimum wage. To prevent the estimated wage gains from being driven by wage values that could not plausibly be affected by the minimum wage, we censor our hourly wage variable at $15. This moderately reduces the estimated wage increase in some specifications. Columns 1 and 2 present estimates for individuals ages 16 to 25, Columns 3 and 4 expand the sample to include individuals ages 16 to 35, and Columns 5 and 6 expand the sample to include ages 16 to 65.

When analyzing our baseline samples (hourly workers whose wage rates were not imputed by BLS and who do not receive tips) of individuals ages 16 to 25, we estimate that each

dollar of minimum wage increase generates an hourly wage gain of roughly 27 cents. This estimate is relatively insensitive to whether the specification includes our sets of controls for the demographics of individuals in the sample or for changes in each state's macroeconomic conditions. When we turn to estimates that capture both the pervasiveness and severity of subminimum wage payment, we find that each dollar of minimum wage increase predicts, on average, a 3.8 cent increase in subminimum wage payment. In these particular specifications, increases in subminimum wage payment are about 14 percent of the estimated wage gains. On the sample of individuals ages 16 to 35, as reported in Columns 3 and 4 of Table 8, the corresponding values are 14.9 cents and 2.9 cents, so that underpayment corresponds with roughly 19 percent of estimated wage gains. On the sample of individuals ages 16 to 65, as reported in Columns 5 and 6 of Table 8, the corresponding numbers are 8.9 cents and 1.9 cents, so that underpayment corresponds with just under 22 percent of estimated wage gains.

Our preferred estimates of the aggregate implications of subminimum wage payment apply directly to the samples of hourly wage workers who do not receive tips, commissions, or overtime and for whom no data imputations are required. Sample weights imply that this sample represented 36.6 million individuals ages 16 to 65 in January 2011. (There were an estimated 59.7 million hourly wage workers in total, of whom the observations representing 23.1 million have imputed wage data.) On average across this full sample, a dollar of minimum wage increase predicts an additional 1.9 cent increase in subminimum wage payment. With these individuals working an average of 35 hours per week, increases in subminimum wage payment imply that wages were roughly 67 cents per week lower, on average, for the 36.6 million individuals in question. Multiplied by 52 weeks per year, the total increase in underpayment per dollar of minimum wage increase totals roughly $1.3 billion nationwide (36.6 million x 52 weeks x 35

hours x 1.9 cents in underpayment per hour). If this estimate is extrapolated to all 59.7 million un-tipped hourly wage workers, the total implied increase in underpayment per dollar of minimum wage increase would be about $2.1 billion ($1.3 billion x 59.7/36.6).

Subminimum wage payment is concentrated among relatively young hourly wage workers. The sample of hourly workers ages 16 to 25 with non-imputed wages, for example, accounts for roughly 8.8 million workers. On this sample, a dollar of minimum wage increase predicts an increase in subminimum wage payment of roughly 3.8 cents. This sample accounts for roughly $608 million (47 percent) of the aggregate subminimum wage payment we estimate for the full working-age population.

The sample of hourly workers ages 16 to 35 with non-imputed wages accounts for roughly 17.6 million workers. On this sample, a dollar of minimum wage increase predicts an increase in subminimum wage payment of roughly 2.9 cents. In total, this sample accounts for roughly $916 million (71 percent) of the subminimum wage payment we estimate.

Per dollar of minimum wage increase, the wage bill gains we estimate for those who are employed are roughly $6.15 billion for the samples ages 16 to 65, $4.8 billion for the samples ages 16 to 35, and $4.6 billion for the samples ages 16 to 25. Increases in subminimum wage payment are thus equivalent to roughly 21 percent of the wage gains for the full working-age population, roughly 16 percent of the wage gains for the population ages 16 to 35, and roughly 14 percent of the increase for the population ages 16 to 25.

Section VII: Evidence on the Economics of the Effects of Enforcement Regimes on the Prevalence of Subminimum Wage Payment

This section presents evidence on the economics of the relationship between subminimum wage payment and the stringency of states' minimum wage enforcement regimes. The model presented in Section II highlighted that the effects of enforcement regimes may differ with regard to their effects on overall rates of subminimum wage payment and their effects on subminimum wage payment on the margin. We thus begin this section with an exploration of the cross-sectional relationship between enforcement regimes and rates of subminimum wage payment. We then analyze the manner in which enforcement regimes mediate the pervasiveness of subminimum wage payment on the margin.

Cross-sectional evidence on the relevance of enforcement regimes

This section presents estimates of equation (3), which describes the baseline relationship between subminimum wage payment, the level of the minimum wage, and the stringency of a state's minimum wage enforcement provisions. These estimates appear in Table 9. Because the estimates are purely cross-sectional, they are prone to a variety of biases that our panel empirical methods are designed to address. We thus emphasize a descriptive interpretation of the estimates. Consistent with the framework from Section II, we find that the incidence of subminimum wage payment is positively correlated with the level of the minimum wage and negatively correlated with the stringency of a state's enforcement institutions.

The estimates on the effective minimum wage imply that a one-dollar difference in the minimum wage predicts a 2.7 percentage point difference in the probability that individuals report making a subminimum wage. This is modestly smaller than the estimates we obtain using panel variation. The magnitude of the point estimate on the Galvin enforcement indices varies depending on whether the level of the effective minimum wage is included in the specification. Looking to the point estimate from Column 5, the estimate of –0.0388 implies that moving from an enforcement index of 0 to an enforcement index of 1 would predict a 3.9 percentage point difference in the probability that an individual reports earning a subminimum wage. While the economic magnitude of this difference is substantial, the estimate lacks precision. Because most states' indices lie between 0.05 and 0.55, moving from the low to the high end of the range would predict a roughly 1.9 percentage point difference in the probability of reporting a subminimum wage. The estimate from the broader enforcement index, reported in Column 4, is somewhat larger in magnitude.

Analysis of whether enforcement regimes mediate non-compliance responses on the margin

Finally, we turn to estimates of equation (4), through which we investigate whether there is evidence that states' enforcement regimes mediate the responsiveness of subminimum wage payment to minimum wage increases. Table 10 presents estimates of equation (4), which utilizes the full scope of the available variations in states' minimum wage rates. We find that increases in the minimum wage predict increases in the prevalence of subminimum wage payment, and they do so to a greater degree in states with strong enforcement regimes than in states with weak enforcement regimes. This is consistent with our model's prediction for cases in which minimum

wage increases bind on the value of what some workers produce and, as a consequence, these workers cease to pursue enforcement. The increase in subminimum wage payment can be larger in such cases because its prevalence is lower under relatively strict enforcement regimes at baseline.

Our estimates on interactions between the minimum wage and enforcement provisions are statistically weaker in Columns 5–8 than in Columns 1–4. The dependent variable in the latter columns is our continuous measure of subminimum wage payment, while the dependent variable in the former columns is our binary indicator for subminimum wage payment. It is not obvious, in light of the standard errors associated with each estimate, whether these differences ought to be viewed as economically and statistically substantial. The lack of statistical significance in Columns 5–8 tempers the strength of the conclusions we are able to draw based on this evidence.

Section VIII: Discussion and Conclusion

A holistic assessment of the labor market effects of minimum wage regulation requires understanding employer compliance. This paper attempts to further economists' understanding of subminimum wage payment by investigating two key issues. We first study the extent to which subminimum wage payment rises in response to increases in the minimum wage. We then study how the strength of enforcement regimes affects the prevalence of subminimum wage payment.

We find strong evidence that higher minimum wages lead to a greater prevalence of subminimum wage payment. We consistently estimate that increases in measured subminimum wage payment average between 14 and 22 percent of realized wage gains following minimum wage increases. We interpret this as evidence that minimum wage evasion and avoidance are an important reality in the low-wage labor market.

Using measures of enforcement institutions developed by Galvin (2016), we find that strong enforcement regimes predict relatively lower rates of subminimum wage payment. In states with strong enforcement regimes, we also find that increases in minimum wages lead to more substantial increases in subminimum wage payment. As detailed above, our theoretical framework suggests that this finding may reflect the dynamics of compliance, reporting, and enforcement as the minimum wage becomes increasingly binding.

The key limitation facing our analysis involves the measurement error inherent in self-reported wages. As discussed above, we carefully consider the potential relevance of several margins that would tend to exacerbate measurement error's severity. Although these margins pose difficulties for estimating the overall prevalence of subminimum wage payment, we emphasize that they need not bias efforts, like ours, to analyze the causes of changes in subminimum wage payment's prevalence on the margin. While we are able to provide some evidence on the key assumptions that underlie our estimates, however, it is not scientifically possible to rule out a role for measurement error. This reflects the fact that, in the abstract, "measurement error" has insufficient empirical content to be testable. Nonetheless, we are able to demonstrate that a leading model of measurement error is unable to produce key features of the subminimum wage payment we observe.

Our results suggest that minimum wage increases both raise wages among the employed and increase the prevalence of subminimum wage payment. Aggressive measures to enforce compliance may reduce evasion, but may also risk reducing employment. These considerations point to a tension policymakers must weigh as they debate the appropriate level of the statutory wage floor. The rule of law requires that employers pay workers what they are owed under minimum wage regulations. At the same time, strict enforcement of the minimum wage may preclude some workers and employers from entering into mutually beneficial contracts. Put differently, evasion may, in some cases, mitigate the minimum wage's employment effects. The trade-off between short-run economic efficiency and respect for the rule of law is not one to be taken lightly. Our findings highlight that an appreciation of this trade-off, along with empirical assessments of the prevalence and drivers of subminimum wage payment, is important in fully evaluating the labor market effects of minimum wages.

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Table 1: List of States with Statutory Minimum Wage Increases and Inflation-Indexed Increases Using Changes from 2013 to 2015 and $1 Cutoff

Statutory increasers of $1 or more	Statutory increasers under $1
Alaska	Arkansas
California	Connecticut
District of Columbia	Delaware
Massachusetts	Hawaii
New Jersey	Maryland
New York	Michigan
Rhode Island	Minnesota
South Dakota	Nebraska
	West Virginia
Indexers	
Arizona	
Colorado	
Florida	
Missouri	
Montana	
Ohio	
Oregon	
Vermont	
Washington	

Notes: Data on minimum wage indexing provisions come from the National Council of State Legislatures. The states labeled as "indexers" link annual updates to their minimum wage rates to a measure of inflation. Data on minimum wage changes come from the U.S. Department of Labor. States are counted as statutory increasers of under $1 if the combined statutory increase in the minimum wage from January 1, 2013, through January 1, 2015, was under $1. States are counted as statutory increasers of $1 or more if the combined statutory increase in the minimum wage was $1 or more.

Table 2: Sample Summary Statistics: CPS MORG and Supplemental Data for 2011–2013 and 2016–2018

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Years	2011–2013	2016–2018	2011–2013	2016–2018	2011–2013	2016–2018	2011–2013	2016–2018
Sample	Ages 16–25		Employed Ages 16–25		Hourly Not Imputed		Hourly Not Imputed No Subrates No Exempt	
Paid Subminimum Wage	0.0317	0.0418	0.0655	0.0792	0.0599	0.0678	0.0692	0.0645
	(0.175)	(0.200)	(0.247)	(0.270)	(0.237)	(0.251)	(0.254)	(0.246)
Subminimum Payment ($)	0.0401	0.0642	0.0845	0.124	0.0499	0.0607	0.0634	0.0604
	(0.360)	(0.464)	(0.519)	(0.638)	(0.387)	(0.400)	(0.452)	(0.434)
Employment	0.484	0.528	1	1	1	1	1	1
	(0.500)	(0.499)	(0)	(0)	(0)	(0)	(0)	(0)
Age	20.50	20.53	21.66	21.64	21.23	21.11	20.97	20.78
	(2.873)	(2.916)	(2.477)	(2.557)	(2.506)	(2.616)	(2.508)	(2.625)
Black	0.152	0.151	0.117	0.133	0.118	0.127	0.144	0.152
	(0.359)	(0.358)	(0.321)	(0.340)	(0.322)	(0.333)	(0.351)	(0.359)
High School Degree	0.243	0.252	0.278	0.296	0.292	0.300	0.313	0.313
	(0.429)	(0.434)	(0.448)	(0.457)	(0.455)	(0.458)	(0.464)	(0.464)
Some College Education	0.333	0.323	0.406	0.376	0.430	0.406	0.419	0.393
	(0.471)	(0.468)	(0.491)	(0.484)	(0.495)	(0.491)	(0.493)	(0.488)
Galvin Enforcement Index	0.245	0.243	0.245	0.243	0.248	0.247	0.210	0.211
	(0.0904)	(0.0900)	(0.0884)	(0.0882)	(0.0880)	(0.0852)	(0.0827)	(0.0794)
Galvin Only Penalties Index	0.286	0.283	0.285	0.282	0.291	0.288	0.243	0.243
	(0.138)	(0.137)	(0.135)	(0.134)	(0.135)	(0.131)	(0.124)	(0.120)
House Price Index	332.7	423.8	329.5	419.1	324.1	410.9	291.0	359.0
	(102.9)	(135.0)	(101.1)	(132.6)	(96.36)	(128.1)	(85.49)	(99.73)
Income per Capita ($1,000s)	44.20	51.79	44.16	51.54	43.85	51.08	42.10	48.14
	(6.476)	(8.319)	(6.389)	(8.114)	(6.153)	(7.734)	(6.267)	(6.827)
Effective Minimum Wage ($)	7.542	8.479	7.532	8.441	7.540	8.414	7.375	7.833
	(0.426)	(1.310)	(0.423)	(1.296)	(0.433)	(1.285)	(0.244)	(0.876)
Observations	149,893	137,918	73,733	72,521	34,399	31,059	20,352	18,247

Notes: This table reports summary statistics for four sample groups. Columns 1 and 2 report averages and standard deviations (in parentheses) of each of the variables for our full sample of individuals ages 16 to 25. Columns 3 and 4 report averages and standard deviations (in parentheses) for our subsample of employed individuals ages 16 to 25. Columns 5 and 6 report averages and standard deviations (in parentheses) for our restricted subsample of employed individuals ages 16 to 25 who are paid by the hour; do not receive tips, commissions, or overtime; and do not have imputed wage rates. Columns 7 and 8 report averages and standard deviations (in parentheses) for our most restricted subsample of employed individuals ages 16 to 25 who are paid by the hour; do not receive tips, commissions, or overtime; do not have imputed wage rates; do not live in states with substate minimum wage rates; and do not work in occupations potentially exempt from the minimum wage. Entries for employment, age, race, and education summarize data from the Current Population Survey Merged Outgoing Rotation Groups (CPS MORG). The enforcement and only penalties indices come from Galvin (2016) and are discussed further in the paper. The house price index variable uses data from the quarterly all transactions state index published by the Federal Housing Finance Agency (FHFA). The income per capita variable uses quarterly data by state from the Bureau of Economic Analysis (BEA). The effective minimum wage variable is the maximum of the state and federal minimum wage for large employers and comes primarily from the National Conference of State Legislatures and the U.S. Department of Labor.

Table 3: Unadjusted Differences Across Policy Regimes Using CPS MORG Data for 2011–2013 and 2016–2018

	(1)	(2)	(3)	(4)
	2011–2013	2016–2018	Change	Change Relative to Non-Increasers
Paid Subminimum Wage				
Non-Increasers	0.0264	0.0148	–0.012	
Indexers	0.0598	0.0538	–0.006	0.006
Increase < $1	0.0295	0.0692	0.040	0.051
Increase >= $1	0.0221	0.0715	0.049	0.061
Subminimum Payment ($)				
Non-Increasers	0.0390	0.0311	–0.008	
Indexers	0.0534	0.0655	0.012	0.020
Increase < $1	0.0385	0.0840	0.046	0.053
Increase >= $1	0.0335	0.117	0.084	0.091
Employment Ages 16–25				
Non-Increasers	0.496	0.538	0.042	
Indexers	0.497	0.549	0.052	0.010
Increase < $1	0.516	0.558	0.042	0.007
Increase >= $1	0.440	0.479	0.039	–0.004
Prime-Age Employment				
Non-Increasers	0.760	0.786	0.026	
Indexers	0.757	0.791	0.034	0.008
Increase < $1	0.770	0.803	0.033	0.007
Increase >= $1	0.746	0.780	0.034	0.008
House Price Index				
Non-Increasers	280.0	340.4	60.4	
Indexers	291.1	410.6	119.5	59.1
Increase < $1	305.0	365.6	60.6	0.2
Increase >= $1	466.4	614.5	148.1	87.7
Income per Capita ($1,000s)				
Non-Increasers	41.24	47.31	6.07	
Indexers	40.94	48.43	7.49	1.42
Increase < $1	45.45	52.53	7.08	1.01
Increase >= $1	51.21	62.44	11.23	5.16

Notes: This table reports changes in employment rates and subminimum wage payment for each of our four policy groups (non-increasers, indexers, increase < $1, and increase >= $1) between our pre and post periods. Prime-age adults are defined as individuals between the ages of 26 and 54. This table also reports mean values of economic control variables (house price index and income per capita) for each of our four policy groups. Data sources are more fully described in the note to Table 2. Column 1 reports the average value between 2011 and 2013 for each row, Column 2 reports the average value for 2016–2018, and Column 3 reports the difference between the two. Column 4 reports the change in the average value for each row relative to the relevant non-increaser value. Averages are weighted by state population.

Table 4: Relationship Between Minimum Wage Increases and Probability of Subminimum Wage Payment Across Samples of the CPS MORG Using Minimum Wage Policy Categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	Employed		Hourly		Not Imputed		Not Imputed No Subrates or Exempt	
Large Statutory Increaser x Post	0.1102***	0.0911***	0.1445***	0.1186***	0.0906***	0.0603***	0.0724***	0.0706***
	(0.009)	(0.011)	(0.010)	(0.013)	(0.011)	(0.010)	(0.007)	(0.007)
Small Statutory Increaser x Post	0.0790***	0.0783***	0.1015***	0.1000***	0.0750***	0.0720***	0.0602***	0.0604***
	(0.010)	(0.010)	(0.014)	(0.013)	(0.011)	(0.010)	(0.006)	(0.007)
Indexer x Post	0.0114	–0.0023	0.0138	–0.0034	0.0033	–0.0141	–0.0181	–0.0215*
	(0.012)	(0.010)	(0.018)	(0.015)	(0.017)	(0.013)	(0.012)	(0.012)
Ln(Income per Capita)		–0.0412		–0.0584		0.0170		–0.0038
		(0.107)		(0.148)		(0.072)		(0.059)
House Price Index Divided by 1000		0.2685***		0.3403***		0.3196***		0.1075
		(0.077)		(0.109)		(0.085)		(0.092)
State Prime-Age Emp-to-Pop Ratio		0.0029		–0.0092		–0.0204		–0.0203
		(0.025)		(0.025)		(0.031)		(0.031)
Age and Education Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	141,125	141,125	101,607	101,607	65,445	65,445	43,881	43,881

Notes: This table reports regression results examining the effect of minimum wage increases on payment of subminimum wages. The dependent variable is an indicator for whether an individual reported hourly wages more than $0.25 below the effective minimum wage. The sample is from the CPS MORG and consists of all individuals ages 16 to 25. Columns 1 and 2 include all individuals who are employed. Columns 3 and 4 include all individuals who are employed, paid by the hour, and do not receive overtime, tips, or commissions. Columns 5 and 6 include all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; and do not have imputed wage rates. Columns 7 and 8 include all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; do not have imputed wage rates; do not live in states with substate minimum wage rates; and do not work in occupations potentially exempt from the minimum wage. Variable definitions and sources are discussed in the note to Table 2 (and in the paper). All specifications include year and state fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Relationship Between Minimum Wage Increases and Reported Characteristics in the CPS MORG Using Minimum Wage Policy Categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Employed		Hourly		Not Imputed		Not Imputed No Subrates	No Exempt
Large Statutory Increaser x Post	–0.0031	–0.0341***	–0.0114	–0.0291***	–0.0091	–0.0146	–0.0027	–0.0006
	(0.013)	(0.010)	(0.013)	(0.010)	(0.008)	(0.009)	–0.006	–0.005
Small Statutory Increaser x Post	0.0000	–0.0011	0.0017	0.0024	–0.0101	–0.0100	–0.0025	–0.0021
	(0.019)	(0.010)	(0.017)	(0.010)	(0.015)	(0.012)	–0.004	–0.003
Indexer x Post	0.0111	0.0026	0.0039	–0.0000	0.0128	0.0149	–0.0038	–0.0045
	(0.010)	(0.007)	(0.009)	(0.009)	(0.013)	(0.012)	–0.004	–0.003
Ln(Income per Capita)		0.3962***		0.3562***		0.2936***		–0.0048
		(0.105)		(0.112)		(0.082)		–0.031
House Price Index Divided by 1000		–0.0047		–0.0439		–0.1408**		0.0224
		(0.070)		(0.076)		(0.056)		–0.031
State Prime-Age Emp-to-Pop Ratio		0.1082***		0.0852**		0.0823**		0.0017
		(0.040)		(0.041)		(0.032)		–0.014
Age and Education Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	287,811	287,811	287,811	287,811	287,811	287,811	287,811	287,811

Notes: This table reports regression results examining whether minimum wage changes are correlated with self-reported characteristics using discrete categories to measure minimum wage changes. The sample is from the CPS MORG and consists of all individuals ages 16 to 25. Columns 1 and 2 report results with an indicator for whether an individual is employed, Columns 3 and 4 report results with an indicator for whether an individual is paid by the hour, and Columns 5 and 6 report results with an indicator for whether an individual does not have imputed wage rates. Columns 7 and 8 report results with an indicator for whether an individual lives in a state with substate minimum wage rates or works in an occupation potentially exempt from the minimum wage. Variable definitions and sources are discussed in the note to Table 2 (and in the paper). All specifications include month, year, month-year, and state fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Relationship Between Minimum Wage Increases and Probability of Subminimum Wage Payment Across Samples of the CPS MORG Using Continuous Minimum Wage Variation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	Employed		Hourly		Not Imputed		Not Imputed No Subrates No Exempt	
Effective Minimum Wage	0.0463***	0.0485***	0.0610***	0.0641***	0.0404***	0.0410***	0.0303***	0.0334***
	(0.003)	(0.003)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)
Ln(Income per Capita)		–0.0593		–0.0950		–0.0662		–0.0026
		(0.073)		(0.103)		(0.078)		(0.079)
House Price Index Divided by 1,000		–0.0241		–0.0357		0.0186		–0.1608
		(0.082)		(0.111)		(0.101)		(0.148)
State Prime-Age Emp-to-Pop Ratio		0.0091		0.0017		0.0041		0.0101
		(0.027)		(0.026)		(0.026)		(0.025)
Age and Education Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	189,060	189,060	135,964	135,964	86,997	86,997	58,359	58,359

Notes: This table reports regression results examining the effect of continuous minimum wage variation on subminimum wage payment. The dependent variable is an indicator for whether an individual reported hourly wages more than $0.25 below the effective minimum wage. Columns 1 and 2 include all individuals who are employed. Columns 3 and 4 include all individuals who are employed; paid by the hour; and do not receive overtime, tips, or commissions. Columns 5 and 6 include all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; and do not have imputed wage rates. Columns 7 and 8 include all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; do not have imputed wage rates; do not live in states with substate minimum wage rates; and do not work in occupations potentially exempt from the minimum wage. Variable definitions and sources are discussed in the note to Table 2 (and in the paper). All specifications include month, year, month-year, and state fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Relationship Between Minimum Wage Increases and the Amount of Subminimum Wage Payment Across Samples of the CPS MORG Using Continuous Minimum Wage Variation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	Employed		Hourly		Not Imputed		Not Imputed No Subrates No Exempt	
Effective Minimum Wage	0.0773***	0.0755***	0.0845***	0.0843***	0.0375***	0.0379***	0.0418***	0.0416***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.004)	(0.004)	(0.005)	(0.006)
Ln(Income per Capita)		–0.0804		–0.1482		–0.0556		0.0387
		(0.129)		(0.134)		(0.127)		(0.114)
House Price Index Divided by 1,000		0.1233		0.1021		0.0126		0.0217
		(0.109)		(0.107)		(0.091)		(0.143)
State Prime-Age Emp-to-Pop Ratio		0.0641		0.0243		0.0362		–0.0071
		(0.061)		(0.045)		(0.054)		(0.065)
Age and Education Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	189,060	189,060	135,964	135,964	86,997	86,997	58,359	58,359

Notes: This table reports regression results measuring the effect of continuous minimum wage variation on subminimum wage payment. The dependent variable captures continuous variation in the degree to which an individual's wage falls below the minimum wage. Columns 1 and 2 include all individuals who are employed. Columns 3 and 4 include all individuals who are employed; paid by the hour; and do not receive overtime, tips, or commissions. Columns 5 and 6 include all individuals who are employed; paid by the hour; do not receive overtime pay, tips, or commissions; and do not have imputed wage rates. Columns 7 and 8 include all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; do not have imputed wage rates; do not live in states with substate minimum wage rates; and do not work in occupations potentially exempt from the minimum wage. Variable definitions and sources are discussed in the note to Table 2 (and in the paper). All specifications include month, year, month-year, and state fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Relationship Between Minimum Wage Increases, Hourly Wage Increases and Subminimum Payment Among Individuals Ages 16–25, Ages 16–35, and Ages 16–65 Using Continuous Minimum Wage Variation

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Ages 16–25		Ages 16–35		Ages 16–65	
Dependent Variable	Hourly Wage	Wage Theft	Hourly Wage	Wage Theft	Hourly Wage	Wage Theft
Effective Minimum Wage	0.2725***	0.0379***	0.1493***	0.0286***	0.0886***	0.0194***
	(0.036)	(0.004)	(0.026)	(0.003)	(0.022)	(0.002)
Ln(Income per Capita)	0.2296	–0.0556	0.7003	–0.0697	–0.0675	–0.0062
	(0.789)	(0.127)	(0.607)	(0.074)	(0.481)	(0.047)
House Price Index Divided by 1,000	0.3442	0.0126	–0.0964	–0.0107	0.2474	0.0030
	(0.688)	(0.091)	(0.578)	(0.052)	(0.487)	(0.045)
State Prime-Age Emp-to-Pop Ratio	0.5739*	0.0362	0.4945*	0.0121	0.2269	–0.0004
	(0.302)	(0.054)	(0.250)	(0.035)	(0.167)	(0.025)
Age and Education Controls	No	Yes	No	Yes	No	Yes
Observations	86,997	86,997	170,832	170,832	366,536	366,536

Notes: This table reports regression results examining the effect of minimum wage increases on average hourly wages and subminimum wage payment for different subsamples of workers. The dependent variable is an individual's reported hourly wage in Columns 1, 3, and 5, and the amount of reported underpayment for individuals with reported hourly wages more than $0.25 below the effective minimum wage in Columns 2, 4, and 6. The sample is from the CPS MORG and consists of individuals ages who are employed; paid by the hour; do not receive tips, commissions, or overtime; and do not have imputed wage rates. Columns 1 and 2 display estimates of the effect of minimum wage changes on average hourly wages and subminimum payment among individuals ages 16–25, Columns 3 and 4 display estimates of the effect of minimum wage changes on average hourly wages and subminimum payment among individuals ages 16–35, and Columns 5 and 6 display estimates of the effect of minimum wage changes on average hourly wages and subminimum payment among individuals ages 16–65. Variable definitions and sources are discussed in the note to Table 2 (and in the paper). All specifications include month, year, month-year, and state fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Relationship Between Minimum Wage Increases, Enforcement, and Probability of Subminimum Payment Using Continuous Minimum Wage Variation and Data from 2011 to 2013

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	Paid Subminimum Wage				
Effective Minimum Wage			0.0238***	0.0269***	0.0266***
			(0.007)	(0.008)	(0.008)
Enforcement Index	–0.0155			–0.0550	
	(0.036)			(0.037)	
Only Penalties Index		–0.0192			–0.0388*
		(0.021)			(0.023)
Ln(Income Per Capita)	–0.0006	0.0007	–0.0239	–0.0172	–0.0182
	(0.026)	(0.026)	(0.020)	(0.018)	(0.017)
House Price Index Divided by 1,000	–0.0437	–0.0416	–0.0552	–0.0446	–0.0452
	(0.050)	(0.049)	(0.042)	(0.042)	(0.041)
State Prime-Age Emp-to-Pop Ratio	–0.0890**	–0.0931**	–0.0296	–0.0351	–0.0387
	(0.042)	(0.039)	(0.050)	(0.041)	(0.037)
Age and Education Controls	Yes	Yes	Yes	Yes	Yes
Observations	34,394	34,394	34,394	34,394	34,394

Notes: This table reports regression results examining the relationship between effective minimum wage rates, penalties for noncompliance, and the regularity with which individuals are paid subminimum wages. Data are restricted to 2011 to 2013, which corresponds with the "baseline" period during which the only minimum wage changes to be implemented by states were associated with inflation-indexation provisions. The dependent variable is an indicator for whether an individual's reported hourly earnings are more than $0.25 below the effective minimum wage. The sample is from the CPS MORG and consists of all individuals ages 16 to 25 who are employed; paid by the hour; do not receive tips, commissions, or overtime; and do not have imputed wage rates. Variable definitions and sources are discussed in the note to Table 2 (and in the paper). All specifications include month, year, and month-year fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

Table 10: Relationship Among Minimum Wage Increases, Enforcement, and Subminimum Payment Using Continuous Minimum Wage Variation, Only Penalties Index, and Full Enforcement Index

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Paid Subminimum Wage		Paid Subminimum Wage		Wage Theft		Wage Theft	
Effective Minimum Wage	0.0224**	0.0229**	0.0098	0.0081	0.0293***	0.0298***	0.0229*	0.0221*
	(0.008)	(0.009)	(0.011)	(0.012)	(0.010)	(0.010)	(0.012)	(0.012)
Effective Minimum Wage x Only Penalties Index	0.0457**	0.0507*			0.0209	0.0230		
	(0.021)	(0.026)			(0.020)	(0.022)		
Effective Minimum Wage x Full Enforcement Index			0.0959***	0.1110**			0.0458	0.0534
			(0.035)	(0.045)			(0.031)	(0.035)
Ln(Income per Capita)		–0.0967		–0.0322		–0.0694		–0.0694
		(0.074)		(0.083)		(0.126)		(0.126)
House Price Index Divided by 1,000		–0.0221		0.0050		–0.0059		–0.0059
		(0.090)		(0.026)		(0.087)		(0.087)
State Prime-Age Emp-to-Pop Ratio		0.0039		0.0361		0.0361		0.0361
		(0.026)		(0.054)		(0.054)		(0.054)
Age and Education Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	86,997	86,997	86,997	86,997	86,997	86,997	86,997	86,997

Notes: This table reports regression results examining the effect of minimum wage increases and penalties for noncompliance on payment of subminimum wages and the magnitude of subminimum wage payment. The dependent variable for Columns 1-4 is an indicator for whether an individual's reported hourly earnings are more than $0.25 below the effective minimum wage. The dependent variable for Columns 5-8 is the amount of reported underpayment. The sample is from the CPS MORG and consists of all individuals ages 16 to 25 who are employed; paid by the hour; do not receive tips, overtime pay, or commissions; and do not have imputed wage rates. Variable definitions and sources are discussed in the note to Table 2 (and in the paper). All specifications include month, year, month-year, and state fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

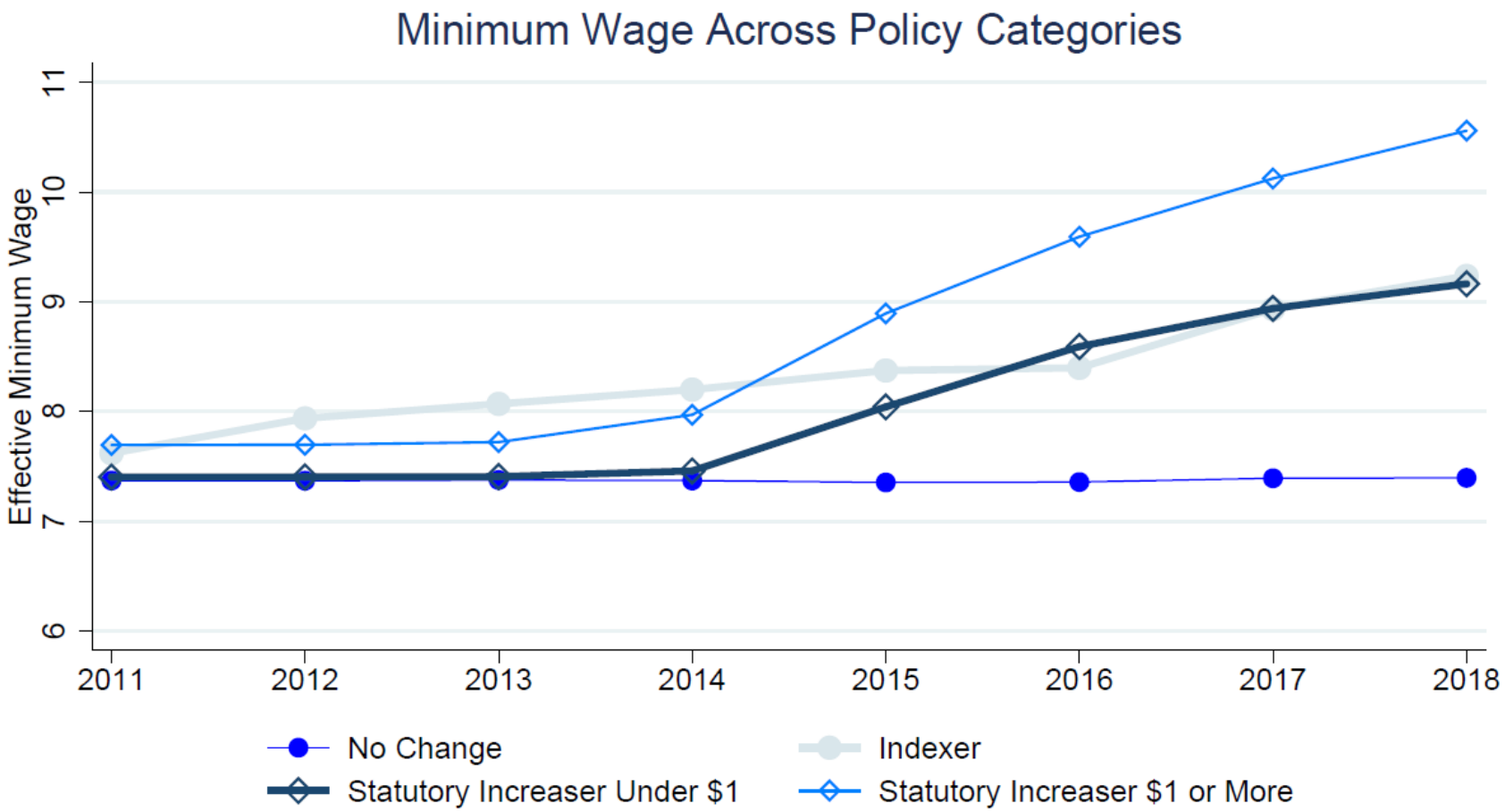

Figure 1. Average Minimum Wage Across Policy Categories: This figure plots the average annual effective minimum wage for states in each of our four policy categories from January 2011 to January 2018. States are defined as statutory increasers under $1 if the combined statutory increase in their minimum wage between January 2013 and January 2015 was under $1. States are defined as statutory increasers of $1 or more if the combined statutory increase in their minimum wage was $1 or greater. Indexers are states that index their minimum wage to inflation. The effective minimum wage is defined as the maximum of the state and federal minimum wage. Data on minimum wage rates come from the U.S. Department of Labor. Data on minimum wage policies come primarily from the National Conference of State Legislatures and the U.S. Department of Labor. Averages are weighted by state population.

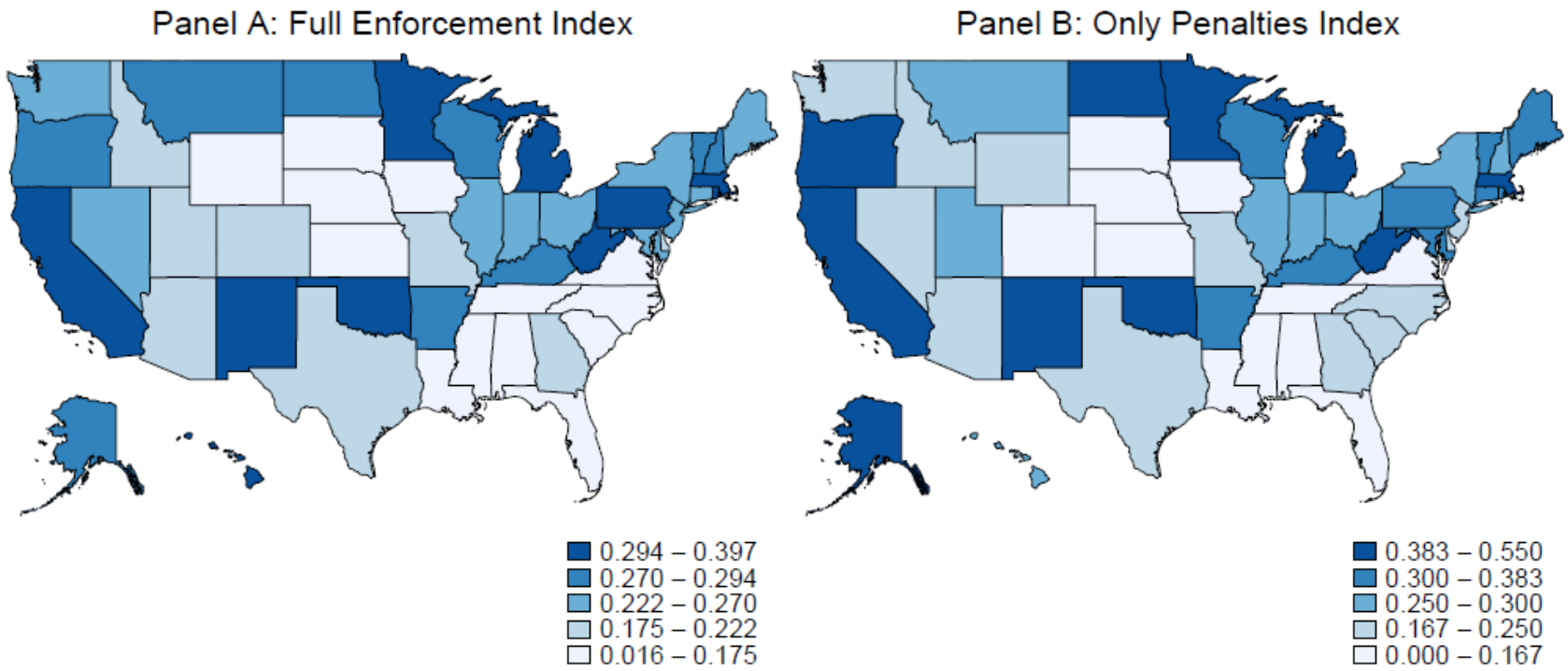

Figure 2. Maps of Minimum Wage Enforcement Indices by State: This figure plots values of the Galvin (2016) minimum wage enforcement indices. Panel A reports the "full enforcement index" and Panel B the "only penalties index" by state, based on enforcement regimes as of December 31, 2013. Higher values indicate more stringent enforcement regimes. The "full enforcement index" on the left includes both information regarding the claims process and laws regarding criminal and civil penalties levied in the event of violation. The "only penalties index," mapped in the figure on the right, includes only civil and criminal penalties levied in the event an employer is found guilty of a violation.

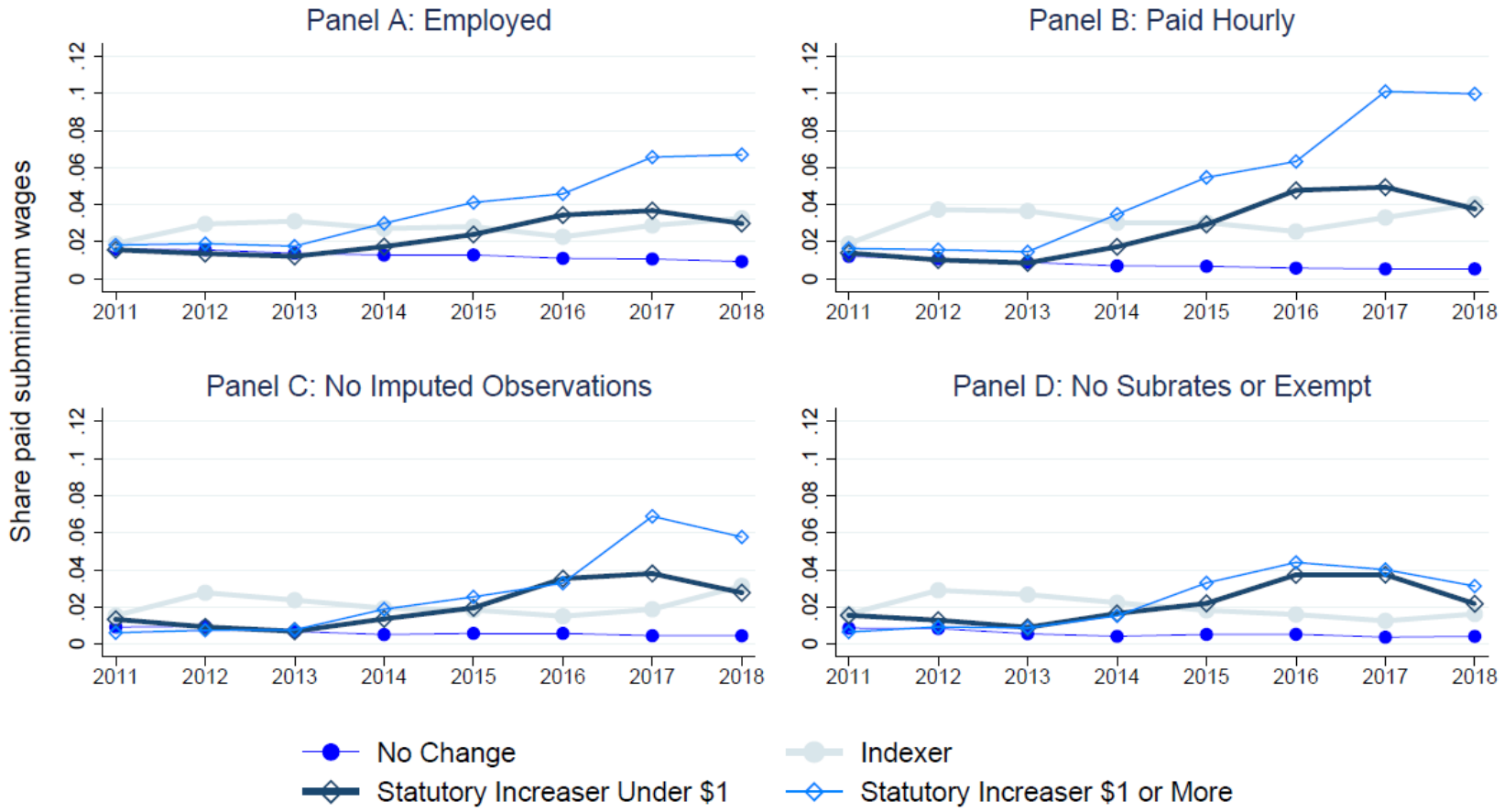

Figure 3. Incidence of Subminimum Wage Payment Across Policy Categories: This figure plots the share of individuals who reported hourly wages more than $0.25 below the effective minimum wage for each of our four policy groups, broken out across four subsamples, from 2011 to 2018. Data come from the Current Population Survey Merged Outgoing Rotation Groups (CPS MORG). Panel A includes all individuals ages 16-25 who are employed. Panel B restricts the sample to all individuals who are employed; paid by the hour; and do not receive overtime, tips, or commissions. Panel C restricts the sample to all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; and whose wage rates are not imputed. Panel D restricts the sample to all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; whose wage rates are not imputed; who do not live in states with local minimum wage rates; and who do not work in occupations exempt from the federal minimum wage. States are defined as statutory increasers under $1 if the combined statutory increase in their minimum wage between January 2013 and January 2015 was under $1. States are defined as statutory increasers of $1 or more if the combined statutory increase in their minimum wage was $1 or greater. Indexers are states that index their minimum wage to inflation. Averages are weighted by state population.

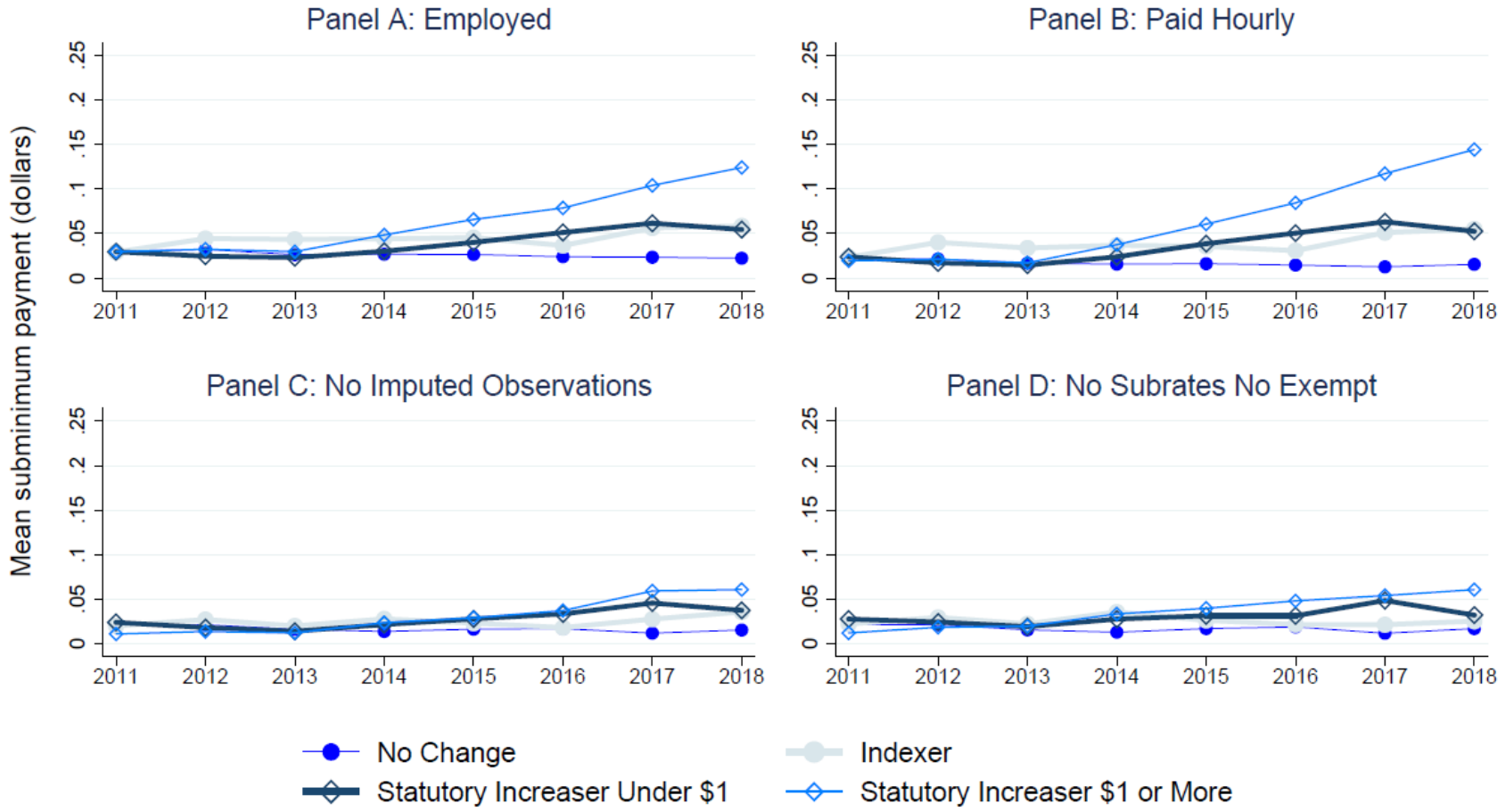

Figure 4. Average Value of Subminimum Wage Payment Across Policy Categories: This figure plots average subminimum payment for each of our four policy groups, broken out across four subsamples, from 2011 to 2018. Data come from the Current Population Survey Merged Outgoing Rotation Groups (CPS MORG). Panel A includes all individuals ages 16-25 who are employed. Panel B restricts the sample to all individuals who are employed; paid by the hour; and do not receive overtime, tips, or commissions. Panel C restricts the sample to all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; and whose wage rates are not imputed. Panel D restricts the sample to all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; whose wage rates are not imputed; who do not live in states with local minimum wage rates; and who do not work in Occupations exempt from the federal minimum wage. States are defined as statutory increasers under $1 if the combined statutory increase in their minimum wage between January 2013 and January 2015 was under $1. States are defined as statutory increasers of $1 or more if the combined statutory increase in their minimum wage was $1 or greater. Indexers are states that index their minimum wage to inflation. Averages are weighted by population.

Table A1: List of States with Statutory Minimum Wage Increases and Inflation-Indexed Increases Using Changes from 2013 to 2017 and $2 Cutoff

Statutory increasers of $2 or more	Statutory increasers under $2
Alaska	Arkansas
Arizona	Colorado
California	Connecticut
District of Columbia	Delaware
Hawaii	Maine
Massachusetts	Maryland
Minnesota	Michigan
New York	Nebraska
	New Jersey
	Oregon
Indexers	Rhode Island
Florida	South Dakota
Missouri	Vermont
Montana	Washington
Ohio	West Virginia

Notes: Data on minimum wage indexing provisions come from the National Council of State Legislatures. The states labeled as "indexers" link annual updates to their effective minimum wage rates to a measure of inflation. Data on minimum wage changes come from the U.S. Department of Labor. States are counted as statutory increasers of under $2 if the combined statutory increase in the minimum wage from January 2013 through January 2017 was under $2. States are counted as statutory increasers of $2 or more if the combined statutory increase in the minimum wage was $2 or more.

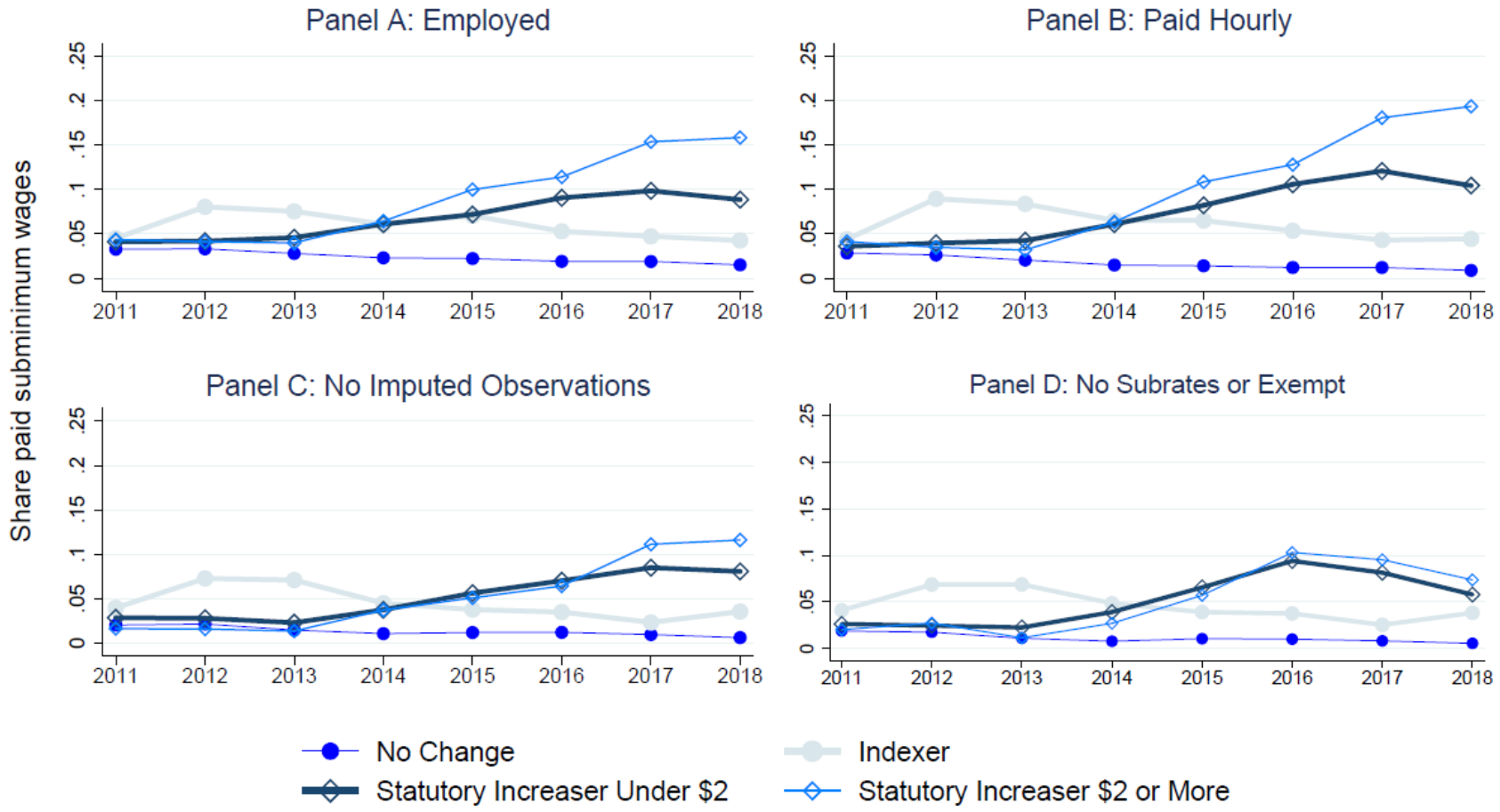

Figure A1. Incidence of Subminimum Wage Payment Across Policy Categories: This figure plots the share of individuals who reported hourly wages more than $0.25 below the effective minimum wage for each of our four policy groups, broken out across four subsamples, from 2011 to 2018. Data come from the Current Population Survey Merged Outgoing Rotation Groups (CPS MORG). Panel A includes all individuals ages 16-25 who are employed. Panel B restricts the sample to all individuals who are employed; paid by the hour; and do not receive overtime, tips, or commissions. Panel C restricts the sample to all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; and whose wage rates are not imputed. Panel D restricts the sample to all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; whose wage rates are not imputed; who do not live in states with local minimum wage rates; and who do not work in Occupations exempt from the federal minimum wage. States are defined as statutory increasers under $2 if the combined statutory increase in their minimum wage between January 2013 and January 2017 was under $2. States are defined as statutory increasers of $2 or more if the combined statutory increase in their minimum wage was $2 or greater. Indexers are states that index their minimum wage to inflation. Averages are weighted by population.

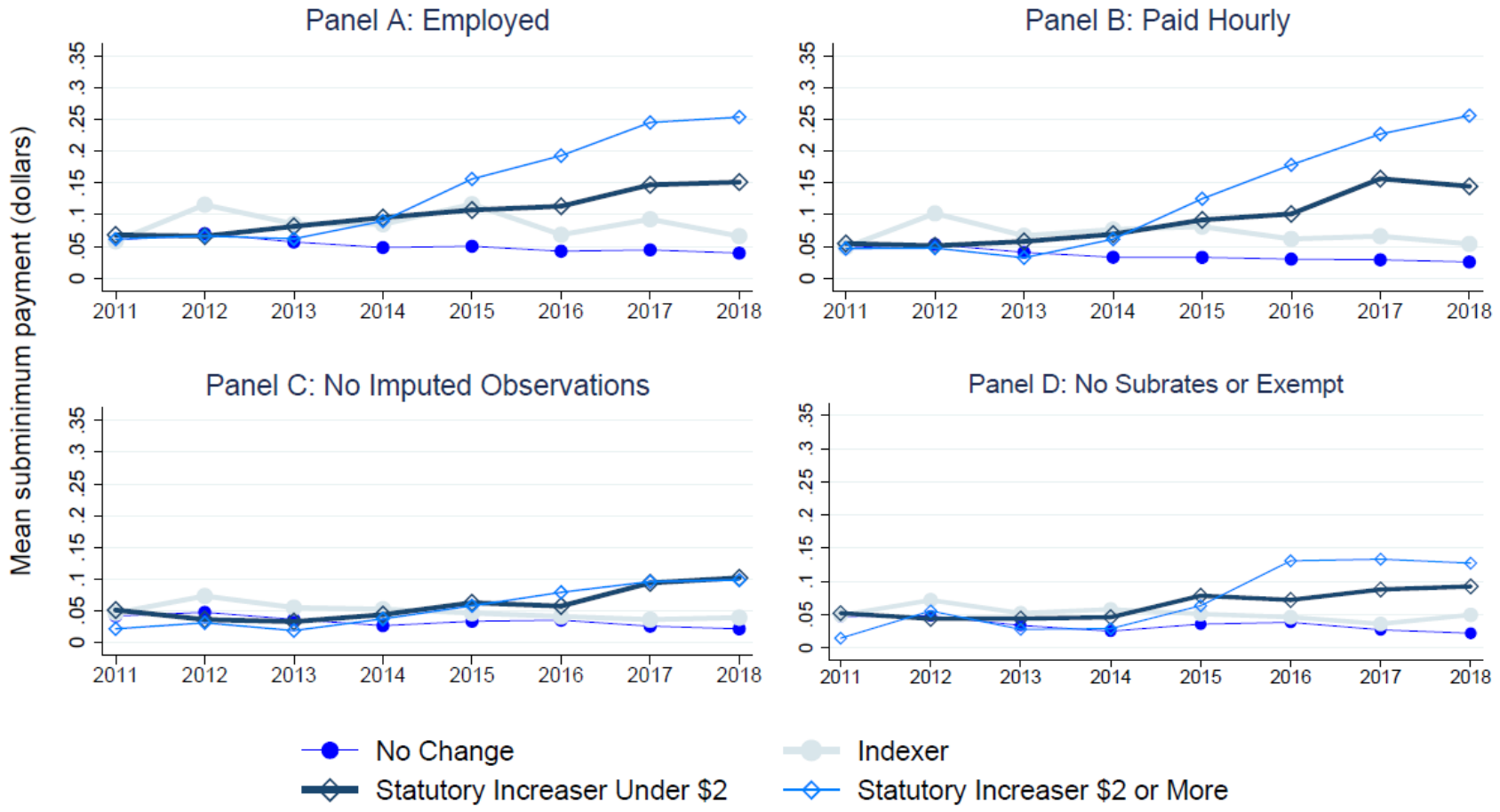

Figure A2. Average Value of Subminimum Wage Payment Across Policy Categories: This figure plots average subminimum payment for each of our four policy groups, broken out across four subsamples, from 2011 to 2018. Data come from the Current Population Survey Merged Outgoing Rotation Groups (CPS MORG). Panel A includes all individuals ages 16-25 who are employed. Panel B restricts the sample to all individuals who are employed; paid by the hour; and do not receive overtime, tips, or commissions. Panel C restricts the sample to all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; and whose wage rates are not imputed. Panel D restricts the sample to all individuals who are employed; paid by the hour; do not receive overtime, tips, or commissions; whose wage rates are not imputed; who do not live in states with local minimum wage rates; and who do not work in Occupations exempt from the federal minimum wage. States are defined as statutory increasers under $2 if the combined statutory increase in their minimum wage between January 2013 and January 2017 was under $2. States are defined as statutory increasers of $2 or more if the combined statutory increase in their minimum wage was $2 or greater. Indexers are states that index their minimum wage to inflation. Averages are weighted by population.

Appendix 2: Additional Analysis of Measurement Error

Measurement error is a crucial issue for our analysis to address. Our preferred estimates focus on samples of individuals ages 16 to 25 who are employed at hourly wage rates and whose wage rates are not imputed. This sample is less prone than others to the concern that wage rates recorded below the minimum wage are a result of measurement error rather than reflecting instances of true underpayment. Still, measurement error remains a potentially significant issue for our analysis. In this section we further probe the plausibility of the hypothesis that the underpayment we observe is driven primarily by measurement error.

To be testable, the hypothesis that measurement error drives observed instances of underpayment must posit a specific form of measurement error. The leading candidate in the literature is measurement error of the form hypothesized by Autor, Manning, and Smith (2016) (hereafter, AMS) in their assessment of whether minimum wage spillovers can be distinguished from measurement error.

The AMS model of measurement error has two key components. First, it assumes that some fraction of the population correctly reports their wage rates while the remainder reports with error. Second, it assumes that the errors from those who misreport are normally distributed. It is straightforward to show that measurement error of this form can produce a combination of illusory underpayment as well as spillovers. Our simulations reveal, however, that the AMS model of measurement error is far from sufficient to explain the patterns of spillovers and underpayment that we observe in the data.

We begin our simulation of the wage data implied by the AMS model by estimating the mean and variance of the distribution of log wages across our primary analysis sample. Because

this sample consists of relatively unskilled individuals, its mean is modest. The mean wage is just under $10.40, while the mean of the log wage is 2.34. The standard deviation of the log wage is 0.32.

The first step in simulating the AMS model is to generate a "true and latent" wage distribution using these parameters. The use of "true" in this simulation refers to the absence of measurement error, while the use of "latent" refers to the hypothetical absence of a minimum wage. The model enables a test of the conjecture that measurement error of a particular form may be *sufficient* to explain patterns of spillovers and underpayment in the self-reported wage data. It does this by simulating how these data would look if the minimum wage generated neither spillovers, nor subminimum wage payment, nor declines in employment. The second step is to generate a "true" and "actual" distribution in which the minimum wage is introduced but measurement error is not. The third step is to inject measurement error based on the two key components mentioned above, namely a probability of reporting with error and a variance for the normally distributed error among those who report incorrectly.

We execute our simulation on a sample consisting of 100,000 observations for which we have generated a "true and latent" wage. To examine the effects of minimum wage changes under alternative assumptions regarding the measurement error parameters, we divide the simulated sample into 4 cells of equal size. These cells correspond with 2 "states" and 2 "time periods," where state 1 has a minimum wage of $8 in both time periods while state 2 has a minimum wage of $8 in period 1 and $9.50 in period 2. This is representative of the typical minimum wage change we analyze in our data.

We select the two parameters in the AMS model to match key moments in the data. The first moment in the data involves the mass of individuals who report working for wage rates at the minimum wage itself. As AMS emphasize, the effect of a minimum wage change on this mass can be used to infer the fraction of individuals who misreport their wage rates under the assumption that minimum wage increases result in neither positive spillovers nor true instances of underpayment. This is the sense in which the model is proposed as an alternative interpretation of the data. Second, the variance of the error among those who are assumed to misreport their wage rates can be chosen to fit moments that relate to the dispersion in observed wages both above and below the minimum. We choose this parameter to match the mass we observe at wage rates that are either (a) between the minimum wage itself (non-inclusive) and $1 above the minimum wage, or (b) between the minimum wage itself (non-inclusive) and $1 above the minimum wage. Having selected the parameter in this way, we can then ask whether data simulated to match positive spillovers (the primary emphasis of AMS) also match the degree of underpayment. Similarly, we can ask whether data simulated to match underpayment also match the degree of positive spillovers. Three facts from this exercise provide evidence against the hypothesis that a pure measurement error model is sufficient to explain the underpayment we observe in the data.

First, for measurement error to be the primary driver of our results, the degree of misreporting in the CPS would have to be remarkably large. Consider the mass we observe at the minimum wage itself. In our analysis of CPS data, as shown in Column 1 of Table A2, we find that each dollar of increase in a state's minimum wage predicts a 4.7 percentage point increase in the fraction of employed individuals who are working at precisely the minimum wage. In our simulated data, the "true" fraction is 12 percentage points. For the AMS error model to match

these moments, it must assume that only 39 percent of employed low-skilled individuals who are paid precisely the minimum wage on an hourly basis ultimately report the correct wage. While it is difficult to calibrate what does and does not constitute a reasonable degree of misreported minimum wage employment, the implied misreporting by 61 percent of the relevant individuals is quite high given the high salience of minimum wage rules.

Second, changes in the mass of wages that appear at exactly the minimum vary systematically across states. These variations are simultaneously consistent with real economic factors and inconsistent with a pure measurement error model. As shown in Columns 2 and 3 of Table A3, we find a substantial divergence in the evolution of the mass of workers making exactly the minimum wage when we compare states that have recently enacted new minimum wage laws to states that have indexed their minimum wage rates to adjust predictably with inflation. We do this by running regressions in which we exclude one or the other group from the sample.

This divergence between states with indexed minimum wage changes and changes driven by new legislation is of interest for two reasons. First, inflation-indexed minimum changes and minimum wage increases linked to new legislation differ from one another economically (Brummund and Strain, forthcoming). The former have long been forecastable, meaning both firms and workers have had time to take their implications into account. For increases of this sort, the change in the mass of workers making the minimum wage is quite close to what our simulations predict for the case in which a minimum wage increase has no spillovers and results in no underpayment. Underpayment arises almost exclusively in response to newly legislated minimum wage changes, as we showed previously in Table 4 and through the time series

presented in Figure 3. Models of measurement error provide no basis for expecting a divergence of this sort.

Second, it is well documented that survey respondents have a bias towards reporting round numbers (Schwabish, 2007; Gideon, Helppie-McFall, and Hsu 2017). Notably, new legislation has called for minimum wage rates that take round number values (e.g., $11), while inflation-indexed minimum wage changes often take irregular values (e.g., $8.56). An interpretation of the data that relies on measurement error would thus predict the opposite of what we see when we compare inflation-indexed minimum wage increases to increases connected to recent legislation.

A third issue suggesting that measurement error is not the primary driver of our results involves the shape of the distribution associated with spillover effects and underpayment. We show this in Table A3. If we choose the error model parameters to match spillovers, the simulated data dramatically under-predict the amount of mass beneath the minimum wage. Normally distributed measurement error also fails to capture the shape of positive spillovers. Alternatively, if we simulate data to match the observed degree of underpayment, the simulated data substantially overstate the magnitude of spillovers. These facts reveal that a canonical model of symmetric measurement error struggles to explain the patterns we observe.

Table A2: Relationship Between Minimum Wage Increases and the Mass of Individuals Making Exactly the Minimum Wage in CPS Data As Compared with Data Simulated Using the Autor, Manning, and Smith Model of Measurement Error

	(1)	(2)	(3)
Sample	All States	Indexers	Statutory Increasers
Panel A: Regression Results on CPS Data			
Effective Minimum Wage	0.0472***	0.0950***	0.0365***
	(0.011)	(0.020)	(0.008)
Observations	87,019	57,230	71,782
Panel B: Simulation Output			
Parameters chosen to match column 1	0.047	0.047	0.047

Notes: Panel A in the table reports regression results examining the effect of minimum wage increases on the probability that an individual reports making exactly the minimum wage. The sample in column 1 includes all states. The sample in column 2 excludes states that enacted minimum wage increases through new legislation, so that the estimate is driven entirely by inflation indexing provisions. Column 3 excludes the states with inflation indexation provisions so that the estimate is driven by states that enacted new statutory increases. All specifications include month, year, month-year, and state fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1. Panel B in the table reports the same moments of the data as Panel A, but for simulated rather than actual data. The simulation parameter that is chosen to match output from column 1 is the parameter that describes the fraction of observations that are reported with error. The parameter value that most closely matches the data is 0.39, implying that 61 percent of observations are reported with error.

Table A3: Relationship Between Minimum Wage Increases and Moments of the Wage Distribution in CPS Data As Compared with Data Simulated Using the Autor, Manning, and Smith Model of Measurement Error

Hourly Wage Relative to Effective Minimum	(1) $2 less	(2) $2 more	(3) $1 less	(4) $1 more	(5) $1-2 less	(6) $1-2 more
Panel A: Regression Results on CPS Data						
Effective Minimum Wage	0.0459***	0.0003	0.0396***	0.0146***	0.0063***	-0.0143**
	(0.005)	(0.011)	(0.006)	(0.005)	(0.001)	(0.006)
Observations	87,019	87,019	87,019	87,019	87,019	87,019
Panel B: Simulation Output						
Parameters chosen to match column 4	0.028	0.021	0.0173	0.0168	0.011	0.004
Parameters chosen to match column 3	0.038	0.027	0.036	0.035	0.017	-0.008

Notes: Panel A in the table reports regression results examining the effect of minimum wage increases on the probability that individuals report wages within several specified intervals above and below the minimum wage. The outcome in columns 1 and 2 takes a value of 1 if the wage is within $2 of the minimum wage, below and above, respectively. The outcome in columns 3 and 4 takes a value of 1 if the wage is within $1 of the minimum wage, below and above, respectively. The outcome in columns 5 and 6 takes a value of 1 if the wage is between $1 and $2 below and above the minimum wage, respectively. All specifications include month, year, month-year, and state fixed effects. Age and education controls consist of a dummy variable for each education group and age. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1. Panel B in the table reports the same moments of the data as Panel A, but for simulated rather than actual data. Key parameters are chosen to match the moment described in the left-hand column of the panel. The simulation parameter that is chosen to match output from either column 3 or column 4 is the parameter that describes the variance of the normally distributed error in the error associated with observations with incorrectly reported wage rates. To come close to matching the mass of error in column 3, the value of this parameter is set to 50 cents. To come close to matching the mass of error in column 4, the value of this parameter is set to $1.50. This reflects the fact that we observe a larger density for underpayment within $1 of the minimum wage than for positive spillovers within $1 of the minimum wage. The lower variance of $0.50 is required to keep a larger fraction of observations that are reported with error within the required range.