Minimum Wages and Policy Expectations

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Abstract

We provide evidence from the Current Population Survey to show that the employment effects associated with minimum wage increases depend on whether increases are anticipated and whether minimum wages are indexed to inflation. We develop an equilibrium search model that features a time-varying real minimum wage. Workers and firms form rational expectations with respect to the future evolution of the minimum wage. We use the model to quantify how policy expectations interact with the employment effects induced by minimum wage increases. (1) When minimum wages are not indexed to inflation, any disemployment effect disappears within a few years. (2) Anticipation effects can be so large that there is no detectable employment effect at the time of the actual increase. (3) When a minimum wage is indexed to inflation, disemployment effects can be more than twice as large compared to when minimum wages are set in nominal terms.

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1 Introduction

Economists have tirelessly studied the employment and welfare consequences of minimum wages (Kennan, 1995; Card and Krueger, 1995; Neumark and Wascher, 2008). Usually, researchers compare employment outcomes for individuals affected by a minimum wage increase with individuals who are not by exploiting variation across jurisdictions.[1] The existing literature reports a range of results from no detectable effect at all (Allegretto et al., 2011, 2013) to sizable disemployment effects for young and inexperienced workers (Neumark et al., 2013). Differences often hinge on the data used, sample selection, research design, or the particular minimum wage increases that are studied.

In this paper, we show that it is important to account for workers' and firms' policy expectations when measuring the effect of minimum wage increases on employment. We provide evidence from the Current Population Survey (CPS) to show that the magnitude of employment effects associated with recent minimum wage increases in the U.S. depends on whether minimum wage changes are anticipated (i.e. announced several months before their implementation) and whether the minimum wage is indexed to inflation (i.e. permanent in real terms). We consider nine recent minimum wage increases in the federal minimum wage and state minimum wages in the U.S. and exploit variation across states using a traditional differences-in-difference estimator. We find that minimum wage increases result in substantial negative employment effects when they are unanticipated and no employment effects when they are anticipated. The effects of unanticipated increases are even larger when the increases are indexed to inflation.

We then develop an equilibrium search and matching model that features a time-varying real minimum wage. We use the model to quantify how policy expectations affect the employment effects associated with minimum wage increases. In the model, which is an extension of the model used in Flinn (2006), workers and firms form rational expectations with respect to the future evolution of the minimum wage. Unemployed workers are homogeneous. Employed workers differ in their match-specific productivity. Wages are determined using Nash bargaining subject to a minimum wage constraint. Minimum wages may increase wages for some workers by allocating a larger share of the surplus to them. Minimum wages may also destroy some jobs by rendering them unprofitable from the perspective of the firm. In the model, policy expectations shape the employment response to minimum wage increases, because workers and firms are forward-looking and adjust to changing minimum wages ahead of time. While parsimonious, the model can account for a variety of outcomes related to

[1] The long list of papers that do some variation of this includes, among others, Addison et al. (2009), Allegretto et al. (2011), Allegretto et al. (2013), Burkhauser et al. (2000), Card (1992a), Card (1992b), Card et al. (1993), Card and Krueger (1994), Card and Krueger (2000), Couch and Wittenburg (2001), Deere et al. (1995), Dube et al. (2006), Dube et al. (2010), Dube et al. (2011), Katz and Krueger (1992), Meer and West (2016), Neumark and Wascher (1992), Neumark and Wascher (2000), Neumark et al. (2004), Neumark and Wascher (2006), Neumark et al. (2013), Sabia (2009), and Zavodny (2000).

minimum wage increases. It captures the effects on employment, on the share of workers in minimum wage jobs, and on the wage distribution.

We estimate the model using indirect inference by targeting difference-in-differences estimates from increases in the federal minimum wage between 2007 and 2009. These increases in the federal minimum wage are particularly useful for the identification and estimation of the model, because the initial increase in 2007 was a surprise, whereas the second and third increases in 2008 and 2009 were announced in 2007 and therefore known in advance. In the estimation, we feed policy expectations consistent with the actual staggered implementation of the 2007–2009 federal minimum wage increase into the model and then estimate its structural parameters.

The estimated model allows us to disentangle the role of the minimum wage rate and expectations thereof. In the estimated model, anticipation effects can result in the absence of any measurable employment effect at the time of the minimum wage increase. Indexation can result in vastly larger employment effects. For the 2007 federal minimum wage increase, we find that the disemployment effect would have been twice as large if the increase had been indexed to inflation. The results in this paper indicate that researchers and policy makers need to account for firms' and workers' policy expectations when assessing the impact of minimum wages on employment.

The purpose of this paper is to *quantify* the role that policy expectations can have on the employment effects associated with minimum wage increases. We employ a model to perform this exercise, because in the model, we can characterize and control workers' and firms' policy expectations. The purpose of this paper is *not* to study the welfare implications of minimum wages. In the setup that we choose, the welfare effects of minimum wages are ambiguous due to a search externality (see Flinn (2006) for a discussion). Minimum wages may increase welfare if the Hosios (1990) condition is violated and workers' bargaining power is lower than socially optimal. In that case, the minimum wage effectively raises workers' bargaining power and may improve welfare. We ignore welfare implications, because if minimum wages are welfare improving in the model, then minimum wages should *always* be indexed to inflation. If minimum wages are not welfare improving, then they should be set to a value that renders them non-binding. Regardless, absent additional factors, a time-varying minimum wage policy is never optimal. This also renders the discussion of anticipation effects moot from a normative perspective.[2]

This paper is related to a large body of minimum wage research. However, the minimum wage literature is largely silent on the role of policy expectations. Almost all empirical estimates for the U.S. refer to changes in the nominal minimum wage, yet are often interpreted as

[2] Along the transition path as the economy moves from no minimum wage to the "optimal" minimum wage, the welfare implications may be more subtle. However, such an analysis would also need to focus on the distributional aspects of minimum wages, which arguably requires a more sophisticated model of worker heterogeneity than what we employ in this paper.

if they refer to permanent changes in the minimum wage. The "modern" minimum wage literature begins with a series of papers that exploit variation in state minimum wage laws across the U.S., e.g. Card (1992a,b), Neumark and Wascher (1992), Katz and Krueger (1992), and Card and Krueger (1994). The most influential among these papers is Card and Krueger (1994), who investigate the effects of a 1992 increase in the New Jersey minimum wage by surveying fast food restaurants in New Jersey and Pennsylvania before and after the policy change took effect. Card and Krueger estimate that the increase in the New Jersey minimum wage from $4.25 to $5.05 *increased* employment with an elasticity of approximately 0.7. The difference-in-differences methodology applied by Card and Krueger has subsequently emerged as the defacto standard in this line of research, often applied to survey datasets such as the CPS (e.g. Deere et al. (1995), Burkhauser et al. (2000), Sabia (2009), Zavodny (2000), Couch and Wittenburg (2001), Neumark et al. (2004), Abowd et al. (2000)). Neumark and Wascher (2006) review the literature and conclude that there is a negative yet small employment effect for young workers. Subsequent work has raised various issues that seem noteworthy given the objective of this paper.

First, minimum wages may only affect the labor market with a delay. Even in industries where adjustment costs are considered to be minimal (e.g. because of significant turnover), adjusting non-labor inputs may be costly (Hamermesh, 1993). Similarly, firms may not be able to freely respond to a changed policy environment because of sunk investment costs (Aaronson et al., 2017). It is thus important for empirical studies to allow for minimum wage effects with delay (Baker et al., 1999; Burkhauser et al., 2000; Keil et al., 2001). In addition, not only do firms respond slowly to new policies, it may also take a considerable amount of time for the labor market to transition from one equilibrium to another, as theoretically argued by Diamond (1981). Meer and West (2016) investigate this hypothesis. They find that since adjustments take time, employment effects are more visible in net job creation than in employment levels.

Second, the difference-in-differences methodology heavily rests on a common trend assumption. Difference-in-differences estimators are only appropriate if states with and without the minimum wage change were otherwise subject to the same set of economic shocks. This assumption is not uncontested. Dube et al. (2010) try to reduce potential confounding effects from a failure of the common trend assumption by estimating a difference-in-differences specification using contiguous counties that are on opposite sides of the border of two adjacent states with different minimum wage laws. They find that traditional approaches that do not account for local economic conditions tend to produce spurious negative effects due to spatial heterogeneity in employment trends that are unrelated to minimum wage policies. Using their local identification strategy, they find employment effects that are indistinguishable from zero. Allegretto et al. (2011) address similar concerns by including region-specific time trends in an otherwise standard differences-in-difference estimator and come to the same conclusion.

Other papers include state- and county-specific time trends (Addison et al., 2009) or business cycle conditions (Orrenius and Zavodny, 2008) to account for spatial heterogeneity.

There is relatively little research that considers the role of policy expectations in the labor market in general or with respect to minimum wages in particular.[3] A notable exception is Pinoli (2010), who uses a search and matching model in the tradition of Mortensen and Pissarides (1994) to show that the *observed* employment effect of a minimum wage increase is large for unanticipated changes and low for anticipated changes. While Pinoli's and our paper answer a similar question using similar modeling approaches, there are important differences. First, in her model, all workers earn the minimum wage, whereas in our model, wages are determined using Nash bargaining. Importantly, in our framework, the minimum wage coverage rate is an important variable that we attempt to explain. Second, we explicitly account for the real value of the minimum wage (which may depreciate over time) and we use our framework to study the effect of indexing minimum wages to inflation. In Pinoli, all minimum wages are set in real terms. Third, Pinoli considers an environment with only two possible minimum wages. In contrast, our model admits a rich set of possible minimum wage policies, allowing us to study staggered minimum wage increases as commonly observed in the data.

Papers that explicitly study the indexation of minimum wages include Brummund and Strain (2016). Their results are largely consistent with our findings. Using data and variation from U.S. states, they find that the disemployment effect of indexing the minimum wage to inflation is more than 2.5 times the magnitude of the effect of a nominal minimum wage increase. They do not account for whether minimum wage changes are anticipated or unanticipated.

Methodologically, this paper is closest to Flinn (2006). The model that we introduce extends Flinn's by introducing a stochastically evolving minimum wage. Several other papers estimate structural economic models with search frictions to study the effects of minimum wages. However, none accounts for policy expectations or the fact that the real value of the minimum wage depreciates over time. These papers include Eckstein and Wolpin (1990), Van den Berg and Ridder (1998), and Mabli and Flinn (2009). Dube et al. (2011) develop a model in the tradition of Burdett and Mortensen (1998) and Bontemps et al. (1999) and use a set of reduced-form estimates obtained from variation in the minimum wage between contiguous counties that are separated by a state border to estimate their model. Their estimated model suggests that an increase in the minimum wage from \$5.15 to \$7.25 leads to a 3.4% increase in the average wage and a 0.5 percentage point reduction in employment.

This paper is structured as follows. In Section 2, we provide background on minimum

[3] Various papers focus on policy expectations in the context of social security, e.g. Skinner (1988), Alm (1988), Luttmer and Samwick (2015), Giavazzi and McMahon (2012), and Stiglitz (1982). There is a large literature in macroeconomics that studies the role of expectations regarding monetary policy (Levin et al., 2005; Gertler and Karadi, 2015).

	Federal Minimum Wage	Number of States Binding
January 1, 1978	$2.65	.
January 1, 1979	$2.90	.
January 1, 1980	$3.10	.
January 1, 1981	$3.35	.
April 1, 1990	$3.80	39
April 1, 1991	$4.25	46
October 1, 1996	$4.75	45
September 1, 1997	$5.15	45
July 24, 2007	$5.85	20
July 24, 2008	$6.55	26
July 24, 2009	$7.25	37

Table 1: Changes in the Federal Minimum Wage

wages in the U.S. and recent developments in indexing minimum wages to inflation. In Section 3, we study the impact of minimum wages on employment using data from the CPS and develop a set of stylized facts. In Section 4, we develop a structural model that accounts for time-varying minimum wages. In Section 5, we bring that model to the data and in Section 6, we present our empirical findings. Section 7 concludes.

2 Background on Federal and State Minimum Wages

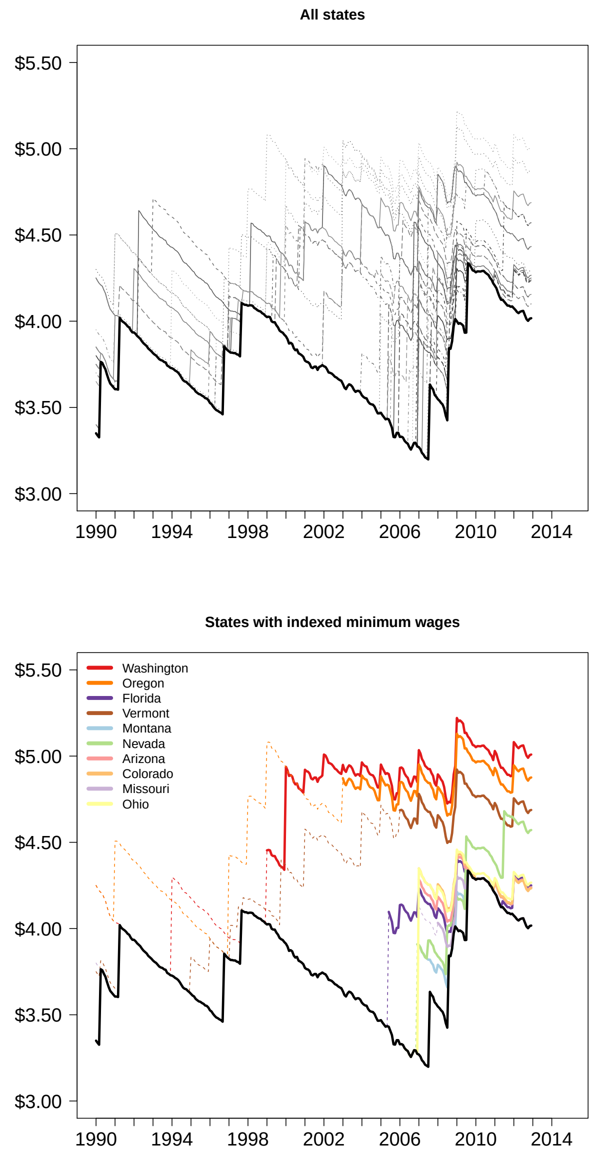
In the U.S., since its introduction as part of the Fair Labor Standards Act in 1938, the federal minimum wage has been set at a nominal rate. Any change of the statutory rate requires an act of Congress. As a result, the nominal federal minimum wage rate only adjusts infrequently. After the federal minimum rate was raised from $4.25 to $5.15 in two steps between 1996 and 1997 during the Clinton administration, it remained unchanged for the following ten years. In 2007, the Fair Minimum Wage Act gradually raised the federal rate to $7.25 over a time horizon of two years. While the nominal value of the federal minimum wage only changes infrequently, the real value declines with inflation, rendering many of the minimum wage increases essentially temporary.

Figure 2 compares the nominal federal minimum wage with its real valuation in 1990 dollars, where we use the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) from the Bureau of Labor Statistics as the deflator. The figure indicates that most raises in the federal minimum wage were eventually eroded by inflation before Congress enacted another minimum wage increase.

In addition to the federal minimum wage, many states have chosen to enact their own minimum wage laws.[4] State minimum wages are either passed by the legislature or result

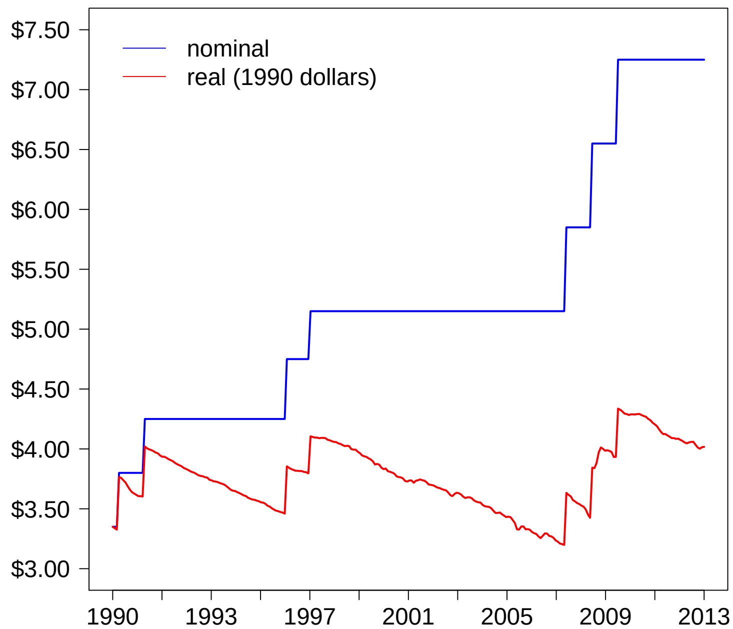
[4]In addition, cities may elect to enact their own minimum wage laws. Among the cities with separate minimum wage laws are San Francisco (see for instance Dube et al. (2006)), Seattle, and New York City.

Figure 1: Real Minimum Wages in the United States



Notes: The first panel shows the real state-level minimum wages for all states. The second panel shows the real state-level minimum wages for states that had indexed their minimum wages to inflation by 2013. Dashed lines refer to the state-level real minimum wage before they were indexed to inflation. Solid lines refer to the state-level real minimum wage after the state passed an indexation law. The nominal minimum wages are deflated using the seasonally adjusted Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W). The base year is 1990. The thick black line refers to the federal minimum wage and provides a floor for all effective state-level minimum wages. The graph captures the following federal minimum wage changes (in nominal terms): Apr 1, 1990 to $3.80, Apr 1, 1991 to $4.25, Oct 1, 1996 to $4.75, Sep 1, 1997 to $5.15, Jul 24, 2007 to $5.85, Jul 24, 2008 to $6.55, and Jul 24, 2009 to $7.25.

Figure 2: Federal Minimum Wage



Notes: The nominal minimum wage is deflated using the seasonally adjusted Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W). The base year is 1990. The graph captures the following federal minimum wage changes (in nominal terms): Apr 1, 1990 to $3.80, Apr 1, 1991 to $4.25, Oct 1, 1996 to $4.75, Sep 1, 1997 to $5.15, Jul 24, 2007 to $5.85, Jul 24, 2008 to $6.55, and Jul 24, 2009 to $7.25.

from referendums. When both the state and federal minimum wage apply to a worker, the higher of the two is binding.

In September 1997, only five states had minimum wage laws that exceeded the national statutory rate.[5] Since then — during a decade with no federal minimum wage increase — more and more states have passed their own minimum wage legislation. As a result, the federal minimum wage increase in 2007 only affected 20 states (see Table 1).

Policy makers are often wary of disrupting the labor market and therefore introduce staggered increases of the minimum wage. For instance, in August 1996, President Clinton signed into law a federal minimum wage increase that took effect in two steps. The first increase was in October of the same year and the second increase came in September 1997. Similarly, the federal minimum wage increases of July 2007, July 2008, and July 2009 all resulted from a law passed in May of 2007.

As can be seen in Figure 1, there is considerable heterogeneity in minimum wages across states and across time. Some states have chosen to remove uncertainty from the evolution of their state minimum wage. There are ten states that have chosen to index their minimum wages to inflation by 2014. These states raise their minimum wages annually according to a pre-determined formula that references a version of the consumer price index and/or a cost of living adjustment. For instance, in September of each year, the state of Washington updates its minimum wage based on the CPI-W. The new minimum wage then takes effect as of January 1 of the following year. Most other states with indexation laws follow similar procedures. Table 2 lists all states that index their minimum wages to inflation and includes information on when the corresponding laws were passed and enacted. With the exception of Vermont, all of these states passed the indexation legislation through ballot initiatives. With the exception of Florida, no more than eight weeks passed between the referendums of the indexation laws and their implementations, limiting the role of anticipation effects. Washington, the first state to index its minimum wage to inflation, raised its minimum wage in two steps from $5.15 to $6.50 between 1999 and 2000 and indexed it to inflation thereafter. Oregon followed in 2003 with a minimum wage increase from $6.50 to $6.90, which was subsequently indexed. The remaining eight states followed suit between 2005 and 2007.

3 Stylized Facts

In this section, we exploit policy variation across U.S. states to estimate the employment effects of increasing the minimum wage under different policy expectations. We distinguish policy expectations along two dimensions: anticipation and indexation.

When a minimum wage increase was passed several months before its implementation, we will consider such an increase as anticipated at the time of its implementation. If, in contrast,

[5] These states consisted of Alaska, Connecticut, Hawaii, Massachusetts, and Oregon.

Table 2: Minimum Wage Indexation Legislation

State	*Date*	*New Minimum*	*Old Minimum*	*Legislated*
Arizona	January 1, 2007	6.75	–	November 7, 2006 (Proposition 202)
Colorado	January 1, 2007	6.85	–	November 7, 2006 (Initiative 42)
Florida	May 2, 2005	6.15	–	November 2, 2004 (Florida Minimum Wage Amendment)
Missouri	January 1, 2007	6.50	–	November 7, 2006 (Missouri Minimum Wage Act, Proposition B)
Montana	January 1, 2007	6.15	–	November 7, 2006 (Montana Minimum Wage, Initiative 151)
Nevada	November 28, 2006	6.15	–	November 7, 2006 (Nevada Minimum Wage Act, Question 6)
Ohio	January 1, 2007	6.85	–	November 7, 2006 (Ohio Minimum Wage Initiative)
Oregon	January 1, 2003	6.90	6.50	November 5, 2002 (Oregon Increase State Minimum Wage, Measure 25)
Vermont	January 1, 2006	7.25	7.00	Passed by the legislature in December 2005.
Washington	January 1, 1999	5.70	5.15	November 3, 1998, Washington Minimum Wage (Initiative 688). The measure increased the minimum wage from $5.15 to $5.70 in 1999 and to $6.50 in 2000 with annual adjustments for inflation thereafter.

Notes: The information was sourced from the Departments of Labor of the respective states. A value of – indicates that the state did not have a state minimum wage law prior to the indexation, implying the federal minimum wage at the time was the effective minimum wage.

a minimum wage increase was passed only weeks before its implementation and when secondary data sources — such as newspaper coverage — do not indicate that this change was foreseeable, we consider such an increase as unanticipated. By indexation, we mean whether or not firms and workers may assume that a minimum wage increase is permanent in real terms, i.e. if it is indexed to inflation.

We exploit variation in the effective minimum wage across states to investigate the impact of increases in the minimum wage on employment and minimum wage coverage. We define minimum wage coverage as the share of the labor force that earns the minimum wage. We consider nine increases of the federal and state minimum wages between 1995 and 2011.

3.1 Data

We use individual-level data from the CPS from 1994 to 2014. The CPS is a monthly survey conducted by the United States Census Bureau and the Bureau of Labor Statistics that collects information on employment, unemployment, and labor force participation. The CPS serves as the source for official employment statistics and contains about 60,000 households per month. Each household is interviewed monthly for the first four months after entering the sample. Households then rotate out of the sample for eight months, before re-entering the sample for four additional months. Information on each of the household members' employment status is collected in every interview. Information on wages and hours is only collected from the outgoing rotation groups, i.e. the fourth and eighth interview. The CPS includes survey weights based on the decennial Census and population projections, which render the survey results representative at the state level.

Throughout we will restrict attention to individuals age 29 or younger without a college degree. This is the subgroup of the population most likely to be affected by the minimum wage. We report estimates for specifications where we include the entire population in Appendix A.

We report summary statistics in Tables 3 and 4. For workers who report that they are paid by the hour, we directly use their reported hourly wage. For salaried workers, we construct the hourly wage from reported weekly earnings (including overtime, tips and commissions) and the reported number of hours worked per week. In the data, few workers earn exactly the minimum wage, which is in part due to measurement error. We define the minimum wage coverage rate, i.e. the share of the population that earns the minimum wage by including every worker who earns less than 105% of the minimum wage per hour.

3.2 Estimation Strategy

We exploit variation in the effective minimum wage across states. If the state minimum wage exceeds the federal minimum wage, then the effective minimum wage refers to the former. If

	Full Sample			*Young Sample*		
	N	Mean	S.D.	N	Mean	S.D.
Employed	24,203,698	0.618	0.486	4,675,404	0.571	0.495
Unemployed	24,203,698	0.040	0.196	4,675,404	0.077	0.267
Out of Labor Force	24,203,698	0.341	0.474	4,675,404	0.351	0.477
Age	24,203,698	44.515	18.103	4,675,404	22.045	4.303
Unemployment Duration	905,569	5.309	6.636	349,039	4.136	5.564
Minimum Wage Coverage	6,097,307	0.025	0.156	1,175,829	0.065	0.246

Table 3: Summary Statistics

Notes: The table shows summary statistics from the Current Population Survey 1994–2014. "Full Sample" refers to all individuals in the CPS age 16 and older. "Young Sample" refers to all individuals in the CPS age 29 or younger and without a college degree. Data are taken from the monthly CPS for all rows except for minimum wage coverage. Minimum wage coverage is constructed using data from the outgoing rotation groups and refers to the share of the population that earns the minimum wage. Unemployment duration is reported as months. All statistics are weighted using the appropriate survey weights.

	N	Mean	S.D.	p10	p25	p50	p75	p90
Full Sample	2,256,825	14.833	11.518	5.993	7.822	11.827	18.502	27.513
Young Sample	462,786	8.609	5.108	5.234	5.995	7.430	9.976	13.363

Table 4: Summary Statistics: Real Hourly Wages

Notes: The table shows summary statistics for the real wage distribution from the Current Population Survey 1994–2014. Data are taken from the outgoing rotation groups. Wages are deflated using the CPI-W with 2000 as the base year. "Full Sample" refers to all individuals in the CPS age 16 and older. "Young Sample" refers to all individuals in the CPS age 29 or younger and without a college degree. All statistics are weighted using the appropriate survey weights.

there is no state minimum wage or it is lower than the federal minimum wage, the effective minimum wage refers to the latter.

We estimate the effects of minimum wage increases on employment and coverage using a difference-in-differences estimator. For each of the minimum wage events that we consider, we identify a set of states that will serve as the control group. Throughout, we will select as control groups all states that contemporaneously did not experience a change in their effective minimum wage between six months before and twelve months after the minimum wage event that we consider. For the difference-in-difference estimator to be valid, we need to ensure that the common trends assumption is satisfied, i.e. that variables of interest (employment and minimum wage coverage) are evolving in parallel for treatment and control states after controlling for observables. In the literature, Allegretto et al. (2011, 2013) argue that the parallel trends assumption is only satisfied when controlling for Census-region (or Census-division) specific time trends, because employment and demographics in different parts of the U.S. evolve differently over time. Neumark et al. (2013) argue that this will result in overfitting. We will report difference-in-difference estimates for specifications with and without region-specific time trends, which in our cases has little impact of our estimates of interest.

Throughout we are interested in two metrics, the effect of the minimum wage change on employment and the effect of the minimum wage change on the minimum wage coverage rate. We denote our variable of interest by y_{ijt}, which is an indicator variable and equals one if person i in state j is employed (or earns the minimum wage) at time t.

We estimate the following linear probability model:

$$y_{ijt} = \alpha m_{jt} + \mathbf{x}'_{ijt}\beta + \mathbf{w}'_{jt}\varphi + \varepsilon_{ijt}, \tag{1}$$

where m_{jt} refers to the effective minimum wage in state j at time t and $\mathbf{x}_{ijt}$ is a vector of individual-specific characteristics, such as age, gender, race, and education. $\mathbf{w}_{jt}$ is a vector with fixed effects. This vector includes state fixed effects, calendar time fixed effects, and — in some specifications — Census region-specific time trends. Here α is informative about the effect that a one dollar increase in the effective minimum wage has on the dependent variable. Note that by the construction of the data, the effective minimum wage is constant in all control states. It only varies in the treatment states and therefore represents the difference-in-difference estimate. This specification controls for the magnitude of the change in the minimum wage. We report results from alternative specifications — including a specification that explicitly accounts for anticipation effects — in Appendix A. The results are similar.

3.3 Results

We consider nine different minimum wage changes. Five of these changes occurred at the federal level. The remaining four occurred at the state level.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Effective Minimum Wage	-0.0663***	-0.0109	-0.0298*	-0.0670*	0.0035	-0.0344***	0.0042	-0.0010	0.0187
	(0.0165)	(0.0213)	(0.0158)	(0.0353)	(0.0066)	(0.0066)	(0.0061)	(0.0061)	(0.0266)
R-squared	0.165	0.153	0.154	0.156	0.166	0.174	0.175	0.168	0.174
Observations	281532	275240	312038	322166	273546	152488	165259	219250	328046

Table 5: Diff-in-Diff Estimates of Marginal Effect on Employment

Note: The table shows the regression coefficient α associated with equation (1) for a variety of minimum wage increases. α is interpreted as the effect of a one dollar change in the effective minimum wage on employment. The data are restricted to individuals age 29 and younger without a college degree. The changes in 1996, 1997, 2007, 2008, and 2009 were federal increases in the minimum wage, where we classify 1996 and 2007 as unanticipated and 1997, 2008, and 2009 as anticipated. The changes in 1999, 2003, and 2005 refer to the initial indexation of the minimum wage in Washington, Oregon, and Florida. The change in 2011 refers to the automatic increase in the minimum wage in a number of states that index their minimum wage to inflation.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Effective Minimum Wage	0.1876***	0.1734***	0.0683***	0.1038***	0.0284***	0.0282***	0.0378***	0.0583***	0.0989***
	(0.0183)	(0.0265)	(0.0196)	(0.0322)	(0.0059)	(0.0064)	(0.0066)	(0.0070)	(0.0307)
R-squared	0.022	0.032	0.027	0.018	0.017	0.015	0.017	0.017	0.016
Observations	70429	68948	78106	80932	68899	38320	41616	55145	82449

Table 6: Diff-in-Diff Estimates of the Marginal Effect on Coverage

Note: The table shows the regression coefficient α associated with equation (1) for a variety of minimum wage increases. α is interpreted as the effect of a one dollar change in the effective minimum wage on the minimum wage coverage rate (i.e. the percentage of the population who works in minimum wage jobs). The data are restricted to individuals age 29 and younger without a college degree. The changes in 1996, 1997, 2007, 2008, and 2009 were federal increases in the minimum wage, where we classify 1996 and 2007 as unanticipated and 1997, 2008, and 2009 as anticipated. The changes in 1999, 2003, and 2005 refer to the initial indexation of the minimum wage in Washington, Oregon, and Florida. The change in 2011 refers to the automatic increase in the minimum wage in a number of states that index their minimum wage to inflation.

We include all recent changes in the federal minimum wage (see Table 1). Recall that the federal minimum wage is not indexed to inflation. The increases in 1996 and 1997 were staggered, i.e. they were passed in August 1996 and then implemented in October 1996 and September 1997. Similarly, the increases in 2007, 2008, and 2009 were staggered. These were passed in May of 2007 and then implemented in the month of July in 2007, 2008, and 2009. Both in 1996 and in 2007, the minimum wage increases were the result of short, but intense political bargaining in Congress. We classify the increases in 1996 and 2007 as unanticipated policy changes. In contrast, we classify the increases in 1997, 2008, and 2009 as anticipated changes, because they were announced more than one year in advance.

In October 1996 the federal minimum wage increased from 4.25 to 4.75. The new minimum was binding in 45 states (see Table 1). Therefore, the number of states that serve as the control group is very small. In fact, it consists only of Hawaii. See Appendix A for a list of treatment and control states for each estimation exercise that we report. The remaining four states had their own minimum wage increases in 1996. While we report estimates for the minimum wage change in 1996 in Tables 5 and 6 in the interest of completeness, we do not discuss these results here. The lack of a suitable group of control states renders these estimates essentially uninformative.

In July 2007 the federal minimum wage was increased from $5.15 to $5.85. Seventeen states were directly affected by this federal minimum wage increase and did not have additional state minimum wage increases shortly thereafter. The list of states that did not have an effective minimum wage change between January 2006 and December 2007 — because these states had a state minimum wage above the federal minimum wage — includes six states. These states will serve as the control group. See Appendix A for complete list of treatment and control states.

We report the estimated marginal impact on employment and minimum wage coverage in Tables 5 and 6. The point estimate for 2007 indicates that a one dollar increase in the federal minimum wage resulted in a decline in employment by 3.44 percentage points. This effect is statistically significant and robust to controlling for Census region-specific time trends (see Table 11). A minimum wage increase of one dollar raises the share of the population employed at the minimum wage by 2.82 percentage points. This effect is also highly significant and robust to the inclusion of additional Census region-specific time trends (see Appendix A).

The federal minimum wage increases in 1997, 2008, and 2009 were fully anticipated. The federal minimum wage increase in 1997 (from $4.75 to $5.15) was passed in August 1996. Similarly, the federal minimum wage increases in 2008 (from $5.85 to $6.55) and 2009 (from $6.55 to $7.25) were passed in May 2007.

We report the estimates of the employment effects in Table 5. The employment effects for 1997, 2008, and 2009 are all indistinguishable from zero. This null effect is robust to the inclusion of region-specific time trends or alternative specifications (see Appendix A). Coverage increased significantly as shown in Table 6. The point estimates indicate that coverage increased by 4.95 percentage points in 1997, 3.27 percentage points in 2008 and 2.27 percentage points in 2009.

Next, we consider the introduction of an indexed minimum wage in Washington in 1999, Oregon in 2003, and Florida in 2005. Our estimates suggest that an indexed one dollar increase in the minimum wage reduced employment by 2.06 percentage points in Washington and 4.92 percentage points in Oregon (see Table 5). For Florida, we find no effect. However, Florida stretches our definition of unanticipated change, because the policy change was announced six months in advance.

Last, we consider the increase in the minimum wage in January 2011 in a number of states that index their minimum wage to inflation. Here, we focus on Arizona, Colorado, Montana, Ohio, Oregon, Vermont, and Washington. The control group consists of 41 states — all states with no minimum wage increase between July 2010 and December 2011. We find no statistically significant effect on employment (see Table 5). However, coverage increased substantially (see Table 6), where a one dollar increase in the minimum wage corresponds to an increase in the minimum wage coverage by 9.89 percentage points.

Altogether, the results indicate the following. First, minimum wage increases that are anticipated have little or no effect on employment. This is true regardless of whether these minimum wage increases are indexed to inflation. Second, minimum wage increases that are unanticipated have considerable employment effects. This is true regardless of whether these minimum wage increases are indexed to inflation. However, employment effects are larger when the minimum wage increase is indexed to inflation. All changes of the minimum wage have substantial effects on coverage.

We consider the evidence presented in this section as suggestive. There are at least two shortcomings. First, classifying policy expectations as anticipated vs. unanticipated is of course insufficient to appropriately address the role of expectations. There are some states with very frequent minimum wage increases, which limits the extent to which workers and firms should be surprised by a minimum wage hike, even if the increase itself was not announced in advance. Second, we presented evidence from nine different minimum wage increases and then provided an after the fact interpretation for these estimates using anticipation and indexation. Clearly, anticipation and indexation are not the only dimensions along which the various minimum wage increases differ and there may be other explanations.

4 Model

4.1 Basics

This section extends the equilibrium search model of the labor market used by Flinn (2006). Since our goal is to capture the role of policy expectations, the model needs to accommodate a time-varying real minimum wage. We develop and solve a non-stationary model, which makes our analysis distinctly different from Flinn's 2006, who characterizes the labor market in its steady state at a constant real minimum wage.

Time is discrete and indexed by $t = 1, 2, \ldots$. There is a unit measure of workers and a positive measure of firms. Workers and firms are both risk neutral and discount the future with factor β. The labor market is characterized by search frictions. Individuals can be either employed or unemployed. Unemployed workers receive a flow utility of $b \geq 0$. All unemployed workers search for jobs. When an unemployed worker and a vacant firm meet, they draw a match productivity, $x \in \mathcal{X}$, from a time-invariant distribution $G(x)$ and then decide whether they want to consummate the match. If they choose to match, production will begin in the next period. Wages are determined using Nash bargaining and renegotiated every period. The worker's bargaining share is given by $\alpha \in [0, 1]$. New firms can enter and create new vacancies subject to an entry cost of $c > 0$.

Existing matches inherit their match productivity from the previous period with probability $1 - \gamma$. With probability γ, they draw a new match value from the distribution $G(x)$.[6] At the beginning of the period, after observing x, employed workers may quit or be laid off. This occurs endogenously whenever the worker or the firm does not find it profitable to continue the employment relationship.[7] When a firm-worker match is destroyed, the worker joins the pool of unemployed workers and the firm leaves the market with zero scrap value. The model features endogenous contact rates, i.e. a worker's probability of meeting a firm is endogenous and depends on the number of vacancies and on the number of unemployed workers through a matching function. We denote the matching function by $M : \mathbb{R}_+ \times \mathbb{R}_+ \mapsto \mathbb{R}_+$, which maps the measure of vacancies, v_t, and the measure of searching workers, u_t, into meetings. We assume that M exhibits constant returns to scale, which implies that a worker's probability of meeting a vacancy and a vacancy's probability of meeting a worker only depend on the market tightness, θ_t, defined as the ratio of vacancies to unemployed workers.[8] We denote the

[6] Allowing matches to redraw their match productivity is a deviation from the model in Flinn (2006). We found this necessary to match the minimum wage coverage rate and changes thereof in the data. If match productivity is persistent, we found it difficult to explain why so many workers work in minimum wage jobs and why the coverage rate is so sensitive to changes in the minimum wage. With $\gamma > 0$, minimum wage jobs become more attractive, because there is a chance that they turn into better jobs in the future. At the same time jobs in the right tail of the productivity distribution become (relatively) less attractive, because there is a chance that they turn into worse jobs in the future.

[7] We do not include an exogenous risk of job separations in the model. Exogenous job separations are captured by drawing a new match productivity (which happens with probability γ) that turns out to be below the reservation productivity of the match.

[8] When the matching function M exhibits constant returns to scale, we can write the probability that a worker meets a firm as

$$M(v_t, u_t)/u_t = M(v_t/u_t, 1) \equiv p(\theta_t).$$

Similarly, the probability that a firm meets a worker is then given by

$$M(v_t, u_t)/v_t = M(v_t/u_t, 1)u_t/v_t = \theta p(\theta_t) \equiv q(\theta_t).$$

probability that a worker meets a firm by $p : \mathbb{R}_+ \mapsto [0,1]$ and the probability that a firm meets a worker by $q : \mathbb{R}_+ \mapsto [0,1]$.

The policy environment features a minimum wage m_t that establishes a wage floor for workers and firms. When a firm is not willing to pay its worker at least the minimum wage, this firm-worker match breaks up and the worker becomes unemployed. We assume that m_t is time-varying for two reasons. First, because m_t denotes the real-value of the minimum wage, m_t depreciates over time. Second, the real value of the minimum wage changes over time, because of policy interventions. We assume that the evolution of the real value of the minimum wage is Markovian and captured by the distribution $F(m|m_{t-1})$. Firms and workers know this distribution F and use it to forecast minimum wage policy.

The time-varying minimum wage renders the economy non-stationary. As long as the minimum wage policy keeps evolving, this economy will not converge to a time-invariant distribution of workers across states. We therefore need to condition agents' behavior in the model on the aggregate state of the economy. We make this explicit by introducing the following notation.

The aggregate state of the economy is denoted by $\boldsymbol{\psi}_t = [u_t, e_t, m_t] \in \boldsymbol{\Psi}$, where $u_t \in \mathbb{R}_+$ refers to the measure of unemployed workers, $e_t : \mathcal{X} \mapsto \mathbb{R}_+$ to the distribution of employed workers across firms, and $m_t \in \mathcal{M}$ refers to the real value of the minimum wage at time t. We denote the expectation with respect to $\boldsymbol{\psi}_{t+1}$ conditional on $\boldsymbol{\psi}_t$ by $\mathbb{E}_{\boldsymbol{\psi}_{t+1}}[\dots|\boldsymbol{\psi}]$. This expectation conditions on equilibrium behavior by all firms and workers in the economy (which governs the evolution of $\boldsymbol{\psi}_t$). We will denote the aggregate transition function of $\boldsymbol{\psi}_t$ by $\boldsymbol{\Lambda} : \boldsymbol{\Psi} \mapsto \boldsymbol{\Psi}$.

To simplify the exposition, we drop the subscript t in this section and instead refer to next period's realization of a generic variable z by z'.

A firm's value from being matched to a worker with match quality x in aggregate state $\boldsymbol{\psi}$ with wage w equals

$$J(\boldsymbol{\psi}, x, w) = x - w + \beta \mathbb{E}_{\boldsymbol{\psi}', x'} \left[(1 - d(\boldsymbol{\psi}', x')) J(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x')) | \boldsymbol{\psi}, x \right], \tag{2}$$

where $w(\boldsymbol{\psi}', x')$ refers to the wage policy function. The job destruction policy function, $d(\boldsymbol{\psi}', x')$, which we define below, captures endogenous separations. $J(\boldsymbol{\psi}, x, w)$ refers to the firm's value at the beginning of the period right after endogenous job destructions. We take expectations with respect to $\boldsymbol{\psi}'$ and x'. The expectation with respect to x' is conditional on x. Recall that with probability $1 - \gamma$, next period's match productivity x' simply equals x. With probability γ, x' is drawn from the distribution $G(x)$.

The firm's value from posting a vacancy is given by

$$V(\boldsymbol{\psi}) = -c + q(\theta(\boldsymbol{\psi})) \beta \mathbb{E}_{\boldsymbol{\psi}', x'} \left[(1 - d(\boldsymbol{\psi}', x')) J(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x')) | \boldsymbol{\psi} \right], \tag{3}$$

which states that a firm incurs the cost of posting a vacancy c and then meets a worker with probability $q(\theta(\boldsymbol{\psi}))$, where we denote the ratio of vacancies, v, to unemployed workers, u by $\theta(\boldsymbol{\psi})$, which is an equilibrium object that we characterize below. When the firm meets a worker, it draws match quality x' from the unconditional distribution $G(x')$. When this new match does not immediately separate — separations occur when $d(\boldsymbol{\psi}', x')$ equals one — the firm receives a continuation value of $J(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x'))$. Otherwise, the firm's continuation value is zero.

A worker's value from being matched to a firm with match quality x in aggregate state $\boldsymbol{\psi}$ with wage w equals

$$W(\boldsymbol{\psi}, x, w) = w + \beta \mathbb{E}_{\boldsymbol{\psi}', x'} \left[(1 - d(\boldsymbol{\psi}', x')) W(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x')) + d(\boldsymbol{\psi}', x') U(\boldsymbol{\psi}') | \boldsymbol{\psi}, x \right]. \quad (4)$$

A worker who is matched receives wage w in the current period. In the subsequent period the worker receives continuation value $W(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x'))$ when the match stays together. When the worker and firm separate at the beginning of the subsequent period, the worker's continuation value is $U(\boldsymbol{\psi}')$.

The value from being unemployed when the aggregate state of the economy equals $\boldsymbol{\psi}$ is given by

$$U(\boldsymbol{\psi}) = b + \beta \mathbf{E}_{\boldsymbol{\psi}', x'} \left[U(\boldsymbol{\psi}') + p(\theta(\boldsymbol{\psi}))(1 - d(\boldsymbol{\psi}', x'))[W(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x)) - U(\boldsymbol{\psi}')] | \boldsymbol{\psi} \right]. \quad (5)$$

An unemployed worker receives flow payoffs b. The worker meets a vacancy with probability $p(\theta(\boldsymbol{\psi}))$ and then draws match quality x' from the unconditional distribution $G(x')$. When the worker does not meet a vacancy (or if the new match immediately separates), the worker remains unemployed and receives continuation value $U(\boldsymbol{\psi}')$ in the subsequent period.

A match separates when either the worker or the firm is better off unmatched. This implies that

$$d(\boldsymbol{\psi}, x) = \begin{cases} 1 & \text{if } W(\boldsymbol{\psi}, x, w(\boldsymbol{\psi}, x)) < U(\boldsymbol{\psi}) \text{ or } J(\boldsymbol{\psi}, x, w(\boldsymbol{\psi}, x)) < 0 \\ 0 & \text{otherwise.} \end{cases} \quad (6)$$

Wages are determined using Nash bargaining subject to the time-varying minimum wage constraint, m. Thus,

$$w(\boldsymbol{\psi}, x) = \arg\max_{w \geq m} (W(\boldsymbol{\psi}, x, w) - U(\boldsymbol{\psi}))^{\alpha} J(\boldsymbol{\psi}, x, w)^{1-\alpha}, \quad (7)$$

where $\alpha \in [0, 1]$ is a parameter that governs the worker's bargaining power. For an interior solution, we take the first-order condition with respect to w and obtain

$$(1 - \alpha)(W(\boldsymbol{\psi}, x, w) - U(\boldsymbol{\psi})) = \alpha J(\boldsymbol{\psi}, x, w).$$

Since the wage enters both the firm's and the worker's value function linearly, we can solve for it and obtain

$$
\begin{aligned}
w^*(\boldsymbol{\psi}, x) = {} & \alpha x + \alpha\beta \mathbb{E}_{\boldsymbol{\psi}',x'}\left[(1 - d(\boldsymbol{\psi}', x'))J(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x'))|\boldsymbol{\psi}, x\right] + (1-\alpha)U(\boldsymbol{\psi}) \\
& - (1-\alpha)\beta \mathbb{E}_{\boldsymbol{\psi}',x'}\left[(1 - d(\boldsymbol{\psi}', x'))W(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x')) + d(\boldsymbol{\psi}', x')U(\boldsymbol{\psi}')|\boldsymbol{\psi}, x\right],
\end{aligned}
$$

where the star indicates that this is the wage policy function for an *interior* solution only.[9] The actual wage policy function needs to obey the minimum wage constraint. It is given by

$$
w(\boldsymbol{\psi}, x) = \begin{cases} m & \text{if } w^*(\boldsymbol{\psi}, x) \leq m \\ w^*(\boldsymbol{\psi}, x) & \text{if } w^*(\boldsymbol{\psi}, x) > m. \end{cases} \tag{8}
$$

Now that we have characterized the separation policy function and wage policy function, we close the model by imposing a free-entry condition. This free-entry condition pins down how many vacancies v are created each period. Firm entry ensures that the value of opening a vacancy is no greater than zero in equilibrium. The cost of posting a vacancy is equal to or greater than (if no vacancies are created) the firm's expected value of meeting an unemployed worker, i.e.

$$
c \geq q(\theta(\boldsymbol{\psi}))\beta \mathbb{E}_{\boldsymbol{\psi}',x'}\left[(1 - d(\boldsymbol{\psi}', x'))J(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x'))|\boldsymbol{\psi}\right] \tag{9}
$$

with complementary slackness. Note that the above expression implies that under free entry, θ is only a function of m, not the entire aggregate state $\boldsymbol{\psi}$. In particular, knowledge of the evolution of the minimum wage and the market tightness is sufficient for firms to forecast their value from being matched to a worker.

4.2 Equilibrium

We define a recursive search equilibrium for this economy given beliefs over the minimum wage policy $F(m'|m)$. For a realization of the minimum wage m, a recursive search equilibrium consists of

- distributions of workers across states u and e
- a market tightness θ
- value functions J, V, W, U,
- wage policy function w,

[9] Without the minimum wage constraint, we could simplify the expression further. However, $(1-\alpha)(W(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x')) - U(\boldsymbol{\psi}')) \neq \alpha J(\boldsymbol{\psi}', x', w(\boldsymbol{\psi}', x'))$ whenever the minimum wage constraint is binding.

- separation policy function d,
- an aggregate transition function $\mathbf{\Lambda} : \mathbf{\Psi} \mapsto \mathbf{\Psi}$.

such that

- value functions satisfy (2)–(5),
- the value from opening a vacancy equals zero, i.e. (9) holds,
- the separation policy function satisfies (6),
- the wage policy function solves (7),
- the aggregate transition function $\mathbf{\Lambda}$ is consistent with individually rational behavior.

Computing the equilibrium is straightforward. We iterate simultaneously on workers' and firms' value functions, the wage policy function, and the market tightness. Details are relegated to Appendix B. With the equilibrium value and policy functions in hand, we compute distributions of workers across states using flow equations. Note that the model is non-stationary. Therefore, we can only compute distributions of workers across states conditional on a particular realization of the entire minimum wage policy path and an initial condition for the distribution of workers at some time zero.

4.3 Implications

In the model, the minimum wage imposes a constraint on the Nash-bargaining problem in (7) that is used to determine wages. This means that generating a positive surplus $W(\boldsymbol{\psi}, x, \cdot) - U(\boldsymbol{\psi}) + J(\boldsymbol{\psi}, x, \cdot)$ is not sufficient for the continuation of a match (as would be the case without the minimum wage constraint).[10] Consider a firm-worker pair for whom the minimum wage binds. For this pair, two things can happen. First, the firm cannot afford to pay the worker the minimum wage and the worker and firm separate. In this case, the minimum wage generates involuntary unemployment. Second, the firm can afford to pay the worker the minimum wage and the worker stays employed. In this case, the worker enjoys a wage that is higher than what the worker would have received otherwise, i.e., the minimum wage effectively increases the worker's bargaining power. In the model, the minimum wage also has dynamic implications, because it affects the firm's expected value from posting a vacancy and thereby affects vacancy creation. Similarly, it affects the worker's value from unemployment, because workers anticipate that future employment relationships are governed by the minimum wage constraint.

[10] Note that the expression $W(\boldsymbol{\psi}, x, \cdot) - U(\boldsymbol{\psi}) + J(\boldsymbol{\psi}, x, \cdot)$ is independent of the wage paid, because it is simply a transfer from the firm to the worker.

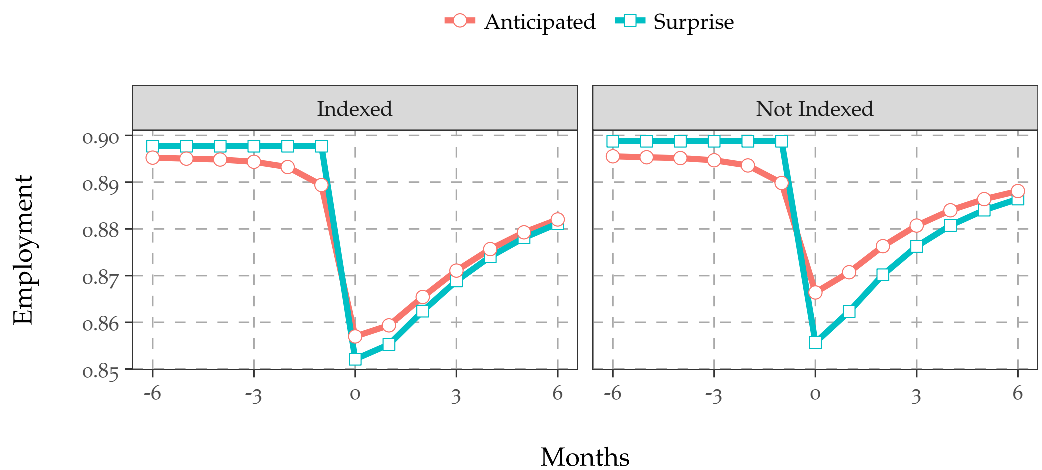


Figure 3: Short-Run Employment Effects of a Minimum Wage Increase

Notes: The figure shows the short-run effect of a minimum wage change on employment under minimum wage policy regimes that differ in their anticipation (surprise vs. anticipated) and commitment (real vs. nominal). The minimum wage increases at time zero.

Even though the model is simple, policy expectations may potentially play an important role. When firms anticipate a minimum wage increase in the near future, this will impact vacancy creation today. When the minimum wage is not indexed to inflation, its effect on vacancy posting is smaller than when it is indexed. Similarly, firms will be willing to tolerate a temporary loss (i.e. pay the worker more than her productivity) in anticipation of a lower real minimum wage in the future.

Figures 3 and 4 illustrate the various ways that minimum wage policies and expectations thereof affect employment, minimum wage coverage, and market tightness. First, we consider the *short-run* effect of a minimum wage increase on employment under four different expectation regimes (see Figure 3). The minimum wage is either anticipated and indexed, anticipated and not indexed, unanticipated and indexed, or unanticipated and not indexed. In this illustration, the real value of the minimum wage increases from \$5 to \$6 at time zero.[11] Without anticipation, employment does not adjust before time zero. With anticipation, employment adjusts by approximately a percentage point in the months before the minimum wage is increased. Under all four expectation regimes, employment decreases substantially at

[11] We simulate data for a total of 161 periods (80 periods before the minimum wage increase and 80 after). When the minimum wage increase is anticipated, workers' and firms' expectations are statistically degenerate up until (and including) period 0. After period 0, workers and firms have non-degenerate expectations with respect to the evolution of the minimum wage. When the minimum wage change is unanticipated, workers have non-degenerate expectations for all 161 periods. Workers know whether a minimum wage is indexed and form expectations accordingly. In the illustration, workers expect minimum wage increases to happen every 80 periods (i.e. with probability 1/80). When a minimum wage increase happens, workers expect it to have mean one. When the minimum wage is not indexed, workers expect it to decrease according to an annual rate of inflation of 2.5%; when it is indexed, workers expect it to remain constant.

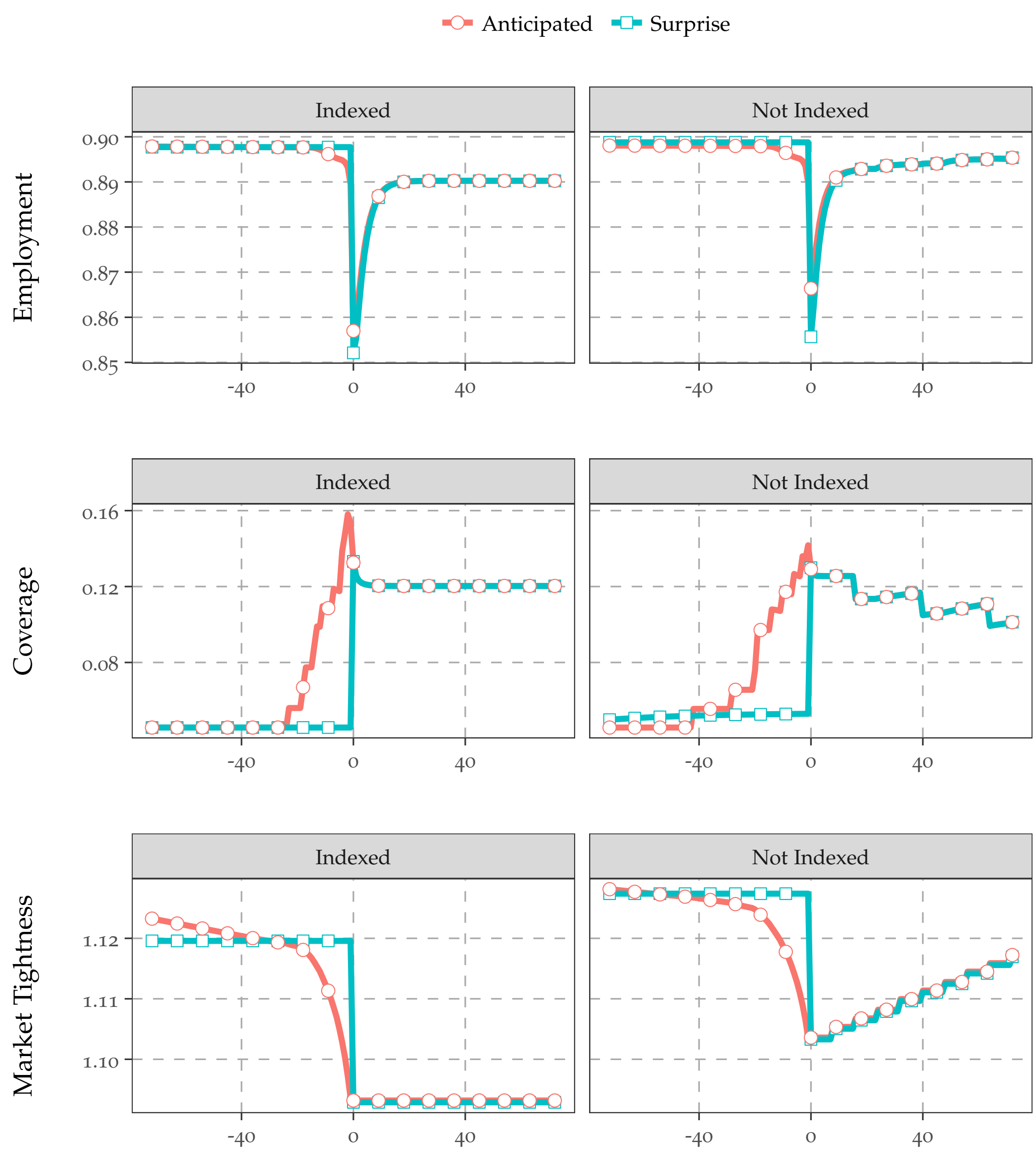


Figure 4: Model Implications under Different Minimum Wage Policy Regimes

Notes: The panels show the employment rate, the real wage, the minimum wage coverage, and the market tightness under minimum wage policy regimes that differ in their anticipation (surprise vs. anticipated) and commitment (real vs. nominal).

the time of the increase. The decrease is larger when the increase is not anticipated (regardless of whether the minimum wage is indexed). The decrease is also larger when the minimum wage is indexed (regardless of whether it is anticipated). When the minimum wage increase is anticipated, fewer matches that would be destroyed by the minimum wage will be created in the months before the minimum wage increase. In the months after the minimum wage increase, employment quickly increases.

Second, we consider the *long-run* implications of the same minimum wage change. Figure 4 shows the effect on employment, coverage, and tightness. As expected, an indexed change in the minimum wage results in a persistent effect on employment. In contrast, a non-indexed change only has temporary effects. Over time, employment will return to its original level. In both cases the long-run effects do not depend on whether the time zero minimum wage increase was anticipated. Minimum wage coverage *before* the increase depends on whether the increase is anticipated. When a minimum wage change is anticipated, coverage increases in the months prior to the increase. This results from the Nash bargaining assumption. Because the worker and firm anticipate that the minimum wage will soon shift a larger share of the surplus towards the worker, the Nash bargaining solution prescribes that the firm receives a larger share of the surplus prior to the minimum wage increase. Coverage after the minimum wage increase depends on whether the change is indexed. When the increase is indexed to inflation, coverage quickly converges to its new constant level. When the increase is not indexed, coverage slowly decreases over time (as the real value of the minimum wage deteriorates). The evolution of the market tightness reflects both the effect that the minimum wage has on firms' incentives to post vacancies and the effect on separations. When the minimum wage increase is unanticipated, market tightness jumps at the time of the increase. When the policy change is anticipated, the market tightness will slowly adjust in the months preceding the minimum wage change. When the change is not indexed, market tightness slowly reverts to its original level. When the change is indexed, the drop in market tightness is persistent and job finding rates will be affected in the long-run.

5 Estimation

Throughout, we assume that one period in the model corresponds to one month in the data. The discount factor, β, is set to 0.9959, which corresponds to an annual interest rate of 5%.

5.1 Parameterization

We parameterize the model as follows. Match productivity x follows a log-normal distribution with location parameter μ and scale parameter σ. The matching function per number of unemployed workers is given by

$$p(\theta) = \frac{\theta}{(1+\theta^{\omega})^{\frac{1}{\omega}}},$$

which is in line with, e.g., den Haan et al. (2000). The benefit of using this matching function relative to others (e.g. Cobb-Douglas) is that it is guaranteed to return a meeting probability on the unit interval. The matching function per number of vacancies is given by

$$q(\theta) = \frac{1}{(1+\theta^{\omega})^{\frac{1}{\omega}}}.$$

Workers and firms have rational expectations with respect to the evolution of the real value of the minimum wage. In the model, we described the evolution of the real value of the minimum wage by the Markov process $F(m|m_{t-1})$. We will use F to interchangeably refer to the stochastic process that governs the minimum wage as well as to workers' and firms' expectations thereof. This process itself is time invariant.

The stochastic process F may vary along three dimensions: (1) the likelihood of a minimum wage increase from one month to the next; (2) whether the minimum wage is indexed to inflation; and (3) the distribution from which changes in the minimum wage are drawn.[12] We parameterize F as follows. Recall that we discretized the possible values that the real minimum wage can take, $\mathcal{M} = \{m_{[1]}, m_{[2]}, \ldots, m_{[M]}\}$, where M denotes the number of elements of $\mathcal{M}$. The elements of $\mathcal{M}$ are equidistant and arranged in increasing order. F is governed by four parameters that we denote by π_F, λ_F, μ_F, and σ_F. The parameter π_F captures the depreciation of the real value of the minimum wage and denotes the probability of transitioning from $m_{[i]}$ to $m_{[i-1]}$ for some $i \in 2, \ldots, M$. We calibrate π_F such that the depreciation of the real value of the minimum wage corresponds to the true depreciation of the real minimum wage in the data measured by the seasonally adjusted Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W). The parameter λ_F governs the month-to-month probability of an increase in the statutory minimum wage rate. The parameter is calibrated to match the average duration between minimum wage increases in the data. The parameters μ_F and σ_F describe the mean and standard deviation of a normal distribution from which minimum wage increases are drawn. These parameters are calibrated to match the magnitude and dispersion observed in the data.

[12] Based on the actual evolution of the real minimum wage policies across states shown in Figure 1, it is clear that assuming that minimum wage policy expectations are governed by a first-order Markov process is a simplification. However, we find that this simplification is warranted because it fits the data well and it is sufficient to investigate the impact of policy expectations on outcomes. More realistic minimum wage expectations would not be first-order Markov. Instead, more realistic expectations would account for the fact that the likelihood of a minimum wage increase is increasing in the number of months since the last increase. Minimum wage expectations also depend on factors other than the past minimum wage, such as which party is currently in power at the state and federal level, the aggregate state of the economy, and the evolution of minimum wages in neighboring states that may affect public opinion.

5.2 Moments

The model is purposefully kept simple. It does not feature worker-level heterogeneity other than match productivity. It also does not allow for any variation over time that is unrelated to the minimum wage. This rules out business cycle fluctuations, seasonal effects, tax policy changes, or demographic changes. Our model also does not feature a labor force participation decision.[13] This simplicity poses three distinct challenges as we bring the model to the data.

First, the lack of worker-level heterogeneity beyond match productivity means that the model will not accurately predict labor supply and earnings at the individual level. We address this concern by estimating the model using only data from individuals who are 29 or younger without a college degree, a relatively homogeneous subgroup for which the model provides a reasonable fit.

Second, the model's lack of variation unrelated to the minimum wage is clearly at odds with the data. In the data, employment is driven by the business cycle, seasonal effects, and demographic changes — none of which are featured in the model. To prevent the possibility that the model attributes any changes in aggregate employment over time to minimum wage policy changes, we do not estimate the model using raw data moments from before and after minimum wage increases. Instead, we use indirect inference and target the difference-in-differences estimates from Section 3. These estimates represent the causal effect of changing the minimum wage on employment and minimum wage coverage. In the underlying regressions, we controlled for other concurrent sources of time variation. Therefore, these difference-in-differences estimates isolate the effects of the minimum wage policy and represent the appropriate analog for the employment effects that the model generates.

Third, minimum wages may also affect individuals' labor force participation decisions. If a minimum wage increase results in layoffs, some of the laid-off workers may leave the labor force. Similarly, if a minimum wage increase raises overall wage levels, this may induce some individuals to join the labor force. In our analysis in Section 3, we were agnostic about whether changes in employment were offset by changes in the unemployment rate or by changes in the share of the population out of the labor force. When we bring the model to the data, we assume that the change in the employment rate in the model (relative to the labor force) is equal to the change in the employment rate in the data (relative to the population). For the coverage rate, we estimate the model analog, i.e. the change in coverage relative to the labor force instead of relative to the population (see Table 17 in Appendix A).

In addition to the difference-in-differences moments that describe the effect of a minimum wage increase on employment and coverage, we also use several cross-sectional moments that

[13] Including a labor force participation decision is straightforward. We abstract from labor force participation in the interest of keeping the model simple. To introduce a labor force participation decision, one could include an out-of-labor-force state into the model. Unemployed workers transition out of the labor force with a fixed probability. Workers out of the labor force transition back into the labor force whenever their expected value from being in the labor force exceeds some stochastic value from being out of the labor force.

describe employment, minimum wage coverage, wages, and unemployment duration.

5.3 Identification

Identification of the model's structural parameters largely follows the arguments in Flinn (2006), where our non-stationary model naturally corresponds to his case with data from multiple cross sections.[14] The observed wage distribution is informative about the coefficients of the productivity distribution. Given our functional form assumption (match productivity follows a log-normal distribution), the accepted wage distribution is also informative about the reservation match value, which in turn is informative about b. The duration of unemployment and the employment rate are jointly informative about γ and c. The variation in the duration of unemployment under different minimum wage regimes is informative about the elasticity of the matching function, ω. In our estimation, we explicitly use the difference-in-differences estimates on employment and minimum wage coverage induced by an actual policy change. This also permits us to pin down the bargaining power, α, without resorting to additional data (such as data on firms' wage bill to revenue ratio). For instance, when a minimum wage increase results in large changes in the coverage rate but has no effect on employment, this would indicate a low value for the worker's bargaining power, α. In contrast, small changes in coverage but large effects on employment would indicate that α is large.

5.4 Estimates

Our estimation is based on the staggered increase in the federal minimum wage in 2007, 2008, and 2009. We proceed in two steps. First, we estimate the parameters π_F, λ_F, μ_F, and σ_F that govern minimum wage expectations, F. We estimate these parameters without solving our structural model. Second, with these estimates for the minimum wage expectations in hand, we estimate the structural model conditional on F.

We estimate the four parameters governing F using historical minimum wage changes in all states that were affected by the federal minimum wage change in 2007 (see Appendix A for a list of these states). Consistent with the actual roll-out of the minimum wage increases, we assume that all workers and firms were surprised by the initial minimum wage increase in 2007, but were subsequently fully aware of the increases in 2008 and 2009. After July 2009, workers and firms again have non-degenerate expectations that are consistent with past minimum wage increases.[15] We report the corresponding estimates for π_F, λ_F, μ_F, and σ_F in the top panel of Table 8. The average monthly arrival probability of a minimum wage increase is 0.018, which corresponds to an average time of 4.5 years between minimum wage increases.

[14] Flinn (2006) argues that with data from a single cross section alone, we cannot pin down some of the parameters of interest, such as the elasticity of the matching function, ω.

[15] The minimum wage process is still Markovian. We add a deterministic sequence to the otherwise stochastic probability transition matrix. Workers' and firms' expectation of transitioning to the starting point of this deterministic sequence is zero.

When a minimum wage increase occurs, it is drawn from a normal distribution with mean 0.528 and standard deviation 0.061. The real value of the minimum wage depreciates at an average inflation rate of 0.027 per year.

With these estimates of the minimum wage process in hand, we proceed with the estimation of the structural model. We estimate seven model parameters: the worker's bargaining power α, the cost of creating a vacancy c, the matching function elasticity ω, the parameters that govern match productivity, μ, σ, and γ, and workers' flow value from leisure, b. We use cross-sectional moments from 2006 to establish baseline numbers for the wage distribution, employment, minimum wage coverage, and unemployment duration. We then use difference-in-differences estimates to match the impact of the 2007 minimum wage increase on employment and coverage.

	Data	Model
Mean Wage	8.1380	8.3007
SD Wage	3.5720	4.0104
Wage p10	5.2135	5.0848
Wage p25	5.9492	6.1291
Wage p50	7.3443	8.4071
Wage p75	9.8032	10.9757
Wage p90	13.1493	15.4122
Employment	0.9270	0.9320
Coverage	0.0518	0.0572
Unemployment Duration	3.4140	3.1815
Employment Change	-0.0210	-0.0208
Coverage Change	0.0310	0.0357

Table 7: Moments Used in Estimation

Note: The table shows the data and model moments that we match to estimate the model. The sample is restricted to workers age 29 and below in states that were subject to the federal minimum wage increase in 2007. The moments describing the wage distribution, employment, minimum wage coverage, and unemployment duration refer to the year 2006 and establish a baseline. The change in employment and change in employment refer to three months before and twelve months after the federal minimum wage increase in 2007.

These estimates are a variant of the difference-in-differences estimator that we used in Section 3. In this variant, which we describe in Appendix A, we explicitly account for anticipation effects by estimating the average impact of the minimum wage increase on employment and coverage between three months before and twelve months after the minimum wage increase. The difference-in-differences estimates from this specification are quantitatively consistent with our findings in Section 3 and we report them in Tables 15 and 16 of Appendix A. We show the entire list of moments used for the estimation in Table 7.

We estimate the model using indirect inference. We match a set of moments and reduced-form estimates that were obtained from the real data with the corresponding analogs from model-generated data. We avoid simulation error by computing the exact solution to the distribution of workers across states (see Appendix B for details). Computing the wage and employment moments using the model-implied distribution of workers across states is straight-

	Estimate
Mean Increase μ_F	0.5284
SD Increase σ_F	0.0607
Arrival Increase λ_F	0.0183
Annual Inflation π_F	0.0273
Worker's bargaining power α	0.5360
Vacancy posting cost c	6.4708
Location of match productivity μ	1.5847
Scale of match productivity σ	0.7788
Draw new match productivity γ	0.0357
Flow value of unemployment b	-4.3594
Matching function elasticity ω	0.5976

Table 8: Estimated Parameters

Note: The table shows the parameter estimates for the model. The first four estimates describe the minimum wage expectations, which we estimate in a first step and then feed into the model. The remaining estimates are estimated by minimizing the distance between the model and data moments shown in Table 7.

forward. We obtain the model-implied causal effect of the 2007 minimum wage increase on employment and coverage by computing moments for a counterfactual economy, which did not experience a minimum wage increase in 2007 (or thereafter). We approximate the duration of an average unemployment spell by the inverse of the expected job finding rate, which is an imprecise approximation (because the model is non-stationary), but it is sufficiently accurate for our purposes.

We denote the model generated moments by $\mathbf{h}(\Theta)$, where Θ denotes the vector of model parameters and the target moments are denoted by $\widehat{\mathbf{h}}$. We then numerically minimize the distance between model moments and data moments, i.e. we solve

$$\min_{\Theta} \left(\mathbf{h}(\Theta)' - \widehat{\mathbf{h}}\right) \mathbf{W} \left(\mathbf{h}(\Theta) - \widehat{\mathbf{h}}\right),$$

where $\mathbf{W}$ is a diagonal weight matrix. We choose the weights judiciously, placing more weight on moments that we want the model to capture precisely (e.g. the employment and coverage effects).

Table 8 reports the parameter estimates. The worker's bargaining power is estimated at about 0.53, which is large for this class of models. For instance, Flinn (2006) estimates α at 0.40. In our estimation procedure, the parameter is estimated from jointly targeting the effect of raising the minimum wage on employment and coverage. A small value of α would require that a minimum wage increase results in large changes in coverage and small changes in employment, which is not what we find in the data.[16] The cost of posting a vacancy is estimated to equal 6.47. The location and scale of the match distribution are estimated at 1.58 and 0.77, respectively. The estimate of γ, which equals about 0.03, implies that ongoing

[16]In Flinn (2006), the identification of α rests entirely on matching his model's implied wage to firm revenue ratio to that of McDonald's.

matches draw a new match productivity after an average of 30 months. The flow value of unemployment is negative and about equal to minus half the average wage. This implies that unemployment is worse than just not receiving income. While uncharacteristic in the literature, this estimate of the flow value is a direct result of our identification strategy. If unemployment was just a little bit worse than employment, the model would not be able to explain why so many workers work in minimum wage jobs, the wage distribution is relatively disperse, *and* unemployment duration is only that short. Instead, the model would prescribe that workers should not accept minimum wage jobs and instead wait for a better match. If we allowed for persistent individual worker heterogeneity (e.g. heterogeneity in workers' outside options or their ability), we would expect the estimate of b to be substantially larger. The estimate of ω is 0.59 and within the range of estimates used in the literature.

The model fit is shown in Table 7. Overall, we are able to match the targeted moments reasonably well. We compare the wage distribution implied by the model against the observed wage distribution in Figure 5.

Figure 5: Wage Distribution: Data vs. Model

Note: The left figure shows the histogram of real hourly wages in the CPS (deflated using the CPI-W with 2000 as the base year) for 2007. The sample is restricted to workers age 29 and below in states that were subject to the federal minimum wage increase in 2007. The right figure shows the same for simulated data based on the model estimates, where the number of observations simulated is equal to that in the real data.

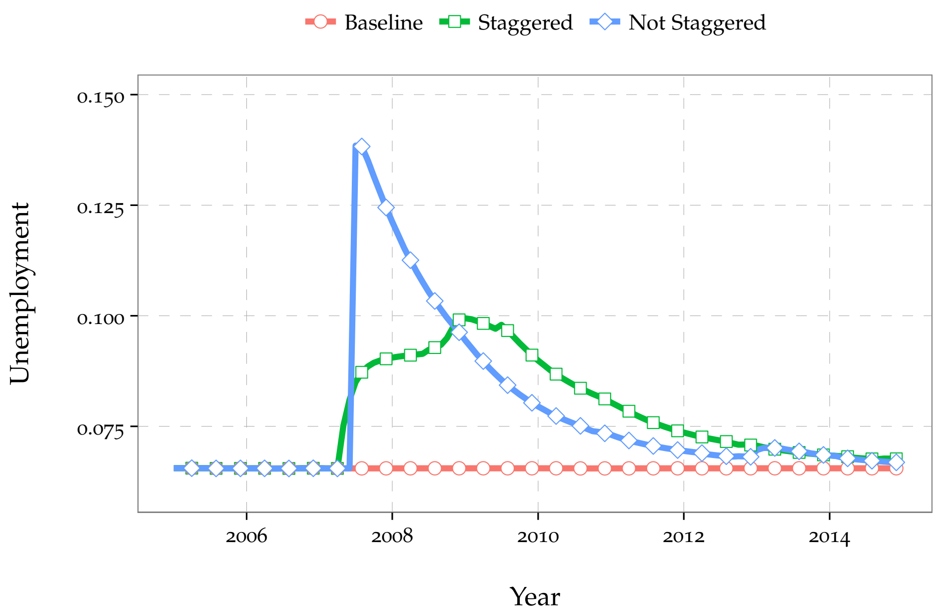


Figure 6: Counterfactuals: Evolution of Unemployment When Increase Is Not Staggered

Note: The figure shows the evolution of the unemployment rate implied by the model for three different scenarios. "Baseline" refers to the counterfactual with no minimum wage increase between 2006 and 2014. "Staggered" refers to the actual minimum wage increases as they occurred in the data. "Not Staggered" refers to the scenario when the federal minimum wage is raised by the same amount as in reality, but the full increase occurs in July 2007.

6 Results

We use our estimated model to investigate how policy expectations impact the employment effects that result from minimum wage increases. We begin by comparing the staggered minimum wage increase (“Staggered”) that occurred in the data against the counterfactual scenario with no minimum wage increase (“Baseline”). The staggered minimum wage increase was announced in May 2007 and consisted of an increase from \$5.15 to \$5.85 in July 2007, from \$5.85 to \$6.55 in July 2008, and from \$6.55 to \$7.25 in July 2009. As shown in Figure 6, the staggered increase resulted in a 2.3 percentage point increase in the unemployment rate in 2007. The increase in 2008 had essentially no impact on employment and the increase in 2009 raised the unemployment rate modestly. Since none of the increases is indexed to inflation, the unemployment rate declines after 2009. By 2015, any effect on unemployment has fully disappeared. Note that we estimated the model only using moments from the 2007 minimum wage increase. The model-implied effects of the 2008 and 2009 increases on employment are consistent with our reduced-form evidence, where we could not detect a statistically significant effect on employment.

We then consider the counterfactual scenario, in which the minimum wage is increased from \$5.15 to \$7.25 in a single step in 2007 (“Not Staggered”), i.e. the minimum wage is raised by the same amount as in reality, but the full increase occurs in July 2007. In this case, the initial rise in the unemployment rate is considerably larger than under the staggered increase and equals about 6 percentage points in 2007. However, as the newly unemployed workers begin to find new jobs, the unemployment rate quickly declines. Notably, this increase in the minimum wage in a single step results in considerably larger disemployment effects in the short-run. However, the long-run implications are similar. Due to inflation, both the staggered and not-staggered minimum wage increases are essentially temporary increases. Staggering minimum wage increases appears to achieve the goal of raising the minimum wage while minimizing unnecessary turbulence in the labor market.

In Figure 7, we explore the role of anticipation effects. We show the unemployment rate under three different scenarios. As before, “Baseline” refers to the counterfactual with no minimum wage increase. “Foresight” refers to the counterfactual when the staggered increase in the minimum wage is announced in January 2006 (instead of in May 2007). “Surprise” refers to the counterfactual where the 2007, 2008, and 2009 minimum wage increases come as surprise.

The “Foresight” scenario shows the importance of anticipation effects. Under this scenario, the unemployment rate increases right after the (presumed) announcement in January 2006. This increase is about one percentage point in magnitude. The unemployment rate then subsequently remains constant (even as the minimum wage goes up in 2007 and 2008) and only increases as a result of the minimum wage hike in 2009. If we were to estimate the employment impact of the 2007 increase in this counterfactual using a difference-in-differences

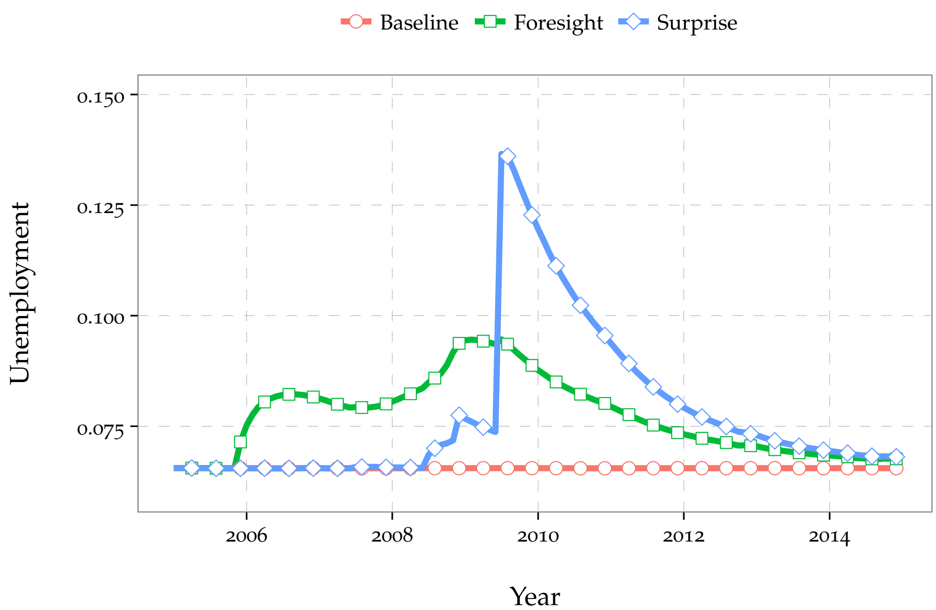


Figure 7: Counterfactuals: Evolution of Unemployment When Increase Is Unanticipated

Note: The figure shows the evolution of the unemployment rate implied by the model for three different scenarios. "Baseline" refers to the counterfactual with no minimum wage increase between 2006 and 2014. "Foresight" refers to the actual evolution of the federal minimum wage under the assumption that it was announced in January 2006 instead of May 2007. "Surprise" refers to the scenario when the federal minimum wage is raised by the same amount as in reality, but each increase is a surprise and not announced in advance.

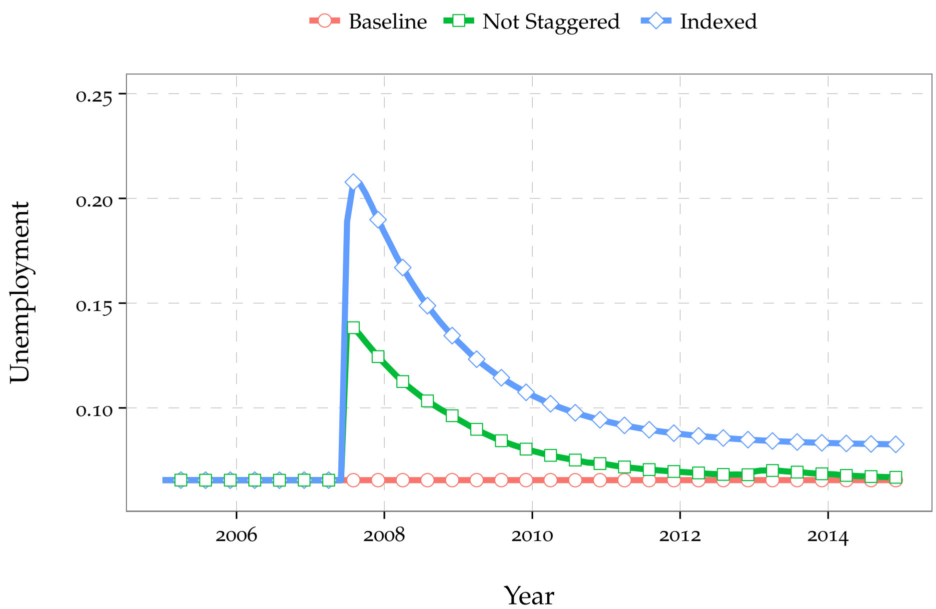


Figure 8: Counterfactuals: Evolution of Unemployment Under Indexation

Note: The figure shows the evolution of the unemployment rate implied by the model for three different scenarios. "Baseline" refers to the counterfactual with no minimum wage increase between 2006 and 2014. "Not Staggered" refers to the scenario when the federal minimum wage is raised by the same amount as in reality, but the full increase occurs in July 2007. "Indexed" refers to the scenario when the federal minimum wage is raised by the same amount as in reality, but the full increase occurs in July 2007 and this increase is indexed to inflation.

estimator — in the same way as we did in Section 3 — we would find no effect on employment. The anticipation effect is strong enough to make the minimum wage rises in 2007 and 2008 appear to have no employment impact.

When each of the three minimum wage increases comes as a surprise, the 2007 increase has little impact on employment. The 2008 increase raises unemployment by half a percentage point. It is only the 2009 increase that raises unemployment substantially (by about 4 percentage points). This suggests that the reason for finding a sizable disemployment effect of the staggered minimum wage increase in 2007 in the actual data is that workers and firms anticipated the subsequent increases in 2008 and 2009.

In Figure 8 we explore the role of indexation. We show the unemployment rate under the previously introduced scenarios "Not Staggered" and "Baseline" as well as the the scenario "Indexation," which refers to the case when the federal minimum wage is raised by the same amount as in reality, but the full increase occurs in July 2007 and this increase is indexed to inflation. Under the scenario "Not Staggered," unemployment rises by 6 percentage points in 2007 and subsequently declines. If this increase is indexed to inflation, unemployment rises by more than 10 percentage points in 2007. Unemployment subsequently declines, but there remains a long-run effect on unemployment of about one percentage point.

Our counterfactuals are of importance to applied researchers and policy makers. We draw two main conclusions. First, we show that anticipation effects can be large. Because of anticipation effects, it may appear as if the actual increase in the minimum wage has no discernible impact on employment, because the majority of labor market adjustments have already occurred by the time the minimum wage is increased. Furthermore, when a minimum wage is known to be followed by a range of subsequent changes, the initial change may appear to have a larger effect on employment than it would otherwise have. Second, we show that the depreciation in the real value of the minimum wage can undo any employment effect of the minimum wage within a few years. When minimum wage increases are indexed to inflation, their short-run effects on employment are considerably larger than when they are not. In addition, they have long-run effects on employment. These results suggest that caution is advised when interpreting traditional estimates using traditional difference-in-differences estimates.

7 Conclusion

In this paper, we investigate how policy expectations interact with the employment effects associated with minimum wage increases. We provide evidence from federal and state minimum wage increases in the U.S. that disemployment effects are larger when minimum wage increases are unanticipated or when they are indexed to inflation. We then develop an equilibrium search model in which workers and firms have rational expectations with respect to the future evolution of the minimum wage. We estimate that model and quantitatively explore the relevance of policy expectations.

Using the 2007 federal minimum wage increase, we find that anticipation effects can be substantial and render traditional techniques to detect employment effects of minimum wages inadequate. Our estimated model further indicates that the employment effects of minimum wage increases that are not indexed to inflation are quickly undone by the declining real value of the minimum wage. In contrast, minimum wage increases that are indexed to inflation may decrease employment by more than twice the amount than minimum wages that are set in nominal terms.

Our results indicate that researchers and policy makers need to account for firms' and workers' policy expectations when assessing the impact of minimum wage increases on employment. Estimates obtained from case studies of minimum wage increases are sensitive to the particular policy expectations held by workers and firms at the time of the policy change. Therefore, researchers and policy makers should not expect that past case studies provide accurate predictions for how future minimum wage increases affect employment.

While we attempt to be comprehensive, our analysis has various shortcomings. In the model, the assumption that minimum wages and expectations thereof follow a relatively parsimonious and time-invariant Markov process is questionable. Often, minimum wage policy is driven by political factors. Firms and workers can update their minimum wage expectations depending on which political party is in power. To account for this, our analysis could be complemented by more direct measurements of policy expectations. Such measurements could come from analyzing media coverage of minimum wage policy (see, e.g., Baker et al. (2016)).

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A Data Appendix

We complement the results from estimating equation (1) by a different specification. In (1) we considered the marginal effect of a change in the minimum wage on our variable of interest. Here, we consider the absolute effect of a particular change in the minimum wage while accounting for anticipation effects. We estimate the specification

$$y_{ijt} = \alpha^d d_{jt} + \mathbf{x}'_{ijt}\beta + \mathbf{w}'_{jt}\varphi + \varepsilon_{ijt}, \tag{10}$$

where d_{jt} is equal to 1 for all states and months no more than three months before and no more than twelve months after a minimum wage increase. For all other states and months, d_{jt} is equal to zero. $\mathbf{x}_{ijt}$ is a vector of individual-specific characteristics, such as age, gender, race, and education. $\mathbf{w}_{jt}$ is a vector with fixed effects. This vector includes state fixed effects, calendar time fixed effects, and — in some specifications — Census region-specific time trends. In this specification, α^d is informative about the absolute effect of a particular minimum wage change, regardless of the magnitude of the policy change. Also, the specification explicitly allows for anticipation effects.

We provide various additional estimation results. In Tables 9 and 10 we show estimates for the effect of the minimum wage on employment and coverage for the same specification that we used in the main text. Here, we do not restrict the sample to young workers without a college education. Instead, we show estimates for all workers in the CPS. As expected, the magnitude of estimates is now smaller, because the general population is less likely to be affected by the minimum wage. However, the general patterns hold.

In Tables 11 and 12 we show estimates for the same specification as in the main text, but this time we include Census region-specific time trends. Again, we focus on young workers without a college degree. The estimates are comparable. In Tables 13 and 14 we report the estimates for the entire CPS.

We now turn to the estimates obtained from the specification introduced in this Appendix. Instead of estimating the marginal effect of increasing the minimum wage, we now estimate equation (10), where our coefficient of interest now captures the employment effect of the entire minimum wage increase (regardless of its magnitude). These are the coefficients that we target in the estimation of our structural model.

We report estimates for young and inexperienced workers in Tables 15 and 16. Overall, the estimates are comparable.

Since our structural model does not feature a labor force participation decision, we do not want to target the effect of minimum wage increases on coverage relative to the entire population. Instead, we want to focus on coverage relative to the labor force ("net coverage"). We report the corresponding estimates in Table 17.

In Tables 18 and 19 we list all states affected by the various minimum wage increases that we study in Section 3. Table 18 makes apparent that the estimates for the 1996 federal minimum wage increase are likely to be unreliable, because the difference-in-differences estimator lacks a suitable control group. It includes only Hawaii.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Effective Minimum Wage	0.0034	-0.0022	-0.0179**	-0.0243	-0.0024	-0.0140***	-0.0005	-0.0036	0.0056
	(0.0083)	(0.0101)	(0.0080)	(0.0173)	(0.0031)	(0.0033)	(0.0032)	(0.0031)	(0.0134)
R-squared	0.301	0.306	0.302	0.272	0.265	0.262	0.243	0.227	0.229
Observations	1032116	1027332	1145405	1190134	985647	542481	573704	775513	1189675

Table 9: Marginal Effect on Employment (Full Sample)

Note: Same as Table 5, except that the data include the entire CPS.

	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Effective Minimum Wage	0.0738***	0.0260***	0.0543***	0.0113***	0.0133***	0.0168***	0.0304***	0.0587***
	(0.0095)	(0.0076)	(0.0120)	(0.0021)	(0.0024)	(0.0026)	(0.0027)	(0.0115)
R-squared	0.041	0.037	0.022	0.022	0.020	0.024	0.026	0.026
Observations	258102	288004	299836	248223	136335	144525	195419	299280

Table 10: Marginal Effect on Coverage (Full Sample)

Note: Same as Table 6, except that the data include the entire CPS.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Effective Minimum Wage	-0.0770***	-0.0047	-0.0185	-0.0660*	-0.0014	-0.0397***	-0.0047	-0.0099	-0.0087
	(0.0175)	(0.0217)	(0.0164)	(0.0361)	(0.0067)	(0.0079)	(0.0071)	(0.0068)	(0.0290)
R-squared	0.165	0.153	0.154	0.156	0.166	0.174	0.175	0.168	0.174
Observations	281532	275240	312038	322166	273546	152488	165259	219250	328046

Table 11: Marginal Effect on Employment (Regional Trends)

Note: Same as Table 5, except that we control for region-specific time trends.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Effective Minimum Wage	0.1801***	0.1810***	0.0715***	0.1209***	0.0280***	0.0180**	0.0392***	0.0587***	0.1041***
	(0.0194)	(0.0270)	(0.0204)	(0.0330)	(0.0060)	(0.0076)	(0.0076)	(0.0079)	(0.0336)
R-squared	0.022	0.032	0.027	0.018	0.017	0.015	0.017	0.017	0.016
Observations	70429	68948	78106	80932	68899	38320	41616	55145	82449

Table 12: Marginal Effect on Coverage (Regional Trends)

Note: Same as Table 6, except that we control for region-specific time trends.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Effective Minimum Wage	-0.0067	0.0000	-0.0181**	-0.0233	-0.0040	-0.0123***	-0.0081**	-0.0056	-0.0138
	(0.0088)	(0.0102)	(0.0083)	(0.0177)	(0.0031)	(0.0039)	(0.0037)	(0.0035)	(0.0147)
R-squared	0.301	0.306	0.302	0.272	0.265	0.262	0.243	0.227	0.229
Observations	1032116	1027332	1145405	1190134	985647	542481	573704	775513	1189675

Table 13: Marginal Effect on Employment (Full Sample, Regional Trends)

Note: Same as Table 5, except that we include the entire CPS and control for region-specific time trends.

	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Effective Minimum Wage	0.0748***	0.0271***	0.0664***	0.0114***	0.0089***	0.0181***	0.0311***	0.0571***
	(0.0097)	(0.0079)	(0.0123)	(0.0021)	(0.0029)	(0.0030)	(0.0031)	(0.0126)
R-squared	0.041	0.037	0.023	0.022	0.020	0.024	0.026	0.026
Observations	258102	288004	299836	248223	136335	144525	195419	299280

Table 14: Marginal Effect on Coverage (Full Sample, Regional Trends)

Note: Same as Table 6, except that we include the entire CPS and control for region-specific time trends.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Minimum Wage Increase	-0.0420	-0.0022	-0.0206	-0.0492***	-0.0049	-0.0260***	0.0087	0.0050	-0.0163**
	(0.0311)	(0.0108)	(0.0146)	(0.0188)	(0.0094)	(0.0072)	(0.0064)	(0.0056)	(0.0067)
R-squared	0.165	0.153	0.154	0.156	0.166	0.174	0.175	0.168	0.174
Observations	281532	275240	312038	322166	273546	152488	165259	219250	328046

Table 15: Absolute Effect on Employment

Note: The table shows the regression coefficient α^d associated with equation (10) for a variety of minimum wage increases. α^d is interpreted as the absolute effect of the minimum wage increase on employment. The data are restricted to individuals ages 29 and younger without a college degree. The changes in 1996, 1997, 2007, 2008, and 2009 were federal increases in the minimum wage, where we classify 1996 and 2007 as unanticipated and 1997, 2008, and 2009 as anticipated. The changes in 1999, 2003, and 2005 refer to the initial indexation of the minimum wage in Washington, Oregon, and Florida. The change in 2011 refers to the automatic increase in the minimum wage in a number of states that index their minimum wage to inflation.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Minimum Wage Increase	0.0012	0.0495***	0.0400**	0.0395**	0.0171**	0.0134*	0.0327***	0.0227***	-0.0126
	(0.0349)	(0.0133)	(0.0190)	(0.0169)	(0.0085)	(0.0070)	(0.0069)	(0.0065)	(0.0078)
R-squared	0.020	0.032	0.027	0.018	0.017	0.015	0.017	0.016	0.016
Observations	70429	68948	78106	80932	68899	38320	41616	55145	82449

Table 16: Absolute Effect on Coverage

Note: The table shows the regression coefficient α^d associated with equation (10) for a variety of minimum wage increases. α^d is interpreted as the absolute effect of the minimum wage increase on the minimum wage coverage rate (i.e. the percentage of the population that works in minimum wage jobs). The data are restricted to individuals ages 29 and younger without a college degree. The changes in 1996, 1997, 2007, 2008, and 2009 were federal increases in the minimum wage, where we classify 1996 and 2007 as unanticipated and 1997, 2008, and 2009 as anticipated. The changes in 1999, 2003, and 2005 refer to the initial indexation of the minimum wage in Washington, Oregon, and Florida. The change in 2011 refers to the automatic increase in the minimum wage in a number of states that index their minimum wage to inflation.

	1996	1997	1999	2003	2005	2007	2008	2009	2011
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Minimum Wage Increase	0.0050	0.0728***	0.0492*	0.0645***	0.0284**	0.0315***	0.0494***	0.0378***	-0.0134
	(0.0502)	(0.0184)	(0.0253)	(0.0242)	(0.0129)	(0.0115)	(0.0107)	(0.0104)	(0.0120)
R-squared	0.067	0.094	0.083	0.049	0.051	0.065	0.067	0.066	0.064
Observations	47956	47919	53591	52919	44248	23807	25912	33386	48332

Table 17: Absolute Effect on Net Coverage

Note: The table shows the regression coefficient α^d associated with equation (10) for a variety of minimum wage increases. α^d is interpreted as the absolute effect of the minimum wage increase on net coverage (excluding labor force participation effects). The data are restricted to individuals ages 29 and younger without a college degree. The changes in 1996, 1997, 2007, 2008, and 2009 were federal increases in the minimum wage, where we classify 1996 and 2007 as unanticipated and 1997, 2008, and 2009 as anticipated. The changes in 1999, 2003, and 2005 refer to the initial indexation of the minimum wage in Washington, Oregon, and Florida. The change in 2011 refers to the automatic increase in the minimum wage in a number of states that index their minimum wage to inflation.

	Federal Minimum Wage Change in 1996
Treatment States	Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maine, Maryland, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming
Control States	Hawaii
	Federal Minimum Wage Change in 1997
Treatment States	Alabama Arizona, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming
Control States	Arkansas, Hawaii, Massachusetts, Rhode Island
	Federal Minimum Wage Change in 2007
Treatment States	Alabama, Georgia, Idaho, Indiana, Kansas, Louisiana, Mississippi, Nebraska, New Mexico, North Dakota, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wyoming
Control States	Alaska, Connecticut, Hawaii, New Jersey, New York, Rhode Island
	Federal Minimum Wage Change in 2008
Treatment States	Alabama, Georgia, Idaho, Indiana, Kansas, Kentucky, Louisiana, Mississippi, Nebraska, North Dakota, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wyoming
Control States	California, Hawaii, Iowa, Massachusetts, Rhode Island
	Federal Minimum Wage Change in 2009
Treatment States	Alabama, Arkansas, Georgia, Idaho, Indiana, Kansas, Kentucky, Louisiana, Maryland, Minnesota, Mississippi, Nebraska, North Carolina, North Dakota, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wisconsin, Wyoming
Control States	California, Hawaii, Iowa, Massachusetts, Michigan, New Hampshire, Rhode Island, West Virginia

Table 18: List of Treatment and Control States for Federal Minimum Wage Increases

Minimum Wage Change in Washington in 1999

Treatment States	Washington
Control States	Alabama, Alaska, Arizona, Arkansas, California, Colorado, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming

Minimum Wage Change in Oregon in 2003

Treatment States	Oregon
Control States	Alabama, Arizona, Arkansas, California, Colorado, Delaware, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming

Minimum Wage Change in Florida in 2005

Treatment States	Florida
Control States	Alabama, Alaska, Arizona, California, Colorado, Delaware, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wyoming

Minimum Wage Change in Several States in 2011

Treatment States	Arizona, Colorado, Montana, Ohio, Oregon, Vermont, Washington
Control States	Alabama, Alaska, Arkansas, California, Connecticut, Delaware, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming

Table 19: List of Treatment and Control States for State Minimum Wage Increases

B Model Appendix

The equilibrium computation is simplified by the fact that value and policy functions only depend on the aggregate state through the minimum wage policy m. Therefore, we drop the dependence on $\boldsymbol{\psi}$ in this section.

We compute the *equilibrium* value functions ($W(m,x)$, $U(m)$, $J(m,x)$), the wage and separations policy functions ($w(m,x)$ and $d(m,x)$), and the market tightness ($\theta(m)$) using value function iteration, where we define $W(m,x) = W(m,x,w(m,x))$ and $J(m,x) = J(m,x,w(m,x))$. The algorithm works as follows. Recall that $x \in \mathcal{X}$ and $m \in \mathcal{M}$ take on a finite set of values.

1. Guess initial values for $\theta(m)$, $W(m,x)$, $U(m)$, $J(m,x)$, $w(m,x)$, $d(m,x)$
2. Set `dist = 1`
3. Iterate `while(dist > tolerance)`
   (a) Compute update for $U(m)$ using (5) and call it $\hat{U}(m)$
   (b) Compute update for $\theta(m)$ using (3) and call it $\hat{\theta}(m)$
   (c) Compute update for $W(m,x)$ using (4) and call it $\hat{W}(m,x)$
   (d) Compute update for $J(m,x)$ using (2) and call it $\hat{J}(m,x)$
   (e) Compute update for $w(m,x)$ using (8) and call it $\hat{w}(m,x)$
   (f) Compute update for $d(m,x)$ using (6) and call it $\hat{d}(m,x)$
   (g) Set `dist` equal to

$$\begin{aligned} &\max_m(|U(m) - \hat{U}(m)|) + \max_m(|\theta(m) - \hat{\theta}(m)|) \\ &+ \max_{m,x}(|W(m,x) - \hat{W}(m,x)|) + \max_{m,x}(|J(m,x) - \hat{J}(m,x)|) \\ &+ \max_{m,x}(|w(m,x) - \hat{w}(m,x)|) + \max_{m,x}(|d(m,x) - \hat{d}(m,x)|) \end{aligned}$$

   (h) Set $U(m)$, $\theta(m)$, $W(m,x)$, $J(m,x)$, $w(m,x)$, $d(m,x)$ equal to their respective updates denoted by hats.

With the value functions, market tightness, and policy functions in hand, computing distributions of workers is straightforward. Take a sequence of minimum wage realizations $\{m_t\}_{t=0}^{T}$. Initialize the distribution of matched workers at time zero,

$$e_0 : \{\mathcal{X}\} \mapsto \mathbb{R}^+,$$

and

$$u_0 = 1 - \sum_x e_0(x).$$

Then compute the distribution at time $t > 0$ as follows. For all $x \in \mathcal{X}$,

$$e_t(x) = [1 - d(m_t, x)] \left(e_{t-1}(x)(1-\gamma) + (1 - u_{t-1})\gamma G(x) + u_{t-1} p(\theta(m_{t-1}))G(x) \right).$$

The measure of unemployed workers is simply

$$u_t = 1 - \sum_x e_t(x).$$