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 (Card and Krueger, 1995; Neumark and Wascher, 2008). There is a huge body of research that investigates how minimum wages affect employment. 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 employment effects from no detectable effect at all (Allegretto et al., 2011, 2013) to sizable disemployment effects for young and inexperienced workers (Neumark et al., 2013), where differences often hinge on the data, research design, or particular minimum wage increases.

In this paper, we argue that it is important to account for workers' and firms' policy expectations when attempting to understand the impact of minimum wages on the labor market. Policy expectations matter for two reasons. First, when a minimum wage increase is anticipated by workers and firms, the effect on the labor market at the time of its implementation is lower than when it is unanticipated, because workers and firms adjust to the new minimum wage ahead of time. This makes employment effects difficult to detect with the traditional methods used in the literature. Second, when the minimum wage is increased, its effect on employment depends on workers' and firms' expectations with respect to the future evolution of the minimum wage. In particular, when the minimum wage is not indexed to inflation, workers and firms anticipate that the real value of the minimum wage will decrease quickly over time. This renders some of the minimum wage increases temporary, dampening both their short-run and long-run impact on the labor market.

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 find that anticipated minimum wage increases result in smaller employment effects than unanticipated changes and

[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), Hamermesh (1995), Katz and Krueger (1992), Meer and West (2016), Neumark and Wascher (1992), Neumark and Wascher (1994), Neumark and Wascher (2000), Neumark et al. (2004), Neumark and Wascher (2006), Neumark et al. (2013), Sabia (2009), Spriggs et al. (1994), and Zavodny (2000).

that minimum wage changes that are indexed to inflation result in larger disemployment effects.

We then develop an equilibrium search and matching model that features a time-varying real minimum wage. We use the model to quantify the role of policy expectations in the employment effects of minimum wages. In the model, which is a variant of the model used in Flinn (2006), workers and firms are forward-looking and 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 the worker. 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. While parsimonious, our model can account for a variety of outcomes related to minimum wage policy changes, such as effects on employment, the share of workers in minimum wage jobs, and various moments of the wage distribution.

We estimate our model using indirect inference by targeting difference-in-differences estimates from increases of the federal minimum wage in 2007—2009. These increases of the federal minimum wage are particularly useful for the identification and estimation of our model. The initial increase in 2007 was essentially a surprise whereas the second and third increase 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. The model is consistent with our earlier findings regarding anticipation and indexation effects. In the estimated model, anticipation effects can result in the absence of any 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 a 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 our model, then minimum wages should *always* be indexed to inflation. If minimum wages are not welfare improving, then they should be set to zero. Regardless, absent additional factors, a time-varying minimum wage policy is never optimal, which also renders the discussion of anticipation effects mute from a normative perspective.[2]

This paper is related to a large body of minimum wage research. Despite its massive volume, the minimum wage literature is largely silent on the role of policy expectations. Almost all empirical estimates for the United States refer to changes of the nominal minimum wage, yet are often interpreted as if they refer to permanent minimum wage changes. 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 of the New Jersey minimum wage from \$4.25 to \$5.05 *increased* employment with an elasticity of approximately 0.7. While this particular result has been questioned (e.g. Hamermesh (1995) and Neumark and Wascher (2000)), the difference-in-differences methodology applied by Card and Krueger has subsequently emerged as the de-facto standard in this line of research, often applied to survey data sets 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

[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.

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 industries were adjustment costs are considered to be minimal (e.g. because of significant turnover), adjusting non-labor inputs may be costly (Hamermesh, 1995). 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; Keil et al., 2001; Burkhauser et al., 2000). 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. That this assumption is satisfied 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 their state-level panel data set 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 and come to similar conclusions. However, including these additional local controls comes at a cost. Neumark et al. (2013) claim that these studies throw out empirically useful variation and that their null result is unsurprising since these studies exclude potentially valid and useful variation.

There is a large literature in macroeconomics that studies the role of expectations regarding monetary policy (Levin et al., 2005; Campbell et al., 2012; Gertler and Karadi, 2015). In contrast, 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. This essentially introduces "aggregate" policy shocks into the model and therefore renders the environment non-stationary. Therefore, we cannot simply compare steady states as in Flinn, where each steady states corresonds to a different 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 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

[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).

(1998) and Bontemps et al. (1999) and use a set of reduced form estimates obtained from minimum wage policy variation 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 percent increase in the average wage and a 0.5 percent reduction in employment.

This paper is structured as follows. In Section 2, we provide background on minimum 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 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. Three appendices provide supporting materials. Appendix A contains additional estimates and robustness checks that complement the results presented in Section 3. Appendix B presents a case study of Washington and Oregon, two states that indexed their minimum wages to inflation in 1999 and 2003. Appendix C contains additional details on how we implement the model introduced in Section 4.

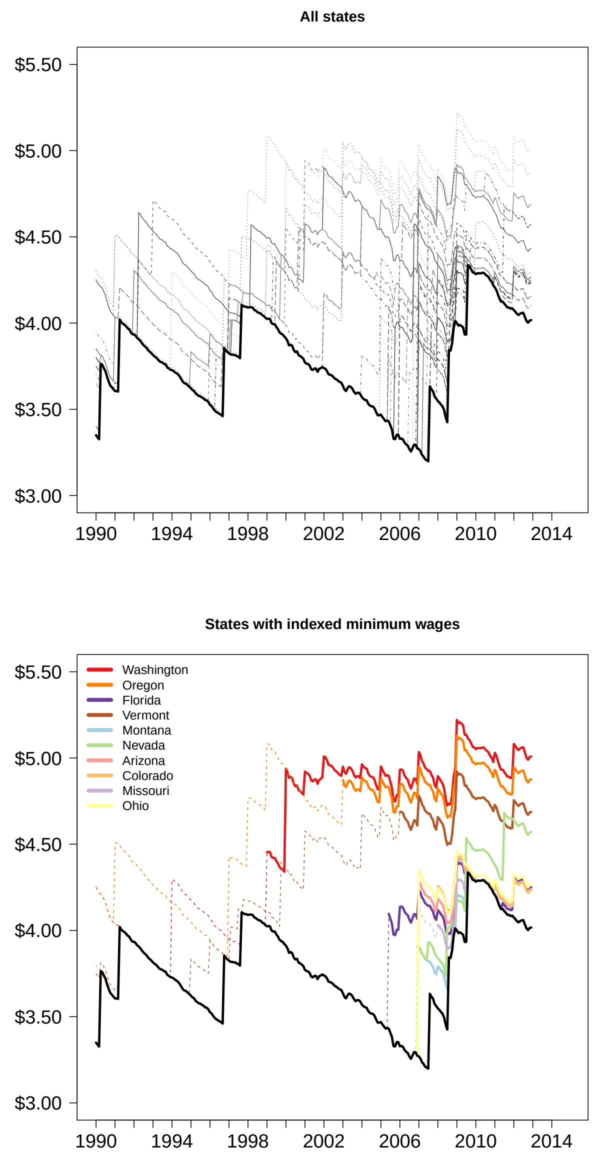
2 Background on Federal and State Minimum Wages

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 such, 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 deflator. The figure indicates that most raises in the federal minimum wage were eventually eroded by inflation before Congress enacted another minimum wage increase.

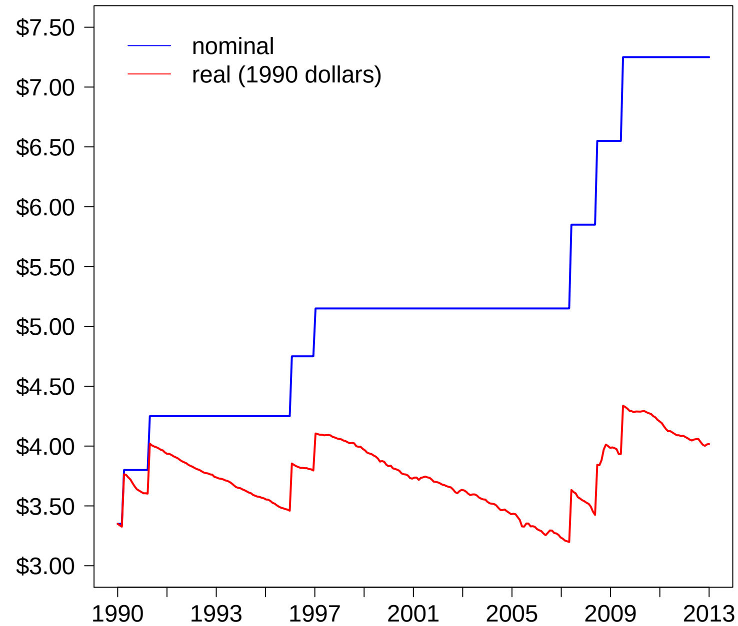
The federal minimum wage does not apply to all workers. There are several ex-

Figure 1: Real Minimum Wages in the United States



Notes: The left panel shows the real state-level minimum wages for all states. The right panel shows the real state-level minimum wages for states that have 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.

	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 of the Federal Minimum Wage

emptions and subminimum wage provisions. For instance, as of 2009, tipped employees are subject to a minimum wage of $2.13 per hour if that amount plus tips exceeds the federal minimum wage. If it does not, the employer has to make up the difference. The list of exempted workers includes young workers under the age of 20 during their first 90 days of employment, workers with disabilities, full-time students, and student learners subject to subminimum wage certificates. Furthermore, the federal minimum wage law only applies to employees of businesses that have annual sales of at least $500,000 or engage in interstate commerce.

In addition to the federal minimum wage, many states have chosen to enact their own minimum wage laws.[4] States minimum wages are either passed by the legislature or result from referendums. When both the state and federal minimum wage apply to a worker, the higher of the two is binding. State minimum wages do not only differ in their magnitude but also along other dimensions. For instance, Minnesota, Ohio, Oklahoma, and Montana tie their minimum wage to an employer's annual sales volume. Arkansas, Georgia, Illinois, Indiana, Michigan, and Nebraska only impose a minimum wage if a business exceeds a given size threshold (depending on the state, between two and six employees).

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 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 a ten states that have chosen to index their minimum wages to inflation by 2014. These states raise their minimum

[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.

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

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 the two dimensions "anticipation" and "indexation".

By anticipation we mean a policy change was anticipated by workers and firms at the time it was implemented. For instance, when a minimum wage increase was passed several months before its implementation, we will consider such an increase as anticipated. If in contrast, 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 that minimum wage changes on employment and minimum wage coverage, defined as the share of the labor force that earns the minimum wage. We consider nine minimum wage hikes between 1995 and 2011. We then investigate the extent to

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.

which anticipation and indexation matter for how minimum wages increases affect employment and coverage.

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 months. 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.

Information on wages and minimum wage coverage is taken from the outgoing rotation groups. All other information comes from the monthly CPS sample. Throughout we will restrict attention to individuals aged 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. In the CPS, some workers report the hourly wage. 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 who earns the minimum wage by including every worker who earns less than 105% of the minimum wage per hour.

We merge this data with monthly federal and state-level minimum wage policies.

	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	23.068	28.837	349,039	17.973	24.179
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 aged 16 and older. "Young Sample" refers to all individuals in the CPS aged 29 or younger and without college degree. Data is 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 who earns the minimum wage. 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 is taken from the outgoing rotation groups. Wages are deflated using the CPI-W with 2000 as base year. "Full Sample" refers to all individuals in the CPS aged 16 and older. "Young Sample" refers to all individuals in the CPS aged 29 or younger and without college degree. All statistics are weighted using the appropriate survey weights.

3.2 Estimation Strategy

We exploit variation in the effective minimum wage across states. We refer to the effective minimum wage as the relevant statutory minimum wage. If the state minimum wage exceeds the federal minimum wage, then the effective minimum wage refers to the former. If 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 difference-in-differences. For each of the minimum wage events that we consider, we identify a set of states that will serve as control group. Throughout, we will select as control groups all states that contemporaneously did not experience a change in their effective minimum wages 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. First, the effect of the minimum wage change on employment. Second, the effect of the minimum wage change on the minimum wage coverage rate, i.e. the share of the labor force who earns exactly the minimum wage. 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 the 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 happened at the federal level. The remaining four occurred at the state level.

We include all recent changes of the federal minimum wage (see Table 1). Recall that the federal minimum wage is not indexed to inflation. The increases in 1996 and 1997 under President Clinton were staggered, i.e. they were passed in August 2006 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. This is supported by textual analysis of the universe of newspaper articles across the U.S. in the months prior to the minimum wage increases, which is the focus of a companion paper (Janetos and Tilly, 2017). In contrast, we classify the federal minimum wage 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 control group is very small. In fact, it only consists of the state 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. 17 states were directly affected by this federal minimum wage increase and did not have

	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 restricted to individuals aged 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 of 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 restricted to individuals aged 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 of the minimum wage in a number of states that index their minimum wage to inflation.

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 control group.

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 of 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 by 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.[6] 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 of 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

[6]We discuss the introduction of the indexed minimum wage in Washington and Oregon in detail in Appendix B.

and December 2011. As one might expect, 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 of the minimum wage coverage by 9.89 percentage points.

Altogether, the results indicate the following. First, minimum wage increases that are anticipated have little to no effect on employment. This is true regardless of whether these minimum wage increases are indexed to inflation or not. Second, minimum wages that unanticipated have considerable employment effects. This is true regardless of whether these minimum wage increases are indexed to inflation or not. 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 minimum wage increases from nine different minimum wage increases and then provided an 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.

4 Model

4.1 Basics

This section extends the equilibrium search model of the labor market used by Flinn (2006). The model features search frictions to provide a mechanism for why minimum wage increases may have ambiguous effects on employment and welfare. The model features a bargaining mechanism to determine wages. This modeling choice is not introduced because it realistically captures the micro-interactions between workers and firms (see for instance Hall and Krueger (2012)). Rather, the bargaining solution is a useful tool to determine wages while summarizing all information on the division of rents from an employment relationship in a single parameter (that can be estimated). One of the advantages of using this bargaining model in the spirit of Mortensen and Pissarides (1994) over models with wage posting such as Burdett and Mortensen (1998), Van den Berg and Ridder (1998) or Bontemps et al. (1999) is that — as Flinn (2006) points out — these models have different consequences for the left tail of the wage distribution. Models with bargaining generate a mass point at the minimum wage, which is supported by the data.

Since our goal is to capture the role of policy expectations, our 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 (2006), who characterizes the labor market in its steady state at a (presumably) 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 either be 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 can then decide whether they want to consummate the match. If they choose to match, production will begin in the next period. The match productivity x will remain constant throughout the lifetime of the match. Real 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 $c \geq 0$. Employed workers can see their match destroyed at the beginning of each period. This occurs either exogenously with probability δ or endogenously whenever the worker or the firm do not find it profitable to continue the employment relationship. 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 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.[7] We denote the probability that a

[7] When the matching function M exhibits constant returns to scale, we can write the probability that

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 a 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 economy features a time-varying minimum wage. This renders the economy non-stationary, in the sense that — as long as the minimum wage policy keeps evolving — this economy will not converge to a time-invariant distribution of workers. 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 $\boldsymbol{\psi} = [u_t, e_t, m_t] \in \boldsymbol{\Psi}$, where $u_t \in \mathbb{R}_+$ refers to the measure of unemployed workers, $e_t : \mathcal{X} \mapsto \mathbb{R}_+$ to the distribution of workers across firms, and $m_t \in \mathcal{M}$ refers to the real value of the minimum wage at time t. We denote expectation with respect to $\boldsymbol{\psi}_{t+1}$ conditional on $\boldsymbol{\psi}_t$ by $\mathbb{E}_{\boldsymbol{\psi}_{t+1}}[\ldots|\boldsymbol{\psi}]$. 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 the future 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

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

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

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

where $w(\boldsymbol{\psi}, x)$ refers to the wage policy function and $d(\boldsymbol{\psi}, x)$ to the separation policy function. $J(\boldsymbol{\psi}, x, w)$ refers to the firm's value at the beginning of the period right after endogenous and exogenous job destructions. The job destruction policy function by $d(\boldsymbol{\psi}, x)$, which we define below, captures both endogenous and exogenous separations.

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

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

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 $G(x')$—as indicated by the subscript x' of the expectation operator. When this new match does not immediately separate—separations occur with probability $d(\boldsymbol{\psi}', x')$—the firm receives a continuation value of $J(\boldsymbol{\psi}', x')$. 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

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

where $U(\boldsymbol{\psi})$ refers to the value from unemployment, which we define below. 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

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

where the subscript x' in the expectation operator indicates that x' is drawn from the unconditional match quality distribution $G(x')$.

Given the value functions and the wage policy function, we can define the separation policy function. A match separates when either the worker or firm are better off unmatched. This implies that

$$d(\boldsymbol{\psi}, x) = \begin{cases} 1 & \text{if } W(\boldsymbol{\psi}, x, w(\boldsymbol{\psi}, x)) \geq U(\boldsymbol{\psi}) \text{ and } J(\boldsymbol{\psi}, x, w(\boldsymbol{\psi}, x)) \geq 0 \\ \delta & \text{otherwise,} \end{cases} \tag{6}$$

where δ is the probability that a worker and firm separate for exogenous reasons.

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

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

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

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

where the star indicates that this is the wage policy function for an *interior* solution only.[8] 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, because firm entry will ensure 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

[8] 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.

firm's expected value of meeting an unemployed worker, i.e.

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

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 $\boldsymbol{\psi}$. All elements of the aggregate state $\boldsymbol{\psi}$ other than the minimum wage m only enter firms' and workers' value functions through the market tightness $\theta(\psi)$. 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 can 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

- distribution of workers across states u and e
- a market tightness θ
- value functions J, V, W, U,
- wage policy functions w,
- separation policy function d,
- an aggregate transition function $\boldsymbol{\Lambda} : \Psi \mapsto \Psi$.

such that

- value functions satisfy (2)–(5),
- the value from opening a vacancy equals zero ((9) holds),
- the separation policy function satisfies (6),
- the wage policy function satisfies (8),
- the aggregate transition function $\boldsymbol{\Lambda}$ is consistent with rational individual 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 C. 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 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).

Consider a firm-worker pair for whom the Nash bargaining solution prescribes a wage below the minimum wage constraint. For this pair, two things can happen. First, the firm cannot afford paying 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 paying 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 vacancy creation. Similarly, it affects worker's value from unemployment, because workers anticipate that future employment relationships are governed by the minimum wage constraint.

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 his or her productivity in anticipation of a lower real minimum wage in the future).

We illustrate the various ways that minimum wage policies and expectations thereof affect employment, minimum wage coverage, and market tightness in Figures 3 and 4.

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

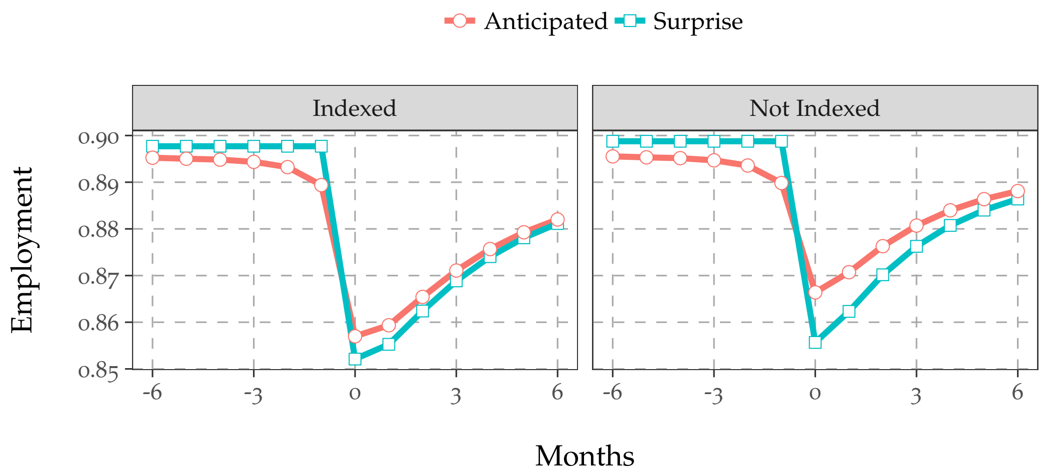


Figure 3: Short-Run Employment Effects of a Minimum Wage Increase

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.

anticipated and indexed, anticipated and not indexed, unanticipated and indexed, or unanticipated and not indexed. In our example, the real value of the minimum wage increases from \$5 to \$6 at time zero.[9] Without anticipation, employment does not adjust before time zero. With anticipation, employment adjust by approximately a percentage point in the months before the minimum wage is increased. Under all four expectation regimes, employment decreases substantially at 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.

[9]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 or not 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.

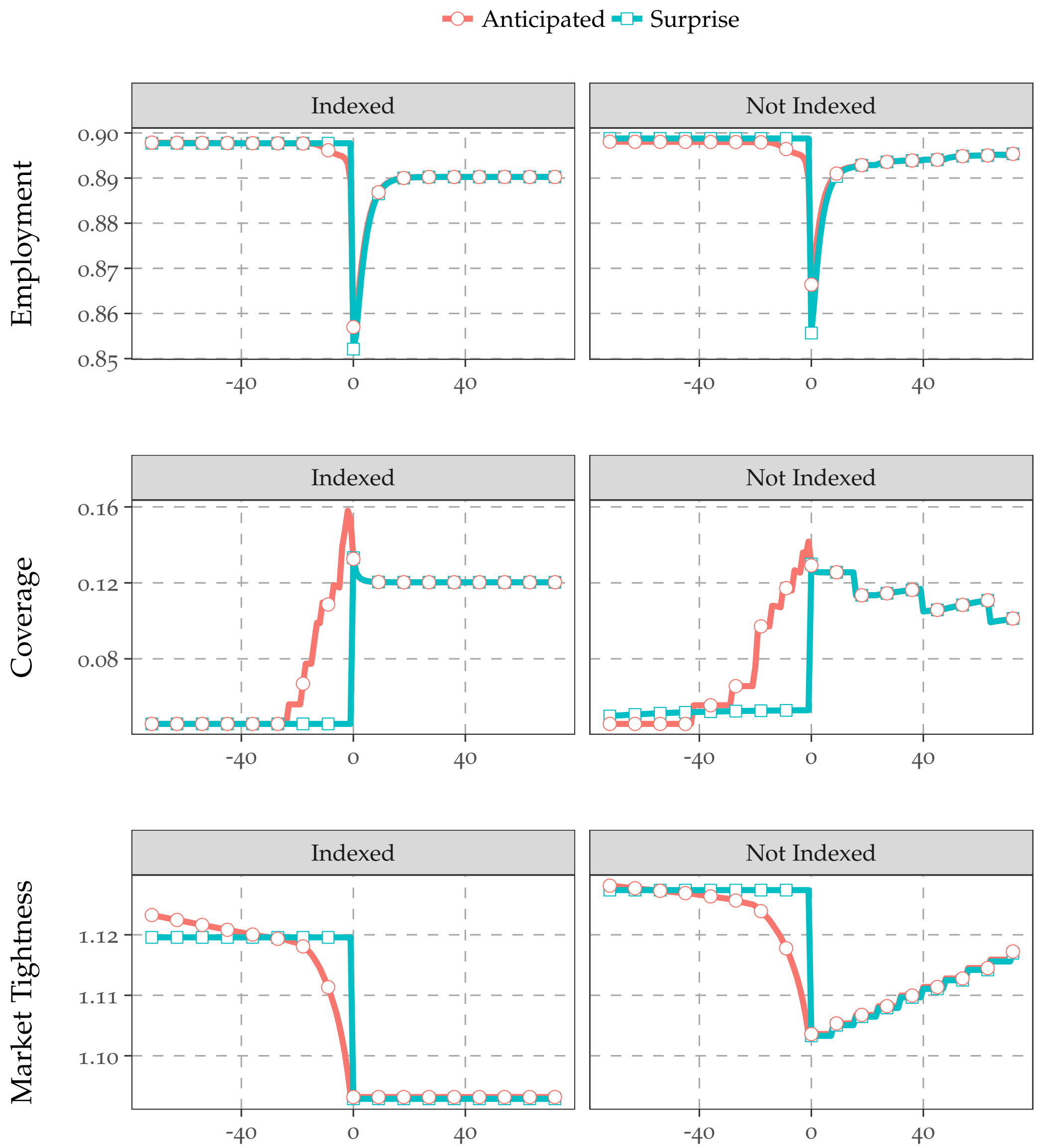


Figure 4: Model Implications under Different Minimum Wage Policy Regimes (1/2)

Notes: The panels show the 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).

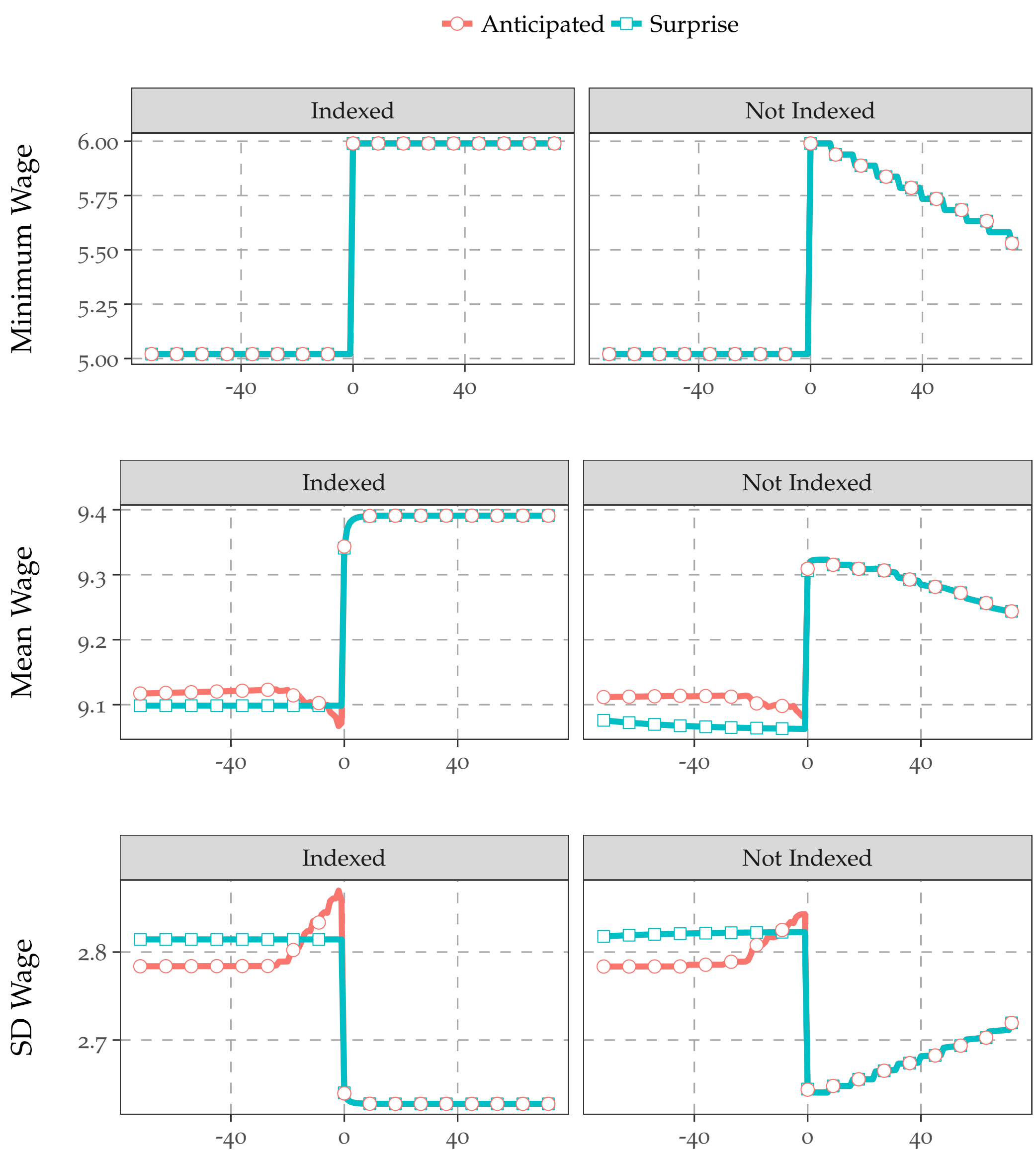


Figure 5: Model Implications under Different Minimum Wage Policy Regimes (2/2)

Notes: The panels show the the real value of the minimum wage and the mean and standard deviation of the real wage under minimum wage policy regimes that differ in their anticipation (surprise vs. anticipated) and commitment (real vs. nominal).

We show the effect on employment, coverage, and tightness in Figure 4. As expected, an indexed change of 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. Again, 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 minimum wage increase. This is a result from forward looking behavior and the surplus sharing 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 was indexed. When the increase is indexed to inflation coverage quickly converges to constant levels. 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 firm's incentives to post vacancies and the effect on unemployment. When the minimum wage increase is unanticipated, market tightness is a jump variable. It only adjusts when the real value of the minimum wage changes. When the policy change is anticipated, the market tightness will slowly adjust in the months preceding the minimum wage change. When a policy change is unanticipated, market tightness moves the most at time zero. When the change is not indexed, market tightness slowly converges to its initial levels. When the change is indexed, the drop in market tightness is persistent and job finding rates will be affected in the long-run.

We show the real value of the minimum wage and its effect on the wage distribution in Figure 5. A minimum wage increases the average wage earned and decreases the dispersion of the wage distribution. When the minimum wage change is indexed, the effects on average wages earned and their standard deviation is persistent. When the minimum wage change is not indexed, mean wages slowly decrease over time and their standard deviation slowly increases over time. Anticipation effects result in higher average wages *before* the minimum wage is increased; once the minimum wage is increased wages evolve similar regardless of whether the increase was initially anticipated.

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 mixture of two log-normal distributions with location parameters μ_1 and μ_2, scale parameters σ_1 and σ_2, and mixing weight ξ.[10] 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 or not. (3) The distribution from which changes in the minimum wage are drawn.[11] We parameterize F as follows. Recall that we discretized the

[10]This distributional assumption gives us additional flexibility relative to just assuming that productivity follow a log-normal distribution as in Flinn (2006). We require this additional flexibility to simultaneously match the evolution of employment and minimum wage coverage in response to a minimum wage change. The evolution of employment primarily depends on the shape of the distribution close to the reservation match value. The evolution of coverage depends on the shape of the distribution close to where the minimum wage stops binding. A mixture distribution allows us to more flexibly control both aspects of the productivity distribution.

[11]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

possible values that the real minimum wage can take on, $\mathcal{M} = \{m_{[1]}, m_{[2]}, \ldots, m_{|M|}\}$, 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 implied by the process F 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.

5.2 Moments

Our 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.[12] This simplicity allows us to analyze the role of policy expectations in a model that is otherwise parsimonious. However, the model's 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

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 expectation 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.

[12] 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.

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 (see the time series shown in Appendix B). In the data, employment is clearly driven by the business cycle, seasonal effects, and demographic changes — none of which are featured in our model. To prevent that our model attributes any changes in aggregate employment over time to minimum wage policy changes, we do not estimate our model using raw data moments from before and after a minimum wage increase. Instead we will 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 our 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 changes in the share of the population out of the labor force. When we bring our model to the data, we assume that the change in the employment rate in our model (relative to the labor force) is equal to the change in the employment rate in the data.[13] 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 23 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 describe employment, minimum wage coverage, wages, and

[13] We do this to not overstate the effect on employment. Our assumption corresponds to the following: Suppose the minimum wage decreases the employment to population ratio by x percentage points. We assume that the corresponding increase in the unemployment rate (relative to the labor force) also equals x percentage points. That means that among the $x \times$ population individuals who were laid off a share that is equal to the labor force participation rate immediately exits the labor force.

unemployment duration.

5.3 Identification

Identification of the model's structural parameters largely follows the arguments in Flinn (2006). The distribution of accepted wages helps us pin down the coefficients of the productivity distribution. The employment rate is informative about exogenous separation rates. The duration of the unemployment rate is informative about the job finding rate, which in turn is informative about the cost of posting a vacancy, c.

In our estimation, we explicitly use the difference-in-differences estimates on employment and coverage induced by an actual policy change. This permits us to pin down the bargaining power, α, without resorting to additional data (such as data on the labor share of profits). 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 of 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 rollout 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.[14] We report the corresponding estimates for π_F, λ_F, μ_F, and σ_F in the top panel of Table 8.

[14] 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.

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. 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 in hand, we proceed with the estimation of the structural model. We estimate ten model parameters: the worker's bargaining power α, the cost of creating a vacancy c, the matching function elasticity ω, the parameters that govern the productivity distribution μ_1, μ_2, σ_1, σ_2, ξ, the exogenous job destruction rate δ, 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 the point estimates for the impact of the 2007 minimum wage increase on employment and coverage.

	Data	Model
Mean Wage	8.1380	7.3710
SD Wage	3.5720	2.6553
Wage p10	5.2135	5.2316
Wage p25	5.9492	5.6143
Wage p50	7.3443	6.4151
Wage p75	9.8032	7.9646
Wage p90	13.1493	10.4855
Employment	0.9270	0.9345
Coverage	0.0518	0.0002
Unemployment Duration	3.4140	4.3249
Employment Change	-0.0210	-0.0210
Coverage Change	0.0310	0.0427

Table 7: Moments used in Estimation

Note: The table shows the data and model moments that we match to estimate our model. The sample is restricted to workers aged 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.

The point estimates are taken from a variant of the simple 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.

	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	0.5885
Vacancy posting cost c	28.8337
Job destruction rate δ	0.0048
Location of match productivity μ_1	1.4036
Scale of match productivity σ_1	0.5686
Location of match productivity μ_2	2.3804
Scale of match productivity σ_2	1.2573
Mixture parameter ξ	0.8943
Flow value of unemployment b	-12.0889
Matching function elasticity ω	0.5514

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.

We estimate the model using indirect inference Gourieroux et al. (1993). We match a set of moments and reduced from 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 C for details). Computing the wage and employment moments using the model-implied distribution of workers across states is straightforward. 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. We approximate the duration of an average unemployment spell by the inverse of the expected job finding rate, which is an imprecise approximation (because our 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- and data moments, i.e. we solve

$$\min_{\Theta} \left(\mathbf{h}(\Theta)' - \widehat{\mathbf{h}}\right) \mathbf{W}^{-1} \left(\mathbf{h}(\Theta) - \widehat{\mathbf{h}}\right),$$

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

We report parameter estimates in Table 8. The cost of posting a vacancy corresponds to about four times an average worker's monthly wage. The worker's bargaining power is estimated at 0.589, which is relatively large for this class of model.

The match productivity distribution consists of a mixture of log-normals with location parameters 1.403 and 2.380 and scale parameters 0.568 and 1.257. The mixture weight is estimated to equal 0.894.

The flow value of unemployment is negative and about equal in value to minus one and 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, our model would not be able to explain why so many workers work in the minimum wage, 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.

The matching function elasticity is estimated to equal 0.551, which is in line with this class of model.

The model fit is shown in Table 7. Overall, we are able to match the targeted moments reasonably well. We underestimate the dispersion of wages, underestimate the baseline minimum wage coverage, and overestimate the duration of unemployment. We match the employment and coverage effects of the minimum wage exactly. We compare the wage distribution implied by the model against the observed wage distribution in Figure 6.

6 Empirical Analysis

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 occured in the data against the counterfactual scenario with no minimum wage increase ("Baseline"). The staggered minimum wage increase was announced in May 2007 and consists 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.

Figure 6: 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 the year 2000 as base year) for the year 2007. The sample is restricted to workers aged 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.

As shown in Figure 7, 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. The increase in 2009 increased the unemployment rate modestly, by about 0.5 percentage points. 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 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 un-

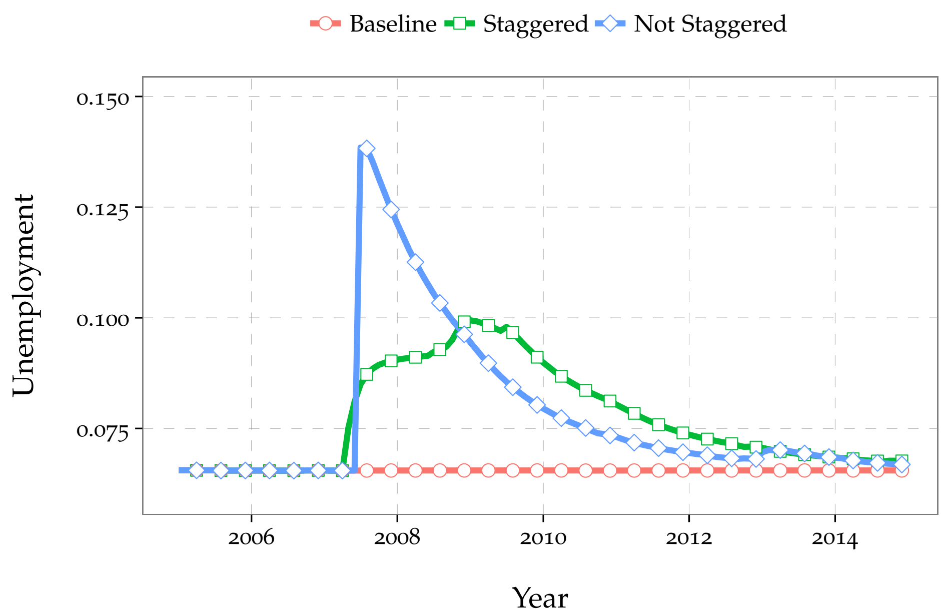


Figure 7: Counterfactuals: Evolution of unemployment when increase is not staggered

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.

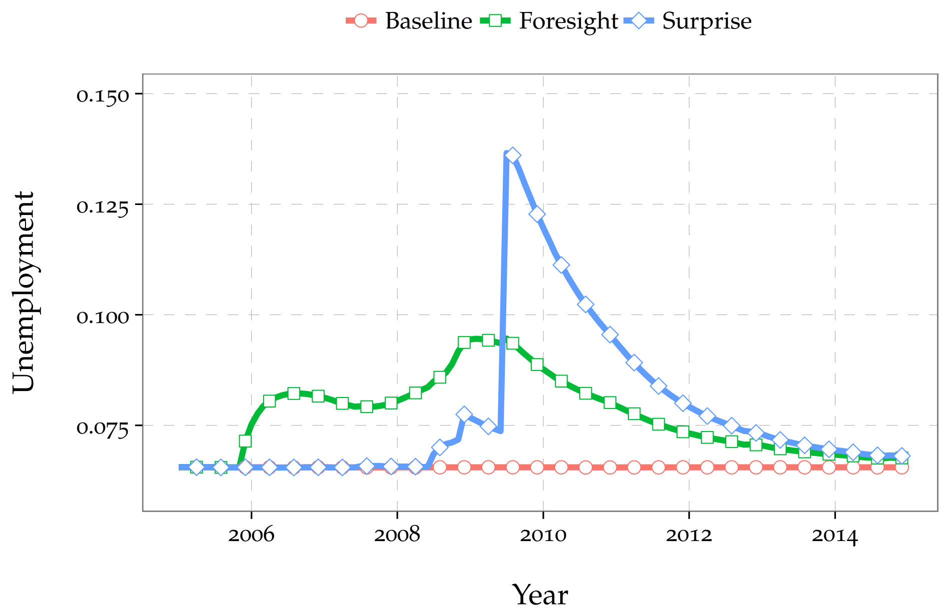


Figure 8: Counterfactuals: Evolution of unemployment when Increase is Unanticipated

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.

employment rate quickly declines. Notably, this large increase of 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 of the minimum wage. Staggering minimum wage increases appears to achieve the goal of raising the minimum wage while minimizing unnecessary turbulence in the labor market.

In Figure 8, 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 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 difference-in-differences — in the same way as we did in Section 3 — we would find no effect on employment. The anticipation effect is strong enough and makes the minimum wage rises in 2007 and 2008 appear to have no employment impact.

When each of the three minimum wage increases comes as surprise, the 2007 increase has little impact on employment. The 2008 effect increases unemployment by a mere half a percentage point. It is only the 2009 increase that raises unemployment substantially (by about 4 percentage points in 2009). 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 9 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 of the minimum wage has no discernible impact on employment, because the majority of labor market adjustments have already taken place. 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 of 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 whey they are not. In addition, they have long-run effects

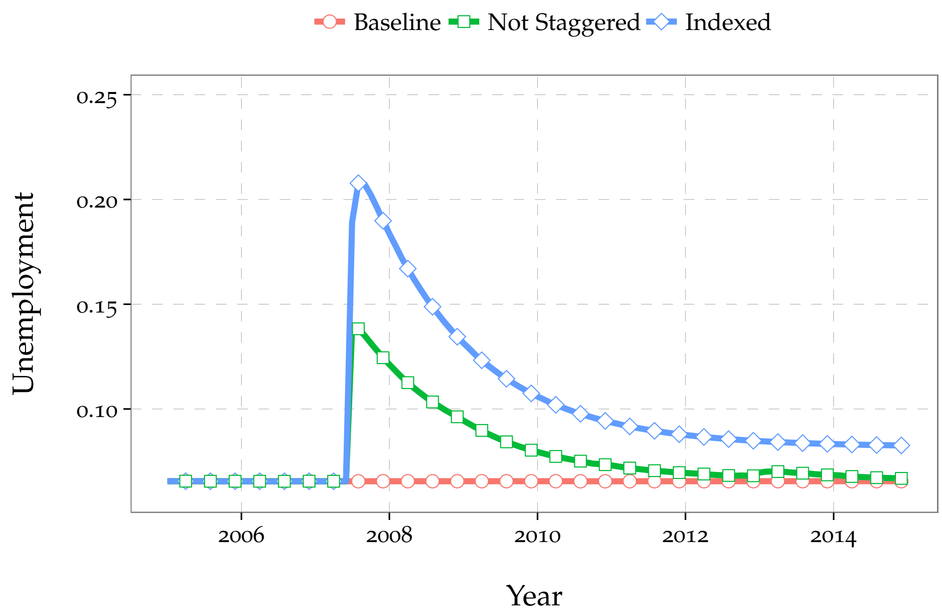


Figure 9: Counterfactuals: Evolution of unemployment under indexation

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.

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 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 when 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 our 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 estimation equation (1) by a different specifications. 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 that a particular minimum wage change had, regardless of the magnitude of the policy change. Also, the specification explicitly allows for anticipation effects.

In this appendix, 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 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 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 and for all workers in Tables 17 and 18. In Tables 19–22 we add additional Census region-specific time trends. Overall, the estimates are comparable.

Since our structural model does not feature a labor force participation decision, we 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 23.

In Tables 24 and 25 we list all states affected by the various minimum wage increases that we study in Section 3. Table 24 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 only includes the state of 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 includes the 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 includes the 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 restricted to individuals aged 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 of 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 who works in minimum wage jobs). The data restricted to individuals aged 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 of 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	0.0015	-0.0075	-0.0094	-0.0146	-0.0048	-0.0109***	-0.0054	0.0014	0.0004
	(0.0158)	(0.0051)	(0.0074)	(0.0092)	(0.0044)	(0.0036)	(0.0033)	(0.0029)	(0.0034)
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 17: Absolute Effect on Employment (Full Sample)

Note: Same as Table 15, except that the data includes the 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
Minimum Wage Increase	0.0253***	0.0140**	0.0206***	0.0097***	0.0059**	0.0176***	0.0141***	-0.0031
	(0.0049)	(0.0069)	(0.0063)	(0.0030)	(0.0027)	(0.0028)	(0.0026)	(0.0029)
R-squared	0.041	0.037	0.022	0.022	0.020	0.024	0.025	0.026
Observations	258102	288004	299836	248223	136335	144525	195419	299280

Table 18: Absolute Effect on Coverage (Full Sample)

Note: Same as Table 16, except that the data includes the 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
Minimum Wage Increase	-0.0415	-0.0002	-0.0115	-0.0484**	-0.0118	-0.0252***	0.0043	-0.0008	-0.0204***
	(0.0312)	(0.0108)	(0.0149)	(0.0189)	(0.0097)	(0.0076)	(0.0067)	(0.0064)	(0.0070)
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 19: Absolute Effect on Employment (Regional Trends)

Note: Same as Table 15, except that we include 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	0.0108	0.0508***	0.0388**	0.0451***	0.0180**	0.0038	0.0302***	0.0223***	-0.0145*
	(0.0349)	(0.0134)	(0.0192)	(0.0171)	(0.0087)	(0.0074)	(0.0072)	(0.0074)	(0.0081)
R-squared	0.021	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 20: Absolute Effect on Coverage (Regional Trends)

Note: Same as Table 16, except that we include 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	0.0052	-0.0069	-0.0081	-0.0136	-0.0067	-0.0087**	-0.0096***	0.0002	-0.0019
	(0.0159)	(0.0052)	(0.0075)	(0.0093)	(0.0045)	(0.0038)	(0.0035)	(0.0033)	(0.0035)
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 21: Absolute Effect on Employment (Full Sample, Regional Trends)

Note: Same as Table 15, 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
Minimum Wage Increase	0.0252***	0.0135*	0.0246***	0.0094***	0.0016	0.0171***	0.0137***	-0.0035
	(0.0049)	(0.0070)	(0.0064)	(0.0031)	(0.0028)	(0.0029)	(0.0029)	(0.0030)
R-squared	0.041	0.037	0.022	0.022	0.020	0.024	0.025	0.026
Observations	258102	288004	299836	248223	136335	144525	195419	299280

Table 22: Absolute Effect on Coverage (Full Sample, Regional Trends)

Note: Same as Table 16, 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	0.0050	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 23: 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 restricted to individuals aged 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 of 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 24: 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 25: List of Treatment and Control States for State Minimum Wage Increases

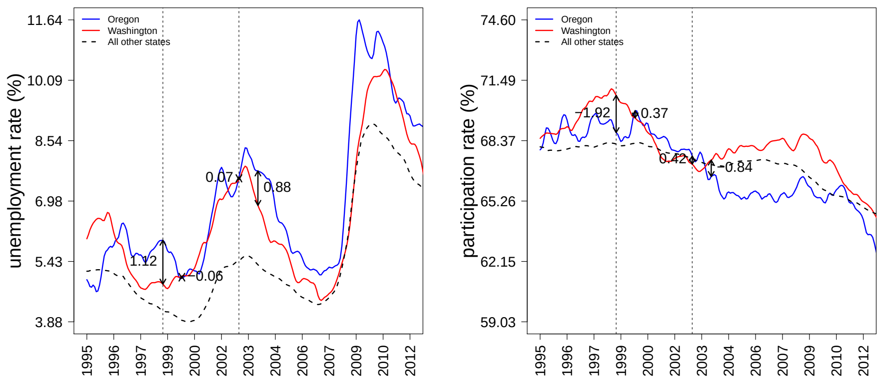
B Case Study of Washington and Oregon

Simply comparing unemployment and labor force participation statistics around minimum wage events is bound to be confounded by other events, the business cycle and measurement error. Not many states with indexation events have an easily identified control group, i.e. a group of other states that are nearby and of similar economic and demographic characteristics, such that a change in employment or labor force participation could in fact be attributed to a minimum wage policy change alone. However, among the states listed in Table 2, Washington and Oregon are two ideal candidates for a head-to-head comparison, because both states are fairly similar in terms of economic and demographic characteristics, have always had a similar minimum wage level and, most importantly, have indexed their minimum wages at different points in time (see also Figure 1).

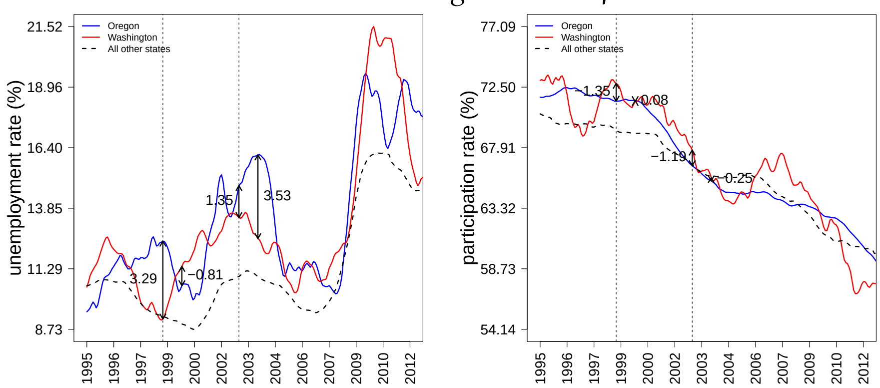
Figure 10 shows the seasonally adjusted unemployment and labor force participation rates for three groups of individuals in Washington and Oregon, all individuals, individuals aged 16 to 25, and individuals without college degree (from top to bottom). The latter two subgroups are more likely to be directly affected by minimum wage provisions than the population at large. The first vertical line refers to January 1999 when Washington increased its minimum wage from $5.15 to $5.70 and subsequently indexed it to inflation. Also in January 1999, Oregon increased its minimum wage from $6.00 to $6.50 (yet without indexing it). The second vertical line refers to January 2003, when Oregon increased its statewide minimum wage from $6.50 to $6.90 and indexed it to inflation. Also in January 2003, due to inflation indexation, Washington increased its minimum wage from $6.90 to $7.01. Visually, the business cycle clearly dominates the unemployment rate. However it appears to affect both states roughly in parallel. All three groups exhibit similar patterns; after Washington increased and indexed its minimum wage in 1999, within the following year, its unemployment rate increased relative to the unemployment rate in Oregon (by 1.18 percentage points for the full population). Similarly, when Oregon introduced and indexed its minimum wage in 2003, within a year, its unemployment rate increased relative to that of Washington (by 0.81 percentage points). The differences are most pronounced among young workers. The labor force participation rate exhibits a similar pattern. Indexation events also coincided with a decrease in the labor force participation rate for the full population and for workers without college degree, yet not for young workers. We the next subsection we show that this positive rela-

Figure 10: Unemployment Rates in Washington and Oregon

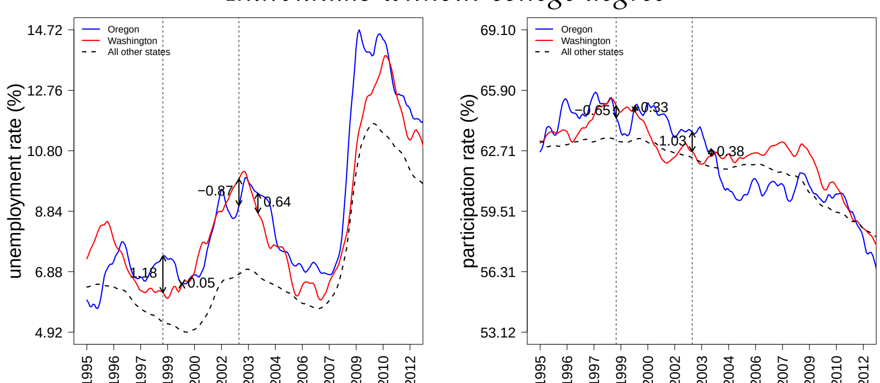
Full population



Individuals aged 16 to 24



Individuals without college degree



Notes: The unemployment rate is computed using the Current Population Survey and seasonally adjusted. The numbers indicate the difference between Oregon's and Washington's unemployment (or labor force participation) rate at the given point in time. The first vertical line refers to January 1999, when Washington increased and indexed the state minimum wage. The second vertical line refers to January 2003, when Oregon increased and indexed its minimum wage.

tionship between minimum wage indexation and unemployment generalizes beyond Washington and Oregon.

C 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 an 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 $x \in \mathcal{X}$,

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

The measure of unemployed workers is simply

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