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Recession Shapes of Regional Evolution: Factors of Hysteresis[*]

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Abstract

This paper empirically investigates sources of hysteresis, focusing on downward nominal wage rigidity and the gender gap in the labor market, using U.S. state-level payroll employment data. Employing a Bayesian Markov-switching model of business cycles, we identify U-shaped and L-shaped recessions, which correspond to quick recoveries and hysteresis, respectively. Both U-shaped and L-shaped recessions are driven by supply and demand shocks; however, U-shaped recessions are associated with recessionary shocks that raise labor productivity, whereas L-shaped recessions are also driven by shocks that reduce labor productivity. Following L-shaped recessions, recoveries in employment, output, and labor productivity are sluggish and accompanied by declining inflation. In contrast, U-shaped recoveries feature stronger rebounds without significant changes in inflation. Greater downward nominal wage rigidity and a larger gender employment gap both increase the likelihood of L-shaped recessions and hysteresis. Downward nominal wage rigidity enhances the effectiveness of both expansionary monetary and tax policies. While expansionary monetary policy becomes more effective with a larger gender gap, the effectiveness of tax cuts remains unaffected.

JEL classification: C22; C51; E32; E37.

Keywords: Hysteresis, Regional business cycles; L-shaped recession; U-shaped recession; Wage rigidity; Gender employment gap; Monetary policy; Fiscal policy.

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1 Introduction

Hysteresis refers to a phenomenon where recessionary shocks have permanent or long-lasting effects on the level of economic activity (Cerra et al., 2023). The hysteresis view has gained attention as an explanation for the slow recovery after the Great Recession and, more recently, as a channel through which monetary and fiscal policies have long-lasting effects on the economy (e.g., Jordà et al., 2020; Antolin-Diaz and Surico, 2025). Reflecting this growing interest, recent studies have discussed various drivers of stagnant recoveries or hysteresis, such as wage rigidity (Shimer, 2012; Schmitt-Grohé and Uribe, 2017), gender convergence (Heathcote et al., 2017; Olsson, 2019; Fukui et al., 2023; Albanesi, 2025), structural changes (Jaimovich and Siu, 2020), and secular stagnation (Hall, 2016; Benigno and Fornaro, 2018). Despite its importance, the determinants of hysteresis have been difficult to empirically explore for several reasons. First, economic recessions are relatively rare events, making it difficult to reliably identify and estimate the drivers of hysteresis. Second, and more fundamentally, there is no consensus about how to measure hysteresis, resulting in relatively few empirical analyses of hysteresis based on a formal statistical framework.[1]

This paper empirically investigates factors of hysteresis and explores their policy implications. To overcome the aforementioned empirical challenges, we exploit regional variations in state-level private payroll employment. We use employment because it is a widely cited monthly cyclical indicator with a long sample period starting in 1960, available for all states, and it contains identifying information about hysteresis (Furlanetto et al., 2025). Adopting the widely-agreed notion of hysteresis as a recovery from an economic recession where economic activity does not return to its pre-recession trend, we estimate the likelihood of this particular type of recession based on a state-of-art Bayesian Markov switching model by Eo and Morley (2022) for state-level data. Eo and Morley's model characterizes economic recessions as L-shaped and U-shaped recessions: an L-shaped recession reflects hysteresis, while a U-shaped recession is one in which the economy returns to its pre-recession growth path. We control for each state's trend employment growth using dynamic detrending to account for state-specific secular changes in employment growth when identifying the two types of recessions.

[1] Previous studies have primarily relied on structural models to analyze the causes and consequences of hysteresis, due to the empirical challenges of identifying hysteresis episodes and their structural drivers using aggregate data. Recent empirical developments include Furlanetto et al. (2025) based on a structural VAR and Antolin-Diaz and Surico (2025) based on a BVAR model.

Among the various factors potentially contributing to hysteresis, we focus on nominal wage rigidity and a gender employment gap in the labor market. In structural models of hysteresis, downward nominal wage rigidity serves as a key mechanism through which recessions inflict lasting damage on the labor market, as downward nominal wage rigidity puts upward pressure on real wages and hence exacerbates job losses during downturns (e.g., Acharya et al., 2022; Alves and Violante, 2024). Recent empirical studies also suggest that higher female employment facilitates faster recoveries (e.g., Cortes et al., 2018; Fukui et al., 2023; Bergholt et al., 2024). These two factors are, in fact, correlated: increased female employment raises downward nominal wage rigidity, as women are disproportionately concentrated at the lower end of the wage distribution, where wages are more likely to be downwardly rigid (Jo, 2024). Since other state-specific structural attributes may influence these factors' effects on hysteresis, it is important to use a coherent empirical framework that controls for a wide range of additional state-level characteristics.

We find that states exhibit broadly similar but distinct recession dynamics in terms of shape, timing, and magnitude. A state's business cycle does not always align with the national cycle and often shows notable idiosyncrasies; just over half of the states experience economic recessions similar to the national recessions identified by the NBER. In addition, U-shaped recessions become less frequent after the 1990s. The emergence of jobless recoveries in the aggregate economy during this period is linked to the decline in U-shaped recessions across states. Even so, our model classifies the sharp and rapid Covid-19 recession as a U-shaped recession.

The two types of recessions are driven by different shocks and show divergent macroeconomic outcomes. Both U-shaped and L-shaped recessions are driven by supply and demand shocks. However, U-shaped recessions are associated with recessionary shocks that increase labor productivity, likely reflecting the restructuring of production process or the cleansing effect of recession (Caballero and Hammour, 1994), whereas L-shaped recessions are driven by shocks that also reduce it. Relative to U-shaped recessions, L-shaped recessions persistently lower growth in employment, output, and labor productivity and lead to a decline in nontradables inflation.[2] This result confirms the hysteresis theory (e.g., Blanchard and Summers, 1986; Blanchard, 2018) — namely, both supply and demand shocks can have long-run effects — and suggests that the productivity consequences of recessionary shocks are important in determining

[2] Effects of L-shaped recessions on nontradables' inflation are consistent with negative effects on market core inflation from reallocation shocks in the labor market that induce job losses (Ahn and Rudd, 2025).

the type of recession recovery that follows a recession.

We also find that downward nominal wage rigidity and a larger gender employment gap raise the likelihood of hysteresis. States with a higher share of zero nominal wage changes during recessions and a larger male-female employment-to-population gap are more likely to experience L-shaped rather than U-shaped recessions. This pattern holds consistently over the full sample period (1978:Q1 – 2019:Q4) as well as in the post-2000 period during which gender convergence in the labor market has slowed. This finding provides empirical support for structural models where downward nominal wage rigidity serves as a crucial mechanism through which hysteresis arises (Acharya et al., 2022), and the recent studies emphasizing the gender evolution in the labor market as a key factor of hysteresis and sluggish recoveries (Cortes et al., 2018; Fukui et al., 2023; Bergholt et al., 2024).

Finally, we examine the extent to which demand-side policies—namely, expansionary monetary and tax policies—mitigate hysteresis, and the roles of nominal wage rigidity and the gender employment gap in shaping policy effectiveness. We find that expansionary monetary and tax policies are more effective in mitigating hysteresis when downward nominal wage rigidity is greater. This finding aligns with the conventional view that monetary policy affects the real economy through nominal rigidities. When labor costs are inflexible due to wage rigidity, tax cuts effectively reduce production costs, helping to sustain labor demand and thereby mitigate hysteresis. This is consistent with Lee (2025), who finds that the multiplier effects of expansionary tax policies are larger when nominal wage rigidity is greater. Meanwhile, gender employment gaps interact differently with the two policies. Monetary policy is more effective when the gender gap is larger, likely because male employment is more capital-complementary and comoves with investment (e.g., Aaronson et al., 2014; Brinca et al., 2016). In contrast, the gender gap has little effect on the transmission of expansionary tax shocks.

These findings suggest that demand-boosting policies help alleviate hysteresis, consistent with prior research highlighting the long-run effects of monetary and fiscal policies (e.g., Jordà et al., 2020, Antolin-Diaz and Surico, 2025) and the hysteresis-mitigating impact of timely interventions of monetary policy (e.g., Acharya et al., 2022). Distinguishing our analysis from previous studies, we further identify the conditions under which demand-side policies are more effective. Our finding highlights the two faces of nominal wage rigidity and gender gap. Though downward nominal wage rigidity is the key mechanism through which hysteresis is more likely to be created, demand-boosting policies become more effective in mitigating hysteresis when downward nominal wage rigidity is greater. Similarly, hysteresis is more likely where male employment is higher, as male-dominated industries and jobs requiring typically male skills often fail to recover after recessions (e.g., Cortes et al., 2018). However, expansionary monetary policy is more effective with higher male employment because male jobs are more capital-complementary and sensitive to interest rate changes. Previous studies on fiscal multipliers have found that the effects of tax policy or government spending are larger when nominal wages are more downwardly rigid (e.g., Shen and Yang, 2018; Jo and Zubairy, 2025; Lee, 2025), although these studies do not account for hysteresis or gender disparities in the labor market.

This paper lies at the intersection of several strands of the macroeconomic and econometric literature on business cycles.[3] We contribute to the growing literature on macroeconomic hysteresis by bridging it with the long-standing yet still evolving econometric literature on recession prediction. To the best of our knowledge, this is the first empirical study to examine the roles of nominal wage rigidity and gender disparities in the labor market as drivers of hysteresis, using a statistical model of business cycle dynamics and regional data.

Unlike the previous studies on hysteresis, we explicitly measure the likelihood of hysteresis using the Markov-switching model developed by Eo and Morley (2022). Previous empirical literature on hysteresis has relied on time series models that distinguish the trend and cycle components of macroeconomic time series and examines effects of structural shocks including supply, demand, and policy shocks on the components of time series (e.g., Furlanetto et al., 2025). Another strand of empirical literature has used cross-country data to study country-level differences in long-run growth experiences or long-run effects of monetary policy (e.g., Cerra and Saxena, 2008; Jordà et al., 2020). In contrast, we first identify the likelihood of hysteresis at the state level and then examine the effects of policy shocks and state-specific structural factors on hysteresis.

Our paper also contributes to the econometric literature on recession prediction. Previous studies on regional business cycles have typically employed two-state Markov-switching models that distinguish only between expansions and recessions, focusing primarily on the determinants of business cycle duration (e.g., Owyang et al., 2005; Hamilton and Owyang, 2012; Francis et al., 2018).[4] Though Eo and Morley (2022) estimate recession probabilities for the aggregate economy based on GDP growth, we focus on regional heterogeneity in recession experiences

[3]A detailed literature review is provided in Section 2.

[4]Separately, Dupraz et al. (2025) analyze asymmetry in business cycles through the lens of plucking theory based on a structural labor-market model.

inferred from private payroll employment data for each state. To identify the two types of recessions for each state, we control for state-specific long-run growth using dynamic detrending, which captures secular changes in each state's economic activity. This state-specific approach effectively identifies the cyclical position of each state, fully capturing regional heterogeneity in structural factors and long-run growth. To the best of our knowledge, this paper is the first one that applies a Markov-switching model with two types of recessions to state-level data.

This paper is also closely related to Fukui et al. (2023), as both studies use state-level data to examine the role of female employment in slow recession recoveries. However, our approach differs from that paper in two key respects: We consider nominal wage rigidity as an additional explanatory factor, and we explicitly identify and distinguish two types of recessions based on a Bayesian Markov-switching model.[5]

This paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the data used in the empirical analysis. Section 4 introduces the Markov-switching model of business cycles applied to state-level data. Section 5 presents the estimation results at both the national and state levels. Section 6 examines the roles of downward wage flexibility and female employment in driving hysteresis. Section 7 analyzes how these factors influence the effectiveness of policy in mitigating hysteresis. Section 8 concludes.

2 Literature Review

Our paper is related to several strands of the literature. The first is the literature on business cycles and hysteresis. A dominant view in macroeconomics has been "the independence assumption" where shocks to trends or structural aspects of the economy and cyclical fluctuations are independent from each other (e.g., Lucas, 1977; Blanchard and Quah, 1989).[6] In this traditional framework, innovations to trends are treated as supply shocks and those to cyclical components are viewed as demand shocks.

The hysteresis view allows for permanent effects of cyclical shocks. Blanchard and Summers (1986) propose a structural mechanism of hysteresis building on the insider–outsider model to characterize labor market hysteresis and account for sclerosis in European labor markets. Gali (2022) incorporates the insider–outsider framework into a New Keynesian model to show that the

[5]Unlike this paper, Fukui et al. (2023) develop a structural model to assess whether increased female employment crowds out male employment.

[6]Cerra et al. (2023) present an extensive review of the literature on hysteresis.

source of hysteresis is an inefficiently high equilibrium wage. Abbritti et al. (2021) construct a New Keynesian model with downward nominal wage rigidity and endogenous growth, demonstrating how cyclical shocks can permanently affect trend growth. Similarly, Acharya et al. (2022) build a structural model featuring a search-and-matching labor market block and show that downward nominal wage rigidity, combined with skill depreciation among displaced workers, can drive the economy toward a steady-state unemployment trap. Alves and Violante (2024, 2025) develop a heterogeneous-agent New Keynesian model with three labor market states and nominal wage rigidity, illustrating how a recessionary shock persistently reduces both employment and labor force participation—particularly among low-skilled workers—along with income.

Empirically, recent studies analyze macro hysteresis by focusing on the long-lasting effects of demand shocks or monetary policy shocks. Examples are Cerra and Saxena (2008), Blanchard et al. (2015) and Jordà et al. (2020), who base their analyses on multi-country data. Ma and Zimmermann (2023) estimate effects of monetary policy on R&D investment, interpreting this effect as the source of hysteresis. Relatedly, Furlanetto et al. (2025) identify a permanent demand shock based on a structural VAR model; this shock has long lasting effects on long-term unemployment and also employment. Cajner et al. (2021) empirically show persistent effects of cyclical shocks on the labor force participation rate based on state-level data. Antolin-Diaz and Surico (2025) uncover long-run positive effects of government spending using a BVAR framework and a newly constructed series of military spending disaggregated by category. Bhattarai et al. (2021) examine local hysteresis effects with a specific focus on the housing crisis in the U.S.

Our paper also intersects with the literature on nominal wage rigidity. Tobin (1972), Akerlof et al. (1996), and Benigno and Ricci (2011) demonstrate that nominal wage rigidity is an important source of nonlinearity in the business cycle. Dupraz et al. (2019) highlight downward nominal wage rigidity as a key channel through which asymmetries in unemployment dynamics arise, echoing the predictions of the plucking theory. Other studies—such as Abbritti et al. (2021) and Acharya et al. (2022)—also emphasize that downward nominal wage rigidity is a critical mechanism behind the lasting economic damage caused by recessions, as it raises real wages during downturns and amplifies the effects of recessionary shocks. Empirically and theoretically, Daly and Hobijn (2014) show that downward nominal wage rigidity is essential for understanding nonlinearities in the Phillips curve and the effectiveness of monetary policy. Jo (2024) develops unique state-level measures of downward nominal wage rigidity and investigates its determinants, and Jo and Zubairy (2025) analyze the role of downward nominal wage rigidity in the transmission of government spending shocks. Our empirical findings suggest that downward nominal wage rigidity plays a critical role in understanding hysteresis and the effectiveness of demand-side policies in mitigating it.

The paper also speaks to the literature on gender convergence in the labor market.[7] Previous studies noted that slower recoveries from recession are largely attributable to a change in trend growth of female employment (see, for example, Stock and Watson, 2012; Fukui et al., 2023; Albanesi, 2025). Cortes et al. (2018) show that college-educated women are increasingly employed in cognitive and high-wage occupations—unlike their male counterparts—and interpret this as evidence of a relative rise in demand for skills more commonly associated with women, such as social skills, within these occupations. Bergholt et al. (2024) identify gender-based trends in labor demand and supply and show these trends are responsible for the overall trend increase in GDP and labor productivity in the 1970s, 1980s, and 1990s, as well as the slowdown in GDP growth over the last 20 years. Donayre and Eo (2025) explore gender differences in recession recoveries based on a Markov switching model similar to the one in this paper with the male and female employment data.

Our paper also relates to the literature on regional business cycles and recession prediction. In this literature, the Markov-switching model has been widely used to detect business cycle phases (e.g., Hamilton, 1989). However, as noted by Francis et al. (2018) and Hamilton and Owyang (2012), this standard approach typically assumes that the depth of recessions, the trajectories of recoveries, and the lengths of recovery periods are the same across all recessions. To provide a more nuanced characterization of recovery patterns—particularly to distinguish between bounce-back recoveries and hysteresis— Francis et al. (2018) model the duration of recessions using an accelerated failure time framework, while Eo and Morley (2022) develop a Markov-switching model that allows for two distinct types of recessions.

The literature on recession prediction has increasingly relied on regional data to investigate the effectiveness of policies in stabilizing business cycles. Francis et al. (2018) and Berge et al. (2021) use state-level data to examine the transmission of monetary and fiscal policy, respectively. This paper is closely related to that work in its use of state-level data to analyze business cycles and policy effectiveness; it differs by focusing on hysteresis and its attempt to distinguish between U-shaped and L-shaped recessions using a Bayesian Markov-switching model.

[7] Goldin (2006, 2014) notes that the twentieth century is characterized by a “Great Gender Convergence.”

3 Data

Section 3.1 examines state-level private payroll employment data. Section 3.2 outlines the measurement of state-level nominal wage flexibility and gender evolution in the labor market. Section 3.3 discusses the externally identified monetary and fiscal policy shocks.

3.1 State-level Employment Data

As a measure of state-level economic activity, we use payroll employment growth by state for several reasons. First, job gains, an indicator of labor demand, are among the most frequently cited cyclical indicators (e.g., Abraham et al., 2013).[8] Second, monthly payroll employment data are available from 1960. Identifying hysteresis separately from a bounce-back recovery and estimating its evolution requires monthly or quarterly data with a sufficiently long sample period. Given that economic recessions are rare events, losing a few recessions is fairly costly, and hence a longer sample period enhances the precision of estimates. This is particularly so, since our focus is to further distinguish the two types of recessions. In this sense, the state-level payroll employment data are ideal for our empirical analysis. Alternatively, one might consider state-level output data or unemployment rates from the Local Area Unemployment Statistics. However, quarterly state-level GDP data are only available from 2005, and state-level nominal output data are available from 1963, but only at an annual frequency. In addition, state-level unemployment and labor force participation rates are available monthly, but only from 1976 onward, omitting several important economic recessions that occurred between 1960 and 1975.[9]

For these reasons, previous research on regional business cycles has frequently relied on payroll employment growth to analyze state-level business cycles (e.g., Hamilton and Owyang, 2012).[10] We convert the monthly data to a quarterly frequency to align with the time frame commonly used in the previous literature on business cycles. The sample period spans from 1960:Q1 to 2023:Q4.

Figures A1 - A2 in the appendix display employment growth (red lines) and its long-run trend

[8] Owyang et al. (2015) mention that payroll employment is the broadest measure of economic activity.

[9] Employment data are relatively free from measurement errors that have cyclical features relative to unemployment rate and labor force participation rate (Ahn and Hamilton, 2022), which is an additional benefit of using the employment data for the identification of recession types.

[10] See Section Appendix A in the appendix for more details. While the BLS produces the data, we retrieve the monthly data from HAVER.

(blue line) by state. Panel (a) also displays national payroll growth. While states exhibit common procyclical variation in payroll growth, they differ in both the magnitude and speed of recoveries. Additionally, some states experience decelerations in payroll employment not seen elsewhere. For instance, Louisiana (Panel (t) in Figure A1) saw a sharp decline in payrolls in 2005 due to Hurricane Katrina. Similarly, North Dakota (Panel (j) in Figure A2) experienced rapid payroll gains following the Great Recession, followed by a prolonged decline, reflecting the boom and subsequent bust of shale oil production.

3.2 Attributes of States: Nominal Wage Rigidity and Gender Gaps

This section examines state-level covariates that are included in our analyses with a particular focus on the presence of nominal wage rigidity and gender gaps in the labor market.

First, as the measure of downward nominal wage rigidity, we employ the fraction of nominal wage cuts out of total wage changes by state constructed by Jo (2024). Based on the Current Population Survey (CPS, 1979–2018), Jo measures the share of workers with no changes in hourly wages, with hourly wage cuts, and with hourly wage increases by state. These three statistics, summarizing the nominal wage change distribution, show asymmetry between wage increases and cuts and a spike at zero, which the author interprets to represent downward nominal wage rigidity.[11] The three shares show sufficient variation across states and over time to permit state-level analyses on the propagation of policy shocks or business cycles (Jo, 2024 Lee, 2025).

As a measure of the gender gap in the labor market, we use the difference in the employment-to-population ratio (EPOP ratio) between men and women. The EPOP ratio is defined as the labor force participation rate multiplied by one minus the unemployment rate. At the state level, these gender-specific labor market indicators are available annually.

As additional state-level attributes, we consider factors reflecting industry structure such as oil production and the employment shares of manufacturing, professional and business services, and finance. Specifically, we construct an indicator variable for oil-producing states, which takes the value of one if a state has positive oil production and zero otherwise. For the other industry measures, we use the industry's employment share out of the state's total private payroll employment. For union membership, we use the fraction of workers who are union members out of the state's private payroll employment. As a proxy for market competition or monopsony power, we use the fraction of workers employed by firms with 500 or more employees. In addition,

[11] The estimates are found in the author's website (https://sites.google.com/view/yoonjoojo/rsearch).

we include indicators for Census regions to account for heterogeneity across broader geographic areas. We also consider state-specific policy variables, including the minimum wage and the tax-to-income ratio (for a state's minimum wage, we use the higher of the state-level minimum wage and the federal minimum wage). Detailed information on the sources of the state-level data is provided in Appendix A.

For state-level inflation in nontradables, tradables, and all categories, we use the estimates from Hazell et al. (2022). We also employ the state-level macroeconomic dataset compiled by Jo and Zubairy (2025), which includes nominal gross state product, employment levels, and the consumer price index at an annual frequency to construct state-level labor productivity.

3.3 Policy Shocks

For externally identified policy shocks, we use monetary policy shocks from Romer and Romer (2004), as extended by Wieland and Yang (2020), and tax shocks constructed by Romer and Romer (2007).[12]

4 Modeling the Shapes of Recoveries at the State Level

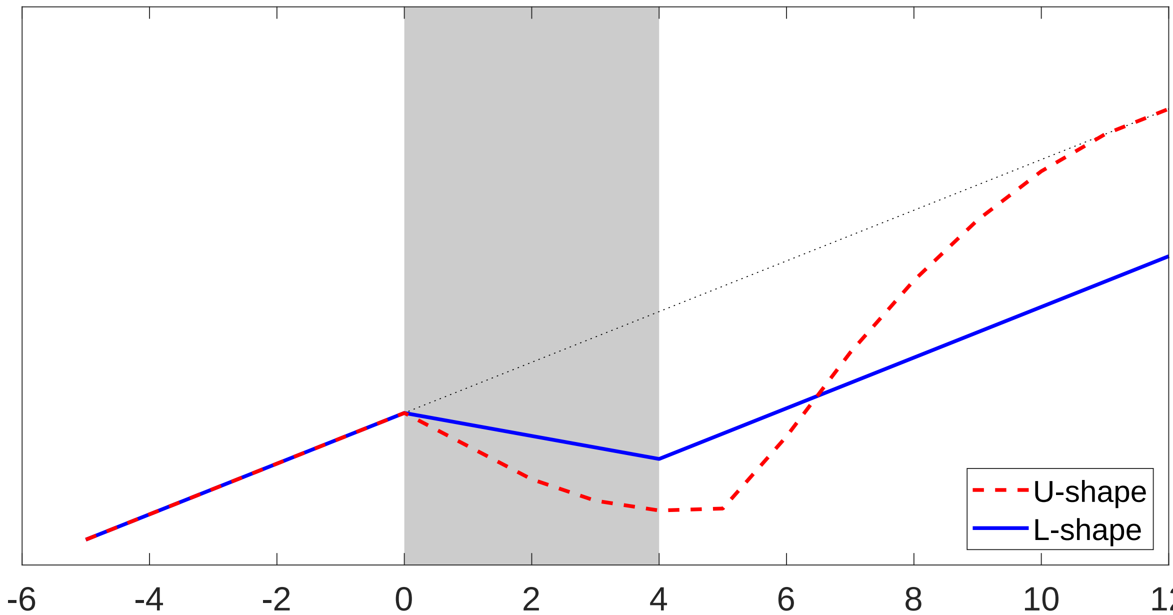
Section 4.1 discusses the model and how we identify the two recession types. Section 4.2 details our estimation procedure.

4.1 Model and Identification

To identify the shapes of recession recoveries across U.S. states, we employ the Markov-switching model of business cycles from Eo and Morley (2022). The model allows a given recession to either permanently alter the level of employment (i.e., an L-shaped recession) or only have a temporary effect (i.e., a U-shaped recession). An L-shaped recovery is characterized by an initial decline in economic activity, followed by an expansion that fails to return to the pre-recession pace of growth (trend growth). In contrast, a U-shaped recovery begins with a similar decline

[12]Since monetary policy shocks identified from high-frequency data are only available from the late 1980s, we use Romer and Romer's estimates, which cover a longer sample period starting in 1969. For tax shocks, Lee (2025) construct state-level average marginal tax shock estimates and corresponding instrumental variables for the period 1980–2000. However, these series are annual and thus not directly applicable to our empirical analysis without strong assumptions regarding the frequency or timing of the shocks. Therefore, for the sake of transparency, we directly employ aggregate tax shock estimates from Romer and Romer (2007).

Figure 1: ILLUSTRATION OF L-SHAPED AND U-SHAPED RECOVERIES



Notes to figure: The X-axis denotes periods after recession. The black dotted line indicates the hypothetical output level if a recession had not occurred. The shaded area represents periods of recession.
Source: Authors' calculation.

but is followed by a strong bounceback, during which growth outpaces that of the expansion pace, allowing the economy to return to its original pace of growth (trend growth). Illustrations of L-shaped and U-shaped recoveries are provided in Figure 1.

The state-level change in private payroll employment is assumed to evolve according to a first-order Markov-switching model with three regimes—expansion, U-shaped recessions, and L-shaped recessions. For the geographic state i,

$$\begin{aligned}\Delta y_{i,t} - \tilde{\mu}_{i,t} = \mu_{i,0} \quad &+ \quad \mu_{i,1} \cdot \chi_{i,t} \cdot \mathbf{1}(S_{i,t} = 1) \\ &+ \quad \mu_{i,2} \cdot \chi_{i,t} \cdot \mathbf{1}(S_{i,t} = 2) + \lambda_i \cdot \sum_{k=1}^{m} \chi_{i,t-k} \cdot \mathbf{1}(S_{i,t-k} = 2) \\ &+ \quad \chi_{i,t} \cdot e_{i,t}, \quad e_{i,t} \sim i.i.d.N\left(0, \sigma_i^2\right) \end{aligned} \tag{4.1}$$

where $\Delta y_{i,t}$ is the quarterly growth rate of payroll employment, $S_{i,t} = 0, 1, 2$ is the regime indicator, with $S_{i,t} = 0$ corresponding to the expansion regime, $S_{i,t} = 1$ to the L-shaped recovery regime, and $S_{i,t} = 2$ to the U-shaped recovery regime, $\mathbf{1}(\cdot)$ is an indicator function, and $\mu_{i,0}$, $\mu_{i,1}$, and $\mu_{i,2}$ are the conditional means for the respective regimes. The bounceback effect λ_i represents the strong recovery over m quarters for $t+1, \ldots, t+m$ following the U-shaped recession shock, $\mu_{i,2}$, at time t, such that $\lambda_i \cdot m + \mu_{i,2} = 0$. Therefore, λ_i is calibrated as a form of the restriction without estimation.

In addition, to account for the extreme outliers due to the COVID-19 pandemic as shown in Figure 2, we use a decay function as suggested by Lenza and Primiceri (2022) and Eo and Morley (2023). The scaling parameter $\chi_{i,t}$ is specified as follows. For the period prior to the onset of the COVID-19 pandemic ($t^* = 2020Q2$), we set $\chi_{i,t} = 1$ (i.e., for $t < 2020Q2$). After this time period, we employ a scaling factor denoted by $\chi_{i,t^*+j} = c_i + (1 - c_i)\rho_i^j$, where j represents the time elapsed since the pandemic began. We estimate these parameters without imposing any restrictions on their values. In particular, we do not impose which type of recession they are associated with *ex ante*. The decay parameter ρ_i is restricted to lie between 0 and 1 in the estimation.

For employment growth during contractionary regimes, we set the conditional means to $\mu_{i,1}$ and $\mu_{i,2}$ for L-shaped and U-shaped recessions, respectively, for $t \neq$ 2020Q2, and to $(\chi_{i,t} \cdot \mu_{i,1})$ and $(\chi_{i,t} \cdot \mu_{i,2})$ otherwise. Accordingly, the bounceback effect for the U-shaped recovery is determined by $\lambda_{i,t-k} = -\mu_{i,2}/m$ for $t \neq 2020Q2$, and $\lambda_{i,t-k} = -\chi_i \cdot \mu_{i,2}/m$ otherwise.

To account for state-specific changes in long-run trend employment growth, we use "dynamic demeaning" for employment growth.[13] The dynamic demeaning is essentially the 10-year moving average of employment growth: $\tilde{\mu}_{i,t} \equiv \frac{1}{40}\sum_{j=0}^{39} \Delta y_{i,t-j}$.

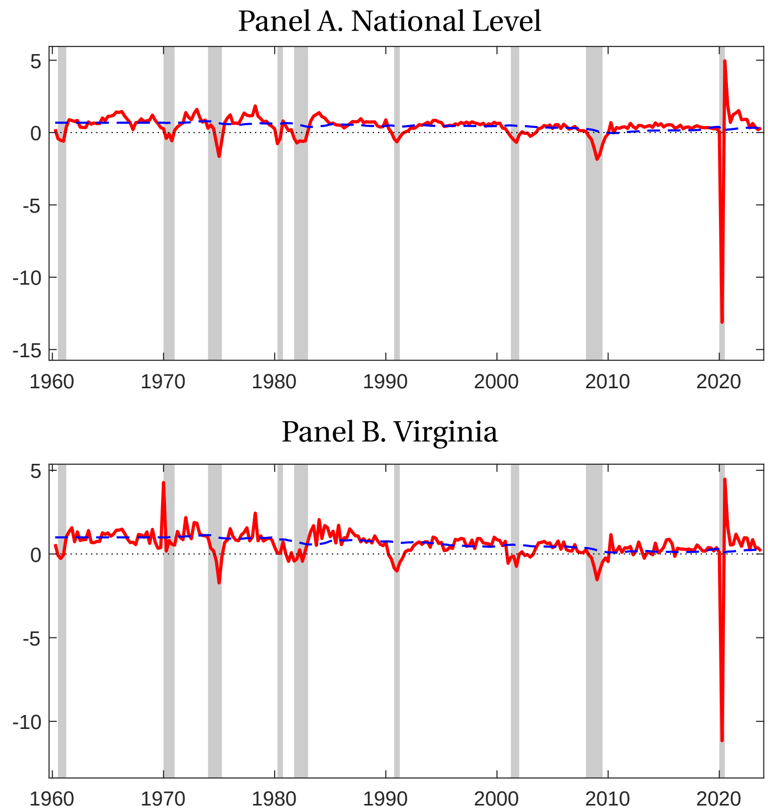
The indicator $S_{i,t}$ is a latent Markov-switching state variable determined by transition probabilities $Pr[S_{i,t} = j | S_{i,t-1} = k] = p_{i,kj}$ for $k, j = 0, 1, 2$. We do not allow direct switching between L- and U- shaped regimes without going through an expansionary regime first, which is expressed as

$$p_{i,12} = Pr[S_{i,t} = 2 | S_{i,t-1} = 1] = 0$$
$$p_{i,21} = Pr[S_{i,t} = 1 | S_{i,t-1} = 2] = 0.$$

The regime transition matrix of state i is given by

[13] Eo and Morley (2022) consider this treatment in their robustness analysis. Relatedly, see Eo and Kim (2016) for the importance of allowing for time variation in long-run trend growth when estimating Markov-switching models of the business cycle.

Figure 2: EMPLOYMENT GROWTH AT THE NATIONAL LEVEL AND IN VIRGINIA



Notes to figure: The figures plot employment growth at the national level and in Virginia. The red line represents employment growth, while the blue dashed line shows the long-run growth rate, calculated using a 40-quarter rolling average.

Source: Authors' calculation

$$\Pi_i = \begin{bmatrix} \underbrace{1 - p_{i,01} - p_{i,02}}_{E \to E} & \underbrace{1 - p_{i,11}}_{L \to E} & \underbrace{1 - p_{i,22}}_{U \to E} \\ \underbrace{p_{i,01}}_{E \to L} & \underbrace{p_{i,11}}_{L \to L} & 0 \\ \underbrace{p_{i,02}}_{E \to U} & 0 & \underbrace{p_{i,22}}_{U \to U} \end{bmatrix},$$

where, for the readers' convenience, we annotate which transitions between states each probability represents, with E, U, and L denoting expansion, U-shaped recession, and L-shaped recession, respectively. The arrow "→" denotes a transition from the business cycle phase on the left to the phase on the right.

4.2 Bayesian Estimation

The length of the post-recession bounce-back period was set to $m = 5$ quarters following Eo and Morley (2022).[14] The model parameters are estimated using a Bayesian approach, accommodating the irregular likelihood function for the regime-switching models as described by Owyang et al. (2005). This estimation method was selected due to its robustness in handling the complexities inherent in our data.

4.2.1 Priors

The prior distribution for the transition probabilities from the expansion regime $\left(p_{0,1}, p_{0,1}, p_{0,2}\right)$ follows a Dirichlet distribution with parameters $Dirichlet(30,5,5)$, while those for the L-shaped and U-shaped recession regimes $\left(p_{i,i}, p_{i,0}\right)$ follow a Beta distribution with parameters $Beta(8,1)$. The prior distributions for the conditional means $\left(\mu_0, \mu_1, \mu_2\right)$ are given by $Normal(1,1)$, $Normal(-2,1)$, and $Normal(-2,1)$, respectively. The prior distributions for the scaling parameters $\left(c, \rho\right)$ are $Normal(5,1)$ and $Beta(8,2)$, respectively. Finally, the prior distribution for the error variance is given by $Inverse\ Gamma(10,5)$. More details about the prior distributions and the sampling algorithm are provided in Appendix B.

4.2.2 MCMC Procedure

For Bayesian estimation, we employ Markov Chain Monte Carlo (MCMC) sampling techniques to estimate the model parameters in each state. For notational convenience, we suppress the state indicator i from the parameters. Specifically, Metropolis-Hastings sampling with a random walk proposal is utilized for the COVID-19 scaling parameters, denoted as c and ρ. For the remaining parameters, Gibbs sampling is implemented. The priors for all parameters are set according to established and standard values found in the literature. The MCMC procedure involves generating 10,000 draws, with the initial 5,000 draws discarded as burn-ins to ensure the convergence of the sampling process. This sampling approach allows for efficient exploration of the posterior distributions of the parameters, particularly given the high dimensionality of the model and the complexity introduced by the COVID-19 scaling parameters. Let $\mathbf{Y} = \left\{\Delta y_t\right\}_{t=1}^{T}$,

[14] As a robustness check, we consider alternative values for m, and the results remain robust to these alternative values.

$\Theta \equiv (\mu_0, \mu_1, \mu_2, \sigma^2)$, $\mathbf{P} \equiv (p_{0,1}, p_{0,2}, p_{1,1}, p_{2,2})$, $\mathbf{S} = \{S_t\}_{t=1}^{T}$, and $\Gamma = (c, \rho)$. The following summarizes the posterior sampling algorithm.

MCMC Sampling Procedure

- Step 1: Gibbs Sampling $\Theta|\mathbf{Y}, \mathbf{S}, \Gamma$
- Step 2: Gibbs Sampling $\mathbf{S}|\mathbf{Y}, \Theta, \Gamma, \mathbf{P}$
- Step 3: Gibbs Sampling $\mathbf{P}|\mathbf{S}$
- Step 4: Metropolis-Hastings Sampling $\Gamma|\mathbf{Y}, \mathbf{S}, \Theta$

We target an acceptance rate for the scaling parameters (c, ρ) using the Metropolis-Hastings algorithm, aiming for a range between 0.2 and 0.4.[15]

5 Estimation Results

Section 5.1 reports the national-level result, and Section 5.2 reports the estimation result by states.

5.1 National Level

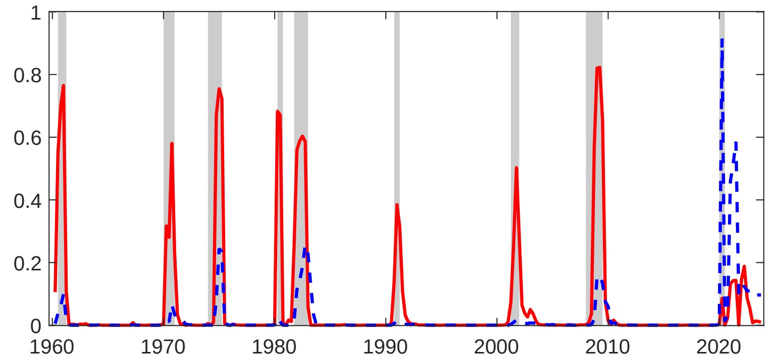
We begin by presenting the estimation results at the national level. To do so, we aggregate payroll employment across all states, including the District of Columbia, and estimate the model described in Section 4. We then compare the national-level results based on employment growth to those based on GDP growth as estimated by Eo and Morley (2022). This national-level analysis offers insights into broader employment dynamics and evaluates the extent to which changes in GDP and employment growth convey consistent signals about the cyclical state of the economy. This analysis highlights potential discrepancies or alignments between these two key economic indicators.

Figure 3 presents the national-level recession probabilities estimated using payroll employment (Panel A) and GDP growth (Panel B). There are several key points to note. First, the payroll-based estimates closely align with the NBER recession dates, highlighting their timeliness and effectiveness in identifying business-cycle phases. One exception is the period of the second

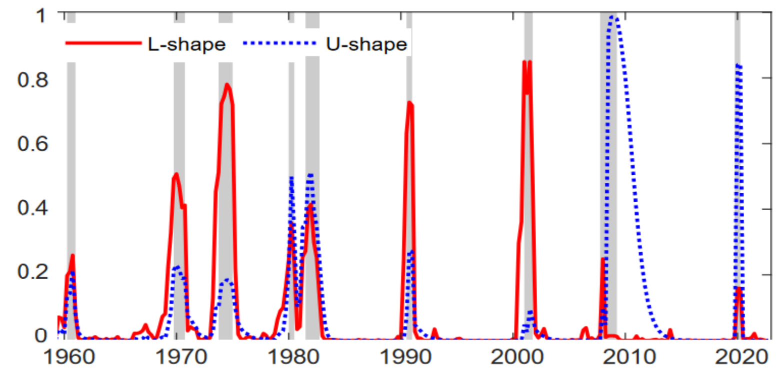
[15] Gelman et al. (1997) suggest an optimal acceptance rate of 0.234 with a random walk proposal.

Figure 3: NATIONAL LEVEL RECESSION PROBABILITIES

Panel A. Payroll Employment



Panel B. GDP Growth



Notes to figure: The figures display the estimated probabilities of L-shaped and U-shaped recessions at the national level. The blue lines represent the probability of a U-shaped recession, while the red lines represent the probability of an L-shaped recession. The Y-axis indicates the probability, and the X-axis represents calendar time in quarter.
Source: Authors' calculation

wave of COVID-19, which the model based on payroll employment interprets as a U-shaped recession, in contrast to the GDP-based estimate, which interprets the period as an expansion.

Second, L-shaped recessions are more pronounced in employment growth than in GDP growth, possibly reflecting the phenomenon of jobless recoveries—a pattern that has become increasingly evident since the 1980s.[16] Notably, the payroll-based estimate classifies the Great Recession as an L-shaped recession, while the GDP-based estimate categorizes it as a prolonged U-shaped recession. This discrepancy—together with the trajectory of the unemployment rate and the sluggish recovery of long-term unemployment—suggests that payroll-based estimates may be more informative for *predicting* recession durations and the persistent damage caused by severe recessionary shocks than GDP growth. Following the Great Recession, both overall and long-term unemployment recovered slowly, taking nearly a decade to return to pre-recession

[16] Jaimovich and Siu (2020) show that the declining employment share of routine occupations has driven jobless recoveries since the 1980s.

levels. Although the GDP-based estimate labels the recession as U-shaped, it still indicates a recovery duration of approximately five years—the longest on record. In contrast, the payroll-based estimate classifies it as L-shaped, capturing near-permanent employment losses that align with the prolonged weakness in both labor market and output recovery in the years that followed.

The COVID-19 recession was characterized by a sharp and sudden economic contraction, followed by a rapid recovery—consistent with a U-shaped rebound in both employment and GDP growth. Notably, the two estimates diverge in their interpretation of the second wave. The output-based estimate, which aligns more closely with the NBER recession dates, does not classify the second wave as a distinct downturn. In contrast, the payroll-based estimate identifies it as another U-shaped recession. Consistent with the interpretation based on payroll employment, initial unemployment claims increased between November 2020 and January 2021. This discrepancy underscores the effectiveness of the payroll-based measure in capturing labor market turbulence more effectively than the output-based estimate.

5.2 State Level

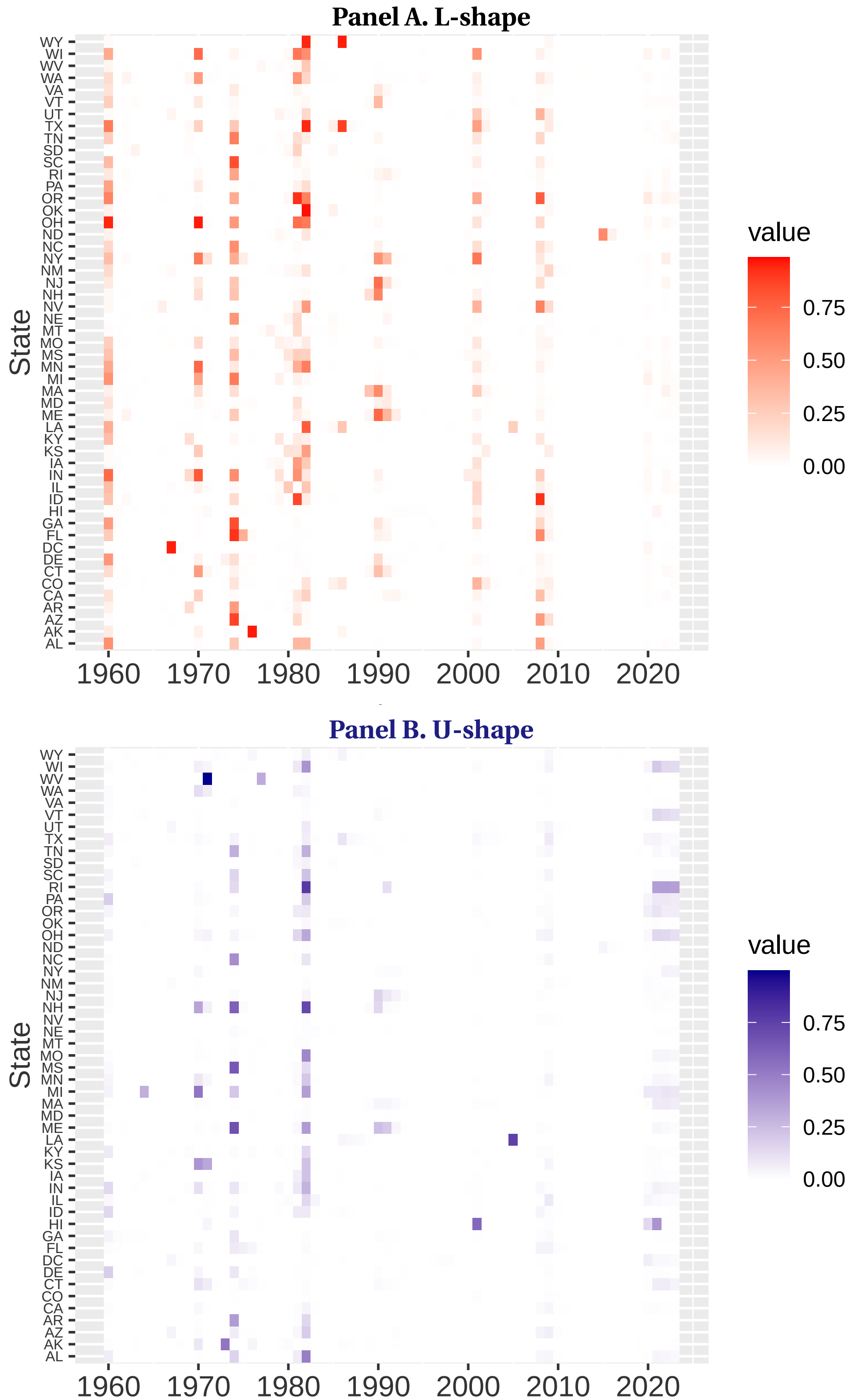
Figure 4 presents a heatmap illustrating the evolution of recession probabilities across all states.[17] The figure highlights variation in the types of recessions across states and over time, revealing several notable patterns.

First, just over half of the states experience economic recessions that closely align with the national recessions identified by the NBER, while other states either did not experience all the NBER recessions or experienced recessions not classified as such at the national level. States also vary in both the shape and timing of their economic downturns. Figure 5 illustrates recession probabilities for New York and Wisconsin. New York did not experience recessions during the 1980s, whereas Wisconsin—a manufacturing-heavy state—underwent prominent L-shaped recessions. In contrast, New York faced an L-shaped recession in the early 1990s, while Wisconsin did not experience a recession during that period.[18] Moreover, some states undergo independent economic downturns not shared by others, as shown by isolated dark dots in both

[17] The full set of state-level recession probability estimates is provided in Figures B3 and B4 in the appendix.

[18] Both New York and Wisconsin experienced U-shaped recessions during the COVID-19 pandemic. In 2021, New York underwent a pronounced L-shaped recession, reflecting severe damage in sectors such as hospitality, tourism, retail, and commercial real estate. Meanwhile, Wisconsin experienced a severe U-shaped pandemic recession similar to New York's, but its subsequent recessions were relatively mild, with recession probabilities declining quickly.

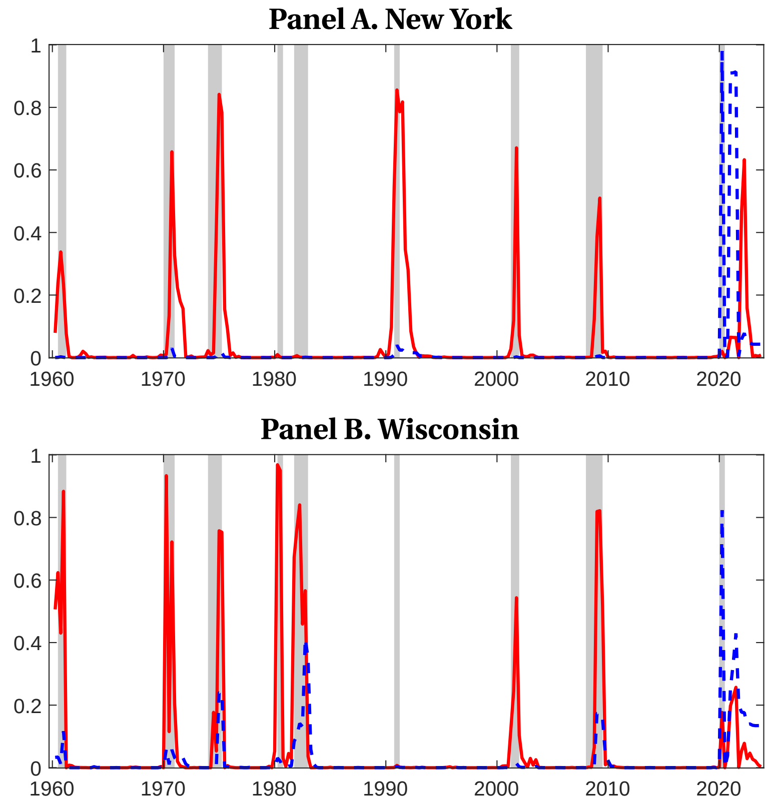
Figure 4: Probabilities of L- and U- Shape Recessions across States over Time



Notes to figure: The figures show the estimated probabilities of states experiencing L-shaped and U-shaped recessions over time. The Y-axis represents the states, while the X-axis gives calendar time. The color legend beside each figure indicates the recession probabilities.

Source: Authors' calculation

Figure 5: L-SHAPED AND U-SHAPE RECESSION PROBABILITIES: NEW YORK AND WISCONSIN



Notes to figure: The figures display the estimated probabilities of L-shaped and U-shaped recessions. The blue lines represent the probability of a U-shaped recession, while the red lines represent the probability of an L-shaped recession. The Y-axis indicates the probability, and the X-axis represents calendar time in quarter. The shaded areas denote the NBER recessions.

Source: Authors' calculation

heatmaps. For example, North Dakota experienced an L-shaped recession in 2015 due to a sharp decline in oil prices, while Louisiana faced a U-shaped recession in 2005 due to Hurricane Katrina. Overall, these patterns highlight substantial heterogeneity in the incidence and nature of recessions across states, indicating that regional business cycles do not always coincide with national ones.

Second, U-shaped recessions became less frequent after the 1990s—a pattern that is widespread across states, as shown in Panel B of Figure 4. This decline coincides with the increased prevalence of jobless recoveries and a slowdown in gender convergence in the labor market. These structural shifts appear to be linked to the reduced incidence of U-shaped recoveries. Nevertheless, our model identifies the COVID-19 recession as more likely to be U-shaped rather than L-shaped across most states, effectively capturing the sharp, short-lived, and rapidly evolving nature of the pandemic-induced downturn.

5.3 Features of U- and L- Shaped Recessions

This section discusses the key characteristics of the two types of recessions. Section 5.3.1 explores the roles of supply and demand factors in shaping U- and L-shaped recessions. Section 5.3.2 examines the effects of these recession types on labor market outcomes and broader macroeconomic variables.

5.3.1 Supply and Demand Shocks

To examine the extent to which supply and demand factors drive each type of recession, we consider the following model:

$$p_{it}^{j} = \beta_s^j I_{it}^s + \beta_d^j I_{it}^d + \gamma^j g_{it} + \alpha_i^j + \epsilon_{it}^j \quad \text{for} \quad j \in [u, l].$$

where p_{it}^u and p_{it}^l are the probabilities of U-shaped and L-shaped recessions experienced by state i, respectively. The supply factor indicator, I_{it}^s, equals one if both the unemployment rate and price inflation in state i increase in quarter t, and zero otherwise. The demand factor indicator, I_{it}^d, equals one if the unemployment rate increases while price inflation decreases in state i during quarter t, and zero otherwise. We use state-level total inflation, including prices of both tradables and nontradables, from Hazell et al. (2022). The coefficients of I_{it}^s and I_{it}^d are β_s^j and β_d^j, respectively. We further examine the magnitude of the recessionary shock, g_{it}, to account for the possibility that L-shaped recessions are more likely to result from larger shocks. Specifically, we measure the magnitude of the shock using the absolute value of changes in the unemployment rate, interacted with the probability of being in a recession (i.e., the combined probability of U-shaped and L-shaped regimes). The parameter γ^j is the coefficient of g_{it}.

We further classify each shock based on its impact on labor productivity growth. Let I_{it}^{s+} denote supply factors accompanied by positive changes in labor productivity growth, and I_{it}^{s-} denote those accompanied by negative changes in labor productivity. Similarly, I_{it}^{d-} and I_{it}^{d+} represent demand factors associated with negative and positive changes in labor productivity growth, respectively.[19] We also include state fixed effects (α_i^j) and the term ϵ_{it}^j is the residual.

[19] State-level labor productivity growth is computed as follows. First, we divide the nominal gross state product (GSP) of each state at time t by the corresponding CPI index to obtain the level of real GSP. This measure is annual, as GSP data are only available on a yearly basis. We then divide the real GSP of each state at time t by the corresponding level of employment (also annual) to calculate the level of labor productivity. Labor productivity growth is defined as the year-over-year percentage change in this measure. The state-level annual data are from Jo and Zubairy (2025).

Table 1: EFFECTS OF SUPPLY AND DEMAND FACTORS

	(1) p^l_{it}	(2) p^u_{it}	(3) p^l_{it}	(4) p^u_{it}	(5) p^l_{it}	(6) p^u_{it}	(7) p^l_{it}	(8) p^u_{it}
[1] I^s_t	0.042***	0.010***			0.020***	0.002**		
	(0.002)	(0.001)			(0.002)	(0.001)		
[2] I^d_t	0.088***	0.014***			0.024***	0.003***		
	(0.004)	(0.002)			(0.002)	(0.001)		
[3] I^{s-}_t			0.064***	0.010***			0.035***	-0.001
			(0.003)	(0.001)			(0.002)	(0.001)
[4] I^{s+}_t			0.032***	0.010***			0.010***	0.003***
			(0.002)	(0.001)			(0.002)	(0.001)
[5] I^{d-}_t			0.073***	0.011***			0.027***	0.002
			(0.007)	(0.003)			(0.004)	(0.002)
[6] I^{d+}_t			0.095***	0.016***			0.022***	0.004***
			(0.005)	(0.002)			(0.003)	(0.001)
[7] g_{it}					0.742***	0.127***	0.739***	0.127***
					(0.006)	(0.003)	(0.006)	(0.003)
State FE	✓	✓	✓	✓	✓	✓	✓	✓
No. of obs.	12,189	12,189	12,189	12,189	8,925	8,925	8,925	8,925
R^2	0.064	0.029	0.072	0.029	0.701	0.252	0.704	0.253

Notes to table: This table presents the coefficient estimates from Equation (5.3.1). State FE denotes state fixed effects. The notation ***, **, and * indicates statistical significance at the 1%, 5%, and 10% levels, respectively. Numbers in parentheses are standard errors.
Source: Authors' calculation.

The sample period 1978:Q1-2017:Q4, aligning with the availability of state-level CPI data from Hazell et al. (2022).

We first consider the case without the magnitude of recessionary shock (columns 1–4 in Table 1). Notably, both supply and demand factors increase the probability of an L-shaped recession (column 1), similarly so for a U-shaped recession (column 2). The statistically significant positive effect of demand shocks on the likelihood of L-shaped recessions supports the hysteresis theory (Blanchard, 2018), which posits that negative demand shocks can have lasting adverse effects on economic activity (row [2], column (1); rows [5]-[6], column (3)). It is notable when distinguishing shocks between those that are productivity-enhancing and productivity-reducing, a supply shock that is productivity reducing has a substantially greater effects on the probability of an L-shaped recession than a supply shock that is productivity reducing (rows [3]-[4], column (3)). Overall, this results remain robust to the inclusion of g_{it} (columns [5]-[8]).

Meanwhile, it is important to note that only productivity-enhancing supply and demand shocks have statistically significant positive effects on the probability of a U-shaped recession when g_{it} is included in the regression (column (8)). This result suggests that the productivity consequences of shocks are critical in a swift recession recovery. To illustrate, following a negative economic shock, firms and workers may operate more efficiently to reduce production costs, or the shocks may have a cleansing effect, which facilitates a swift recovery. This result implies that the productivity consequences of a cyclical shock are important in determining the speed of recovery after an economic recession.

Finally, L-shaped recessions are typically associated with larger shocks, as indicated by the substantially higher coefficient of g_{it} for the L-shaped recession probability compared to that for the U-shaped recession probability (row [7], columns (5)–(8)).

5.3.2 U- and L-shaped Recession and Macroeconomic Variables

This section examines the macroeconomic outcomes of U-shaped and L-shaped recessions with a focus on the year (four quarters) following the recessions.[20] We first consider labor market variables – including labor force participation rate (LFPR) and employment-to-population ratio (EPOP) by gender – as well as labor productivity growth and price inflation.

Consider the following model:

$$y_{i,t+4} - y_{it} = \beta_u p^u_{it} + \beta_l p^l_{it} + \alpha_i + e_{i,t+4}$$

where $(y_{i,t+4} - y_{i,t})$ represents changes in state i's macro variable of interest between $t+4$ and t, p^u_{it} and p^l_{it} denote state i's probabilities of experiencing U-shaped and L-shaped recessions, respectively, and the parameters β_u and β_l are the coefficients associated with these recession probabilities. The term α_i represents a state fixed effect. The term, $e_{i,t+4}$, is the prediction error.

We begin with the LFPR and EPOP ratio both in total and by gender. Table 2 presents the estimation results. Only L-shaped recessions are associated with statistically significant declines in the LFPR four quarters ahead; in contrast, U-shaped recessions show no statistically significant

[20] We consider the one-year horizon, because the bounce-back phase of a U-shaped recession is set to be 5 quarters.

Table 2: PREDICTABILITY OF LFPR AND EPOP RATIO

LFPR	Men	Women	Total
[1] $p^{l}_{i,t-4}$	-0.675***	-0.251**	-0.476***
	(0.106)	(0.123)	(0.070)
[2] $p^{u}_{i,t-4}$	0.288	-0.080	-0.223
	(0.370)	(0.429)	(0.244)
State fixed effects	✓	✓	✓
R^2	0.010	0.007	0.019
No. of obs.	8,772	8,772	8,772
EPOP	Men	Women	Total
[1] $p^{l}_{i,t-4}$	-2.170***	-1.120***	-1.627***
	(0.146)	(0.132)	(0.098)
[2] $p^{u}_{i,t-4}$	3.438***	1.325***	3.009**
	(0.509)	(0.459)	(0.341)
State fixed effects	✓	✓	✓
R^2	0.027	0.013	0.036
No. of obs.	8,772	8,772	8,772

Notes to table: This table presents the coefficient estimates from Equation (6.1), excluding observations with zero recession probabilities. The notations ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Numbers in parentheses are standard errors.
Source: Authors' calculation.

correlation with changes in the labor force participation rate four quarter ahead (see the "Total" column in panel "LFPR").[21]

We also see different effects on the EPOP ratio. L-shaped recessions predict declines in the EPOP ratio four quarters ahead, mirroring their effect on labor force participation, while U-shaped recessions predict a rise in the EPOP ratio, primarily driven by the swift recovery of the unemployment rate. The significant positive association between U-shaped recessions and the four-quarter-ahead EPOP ratio — contrasted with the significant negative association for L-shaped recessions — provides further evidence that our methodology effectively distinguishes between two distinct recession experiences.

We further examine the differential responses of the EPOP ratio and LFPR by gender. Since the labor data by gender are available only at an annual frequency, we analyze one-year changes in these measures to align with the forecasting horizons used for the aggregate data. Overall, the aggregate patterns hold for both genders, though the magnitudes differ. Specifically, L-shaped recessions have more negative effects on men's LFPR than on women's, suggesting that

[21]The result remains robust for $h = 8$.

Table 3: PREDICTABILITY OF MACROECONOMIC VARIABLES

	(1) Productivity Growth (1 year)	(2) Output Growth (1 year)	(3) Total Price Inflation $(\pi_{it} - \pi_{i,t-4})$	(4) Tradables Inflation $(\pi^t_{it} - \pi^t_{i,t-4})$	(5) Nontradables Inflation $(\pi^{nt}_{it} - \pi^{nt}_{i,t-4})$
$p^l_{i,t-4}$	0.017***	-0.046***	-0.896***	-0.416	-1.123***
	(0.002)	(0.003)	(0.320)	(0.412)	(0.387)
$p^u_{i,t-4}$	0.037***	0.112***	0.296	1.123	-0.405
	(0.006)	(0.008)	(1.246)	(1.608)	(1.510)
State FE	✓	✓	✓	✓	✓
No. of Obs.	11,220	11,220	4,479	4,479	4,479
R^2	0.022	0.057	0.006	0.002	0.010

Notes to table: This table presents the coefficient estimates from Equation (5.3.1). The notations ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Numbers in parentheses are standard errors. **Source**: Authors' calculations.

shocks that trigger L-shaped recessions have persistent negative effects on men's labor force participation. Meanwhile, U-shaped recessions lead to stronger positive effects on the EPOP ratio for men than for women, suggesting that the rebound of employment is more concentrated among men. Overall, men's employment and labor force participation are more cyclically sensitive and more heavily affected by the nature of the recovery in the labor market. This result further suggests that the disappearance of U-shaped recessions and the increased prevalence of L-shaped recessions since the 1990s are likely to be associated with the stagnation of male employment (Cortes et al., 2018).

All told, the persistent negative effects of L-shaped recessions on the LFPR and the EPOP ratio are consistent with previous empirical findings on macroeconomic hysteresis discussed by Furlanetto et al. (2025) and Alves and Violante (2025). The results validate our empirical methodology's ability to distinguish effectively between U-shaped and L-shaped recessions and confirm that L-shaped recessions effectively capture the phenomenon of hysteresis.

Next, we examine the extent to which the two types of recessions predict labor productivity growth, output growth, and price inflation using Equation (5.3.2). Note that labor productivity and output growth are available at an annual frequency, while price inflation from Hazell et al. (2022) is measured quarterly.

Table 3 reports the coefficient estimates. Both types of recessions are associated with positive labor productivity growth, largely reflecting the recovery phase, though U-shaped recessions predict faster growth than L-shaped recessions (column 1). This result aligns with the observation that U-shaped recessions are typically driven by shocks that enhance labor productivity growth, with sustained improvements in productivity likely supporting a swift recovery.

It is notable that the two types of recessions have opposite effects on output growth: while an L-shaped recession reduces output growth one year ahead, a U-shaped recession raises it (column 2). This pattern is consistent with the two recessions' contrasting effects on the EPOP ratio.

Lastly, L-shaped recessions have a statistically significant negative effect on the four-quarter change in total price inflation ($\pi_{i,t} - \pi_{i,t-4}$, column (3)). Distinguishing total price inflation into the inflation of tradables ($\pi^{t}_{i,t} - \pi^{t}_{i,t-4}$, column (4)) and nontradables ($\pi^{nt}_{i,t} - \pi^{nt}_{i,t-4}$, column (5)), we find that the negative effects are primarily driven by nontradables inflation. This finding suggests that persistent demand weakness—reflected in subdued output growth and a lower EPOP ratio, indicative of hysteresis—exerts downward pressure on the prices of locally traded goods and services. In contrast, U-shaped recessions show no statistically significant association with inflation.

6 Sources of Hysteresis

This section examines the determinants of hysteresis. Section 6.1 outlines the econometric methodology for this analysis; Section 6.2 presents and discusses the estimation results.

6.1 Linear Competing Risks Model

In this section, we assess the extent to which observable state-level factors influence the likelihood of L-shaped versus U-shaped recessions. When the dependent variable is an unobserved probability across three or more categorical outcomes, a competing risks framework — typically implemented as a multinomial logit model — is used. In such models, outcome probabilities are inferred from observed counts of outcomes. In our case, however, the probabilities of the three business cycle phases are directly observed. Accordingly, we estimate a linear competing risks model using OLS, with the dependent variable defined as the difference in probabilities of the two types of recessions.[22]

[22] While the multinomial logit model can be numerically challenging to estimate—particularly when the model includes a large number of parameters—the linear competing risks model avoids such difficulties. For example, individual fixed effects can be easily incorporated into the linear model using standard panel regression techniques. Such a standard econometric treatment is often infeasible in a multinomial logit framework, as the numerical

Consider the following model for the relative risk of a U-shaped recession compared to an L-shaped recession:

$$\left(p^l_{it} - p^u_{it}\right) = \beta_e p^e_{it} + \beta_z Z^r_{it} + \beta_g Gap_{it} + \mathbf{\Gamma}_x X_{it} + \alpha_i + D_t + \epsilon_{it}. \tag{6.1}$$

In this above equation, we include p^e_{it}—the estimated probability of being in an expansion—to control for the business cycle phases, as the dependent variable is close to zero during an expansion as well as when the recession probabilities are similar during an economic downturn.[23] The coefficient of p^e_{it} is β_e. The vector X_{it} contains control variables capturing state-specific attributes, and β_x denotes the corresponding vector of coefficients. Additional control variables are listed in the panel labeled "Controls" in Table 4, with details on each measure provided in Section 3.2. The term α_i represents the state fixed effect, D_t the time fixed effect, and ϵ_{it} the residual.[24]

Our main focus is on downward nominal wage rigidity and the gender gap in the labor market. Let Z_{it} denote an indicator of nominal wage rigidity, which equals one if the change in the share of zero nominal wage inflation at time t exceeds the cross-state average, and zero otherwise. We focus on the change in the share because an increase at zero indicates heightened nominal wage rigidity. Since downward nominal wage rigidity is primarily relevant during economic downturns, we interact Z_{it} with the recession probability $(1-p^e_{it})$ to construct Z^r_{it}, an indicator of greater downward nominal wage rigidity.[25]

Let Gap_{it} denote the gap between the male and female EPOP (employment-to-population) ratios in state i at time t. As a baseline, we do not account for any nonlinearities arising from business cycle phases and use the level of this gap measure. In robustness checks, we construct an indicator of the gender gap in the labor market—similar to the indicator of downward nominal wage rigidity — which equals one ($s_{it} = 1$) if a state's gender employment gap at time t is above

optimization algorithm often fails to converge with a high-dimensional parameter space. In this regard, the linear competing risks model allows for the comprehensive incorporation of state-level covariates within a coherent statistical framework, facilitating the investigation of the drivers of hysteresis without posing computational challenges.

[23] One might consider constructing a variable by dividing the dependent variable by p^e_{it}. However, this measure is not defined when p^e_{it} is zero or near zero. To get around this issue and account for business-cycle effects, we instead include p^e_{it} as a regressor in the model.

[24] For robustness checks, we also consider a model without the state-level controls. The conclusions remain robust.

[25] We do not include the indicator of nominal wage rigidity during economic expansions, as an increased share of zero wage changes in expansions may also reflect upward nominal wage rigidity, which may prevent gains in labor productivity from translating into higher nominal wages.

the cross-state average, and zero ($s_{it} = 0$) otherwise. As with the wage rigidity measure, we interact this indicator with $(1 - p^e_{it})$ to construct E^r_{it}, which captures potential nonlinearities over business cycle phases in the relationship between the gender gap and the relative probability of a U-shaped versus an L-shaped recession.

The sample period spans 1978:Q1 – 2019:Q4, based on the availability of large-firm share data beginning in 1978:Q1. We exclude the pandemic period from the analysis, as the correlations between the regressors and recession probabilities during that time can substantially differ from pre-pandemic patterns.

6.2 Estimation Results

Table 4 presents the estimation results. First, the model effectively captures the relative probability of an L-shaped recession compared to an U-shaped recession, with an R^2 around 0.8. Second, a larger gender EPOP gap is associated with a higher likelihood of a L-shaped recession relative to an U-shaped one: As shown in columns [1] and [2], the coefficient is positive and statistically significant over the full sample period 1978:Q1 – 2019:Q4 as well as in the sub-sample 2000:Q1 – 2019:Q4 when the rate of gender convergence slowed. Using an indicator of the gender gap during a recession, the estimation results are consistent with those in columns [3] and [4]. This result suggests that a larger gender employment gap raises the likelihood of hysteresis and hinders speedy recession recoveries.

Third, greater downward nominal wage rigidity (Z^r_{it}) raises the relative probability of a L-shaped recession compared to a U-shaped one with statistical significance. This result is robust for the entire sample period and also the post-2000 period. This result confirms the assumption of previous research where downward nominal wage rigidity is an important channel through which hysteresis is generated.

Taken together, the state-level evidence suggests that downward nominal wage rigidity and the gender employment gap are significant contributors to hysteresis.[26]

[26] As a robustness check, we re-estimate the model excluding all controls except for state and time fixed effects, using the same sample period. Overall, the results remain consistent, with the exception of the gender gap coefficient (Gap_{it}), which becomes statistically insignificant for the 1978–2019 period (model (1)). However, this coefficient regains statistical significance when we include the employment shares of the manufacturing and professional services industries, suggesting that gender differences are correlated with the industry composition of employment.

Table 4: EFFECTS OF STATES' ATTRIBUTES ON THE RELATIVE RISKS OF RECESSIONS

	(1) All	(2) 2000-2019	(3) All	(4) 2000-2019
Indicator of DNWR	0.062***	0.052***	0.050***	0.039***
(Z^r_{it})	(0.009)	(0.009)	(0.009)	(0.009)
Gender gap	0.082**	0.178***		
(Gap_{it})	(0.037)	(0.043)		
Indicator of recession gender gap			0.116***	0.081***
(E^r_{it})			(0.010)	(0.015)
(Controls)				
p^e_{it}	✓	✓	✓	✓
oil-producing	✓	✓	✓	✓
minimum wage	✓	✓	✓	✓
union	✓	✓	✓	✓
manufacturing	✓	✓	✓	✓
prof. services	✓	✓	✓	✓
finance	✓	✓	✓	✓
large-firm share	✓	✓	✓	✓
tax-income share	✓	✓	✓	✓
State fixed effect	✓	✓	✓	✓
Time fixed effect	✓	✓	✓	✓
No. of Obs.	8,256	3,856	8,256	3,856
R^2	0.796	0.867	0.799	0.868

Notes to table: This table presents the coefficient estimates from Equation (6.1) with the zero recession probabilities replaced with the minimum of the corresponding estimates and with the share of wage cuts. The notations ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Numbers in parentheses are standard errors. Panels labeled "(Controls)" indicate the inclusion of control variables in the regression model.
Source: Authors' calculation.

7 Effectiveness of Monetary and Fiscal Policy in Mitigating Hysteresis

This section evaluates the extent to which downward nominal wage rigidity and gender disparities in the labor market influence the effectiveness of monetary and fiscal policies in mitigating hysteresis. Specifically, we estimate the state-dependent effects of monetary and tax shocks on the relative probability of L-shaped versus U-shaped recessions, where states differ by their degree of downward nominal wage rigidity and their gender employment gap.

7.1 Model

We examine effects of monetary and tax shocks on the relative likelihood of an L-shaped versus a U-shaped recession, depending on the degree of downward nominal wage rigidity and the gender employment gap in the labor market. To do so, we estimate the following nonlinear local projection:

$$\begin{aligned} y_{i,t+h} - y_{i,t-1} &= \alpha_i^h + \beta_1^h (1 - s_{i,t-1}) z_t + \beta_2^h s_{i,t-1} z_t \\ &+ (\boldsymbol{\gamma}_1^h)' (1 - s_{i,t-1}) \boldsymbol{x}_{it} + (\boldsymbol{\gamma}_2^h)' s_{i,t-1} \boldsymbol{x}_{it} + \epsilon_{i,t+h} \qquad \text{for} \quad h = 1, 2, 3, \cdots H. \end{aligned} \tag{7.1}$$

where $y_{i,t+h} = (p^l_{it} - p^u_{it})$ and hence $(y_{i,t+h} - y_{i,t-1})$ captures the cumulative changes between $t-1$ and $t+h$ in the relative probability of an L-shaped recession over a U-shaped recession. The notation α_i^h captures the state fixed effect at horizon h, $s_{i,t-1}$ captures the probability that state i is in regime 1 at time $t-1$, and $(1 - s_{i,t-1})$ corresponds to the probability of being in regime 2, which we will define below. The externally identified policy shock is denoted by z_t. For monetary policy shocks, we use the estimates from Romer and Romer (2004), as extended by Wieland and Yang (2020). For tax shocks, we use the estimates from Romer and Romer (2007). Since we are interested in the effects of expansionary policy shocks, we retain only negative monetary and tax shocks.[27] The coefficients β_1^h and β_2^h capture the effects of unexpected policy changes on the dependent variable at $t+h$ in regimes 1 and 2, respectively. Negative values of β_1^h and β_2^h indicate that demand policy helps to mitigate hysteresis, while positive values indicate that it does not. We set $H = 12$ quarters.

We construct the regime indicator for downward nominal wage rigidity in a manner analogous to the indicator used in equation (6.1). Specifically, we define an indicator that equals one if the change in the share of zero nominal wage inflation in state i at time t exceeds the cross-state average, and zero otherwise. Since downward nominal wage rigidity is more relevant during economic downturns, we interact this indicator with a recession indicator. Given that the state-level share of zero nominal wage changes is available only at an annual frequency, we construct the recession indicator using the four-quarter moving average of the probability of economic expansion. This recession indicator equals one if the average falls below a certain threshold —defined as 1 minus the threshold expansion probability — and zero otherwise. We

[27] For robustness checks, we consider the original shock estimates along with the contractionary component of shock estimates as detailed in **??**.

set the threshold expansion probability to 0.85 for the tax shock experiment and 0.80 for the monetary policy experiment, to capture significant economic downturns comparable to national recessions.[28] The regime indicator for downward nominal wage rigidity equals one, $s_{it} = 1$, if the state experiences above-average downward nominal wage rigidity during an economic recession, and zero, $s_{it} = 0$, otherwise.

The regime indicator for the gender employment gap is constructed in an analogous manner. Specifically, if state i's difference between the male and female EPOP ratios (a measure of the gender EPOP gap) is higher than the cross-state average, then $s_{it} = 1$; otherwise, $s_{it} = 0$.[29] For notational simplicity, we use the same regime indicator notation for both downward nominal wage rigidity and the gender employment gap. To avoid contemporaneous endogeneity between the regime and external policy shocks, we use the one-year lagged indicator $s_{i,t-4}$ (with "$t-4$" denoting a four-quarter lag), given that state-level data on nominal wage rigidity and the gender gap are available only annually.

For the vector of controls $\boldsymbol{x}_{it}$, we include eight quarterly lags of variables capturing state-level characteristics. Specifically, these controls comprise the employment shares in manufacturing, finance, and professional and business services; the tax-to-income ratio; the employment share of unionized workers; and an oil production indicator variable that equals one if the state produces oil and zero otherwise. In addition, we include state i's probability of being in an expansion at time t to account for the scaling effect of the current business-cycle phase on the relative likelihood of recessions, in line with our treatment in equation (6.1).[30] As our primary interest lies in the effects of monetary policy shocks on the relative likelihood of an L-shaped versus a U-shaped recession outside of expansions, we control for each state's concurrent probability of expansion.[31]

Note that we also interact $\boldsymbol{x}_{it}$—the vector of state-level controls at t— with the lagged regime indicators $s_{i,t-1}$ and $(1 - s_{i,t-1})$ to comprehensively and flexibly account for the underlying

[28]Although these thresholds yield the largest differences between the two regimes, setting the threshold to 0.85 does not significantly alter the main results. This approach, rather than using the raw recession probability, facilitates a more straightforward interpretation of the policy experiments.

[29]The state-level EPOP ratio by gender is available from 1976.

[30]To illustrate this point, the difference between the probabilities of L-shaped and U-shaped recessions can be close to zero during both economic expansions and economic downturns.

[31]We further consider the magnitude of shocks measured with the negative changes in the EPOP ratio to control for effects of large shocks in determining the interaction between policy effectiveness and downward nominal wage rigidity (as considered by Jo and Zubairy, 2025), for robustness analyses. We consider both the contemporaneous value alone and the combination of contemporaneous and lagged values of these shock measures. The estimated impulse responses remain robust to these specifications.

dynamics of each state's economy, in line with Auerbach and Gorodnichenko (2012). The coefficients $\boldsymbol{\gamma}_1^h$ and $\boldsymbol{\gamma}_2^h$, along with the controls $\boldsymbol{x}_{it}$, are $(mn+1)\times 1$ vectors, where n is the number of controls and m is the number of lags. In our model, $m = 8$ and $n = 7$.

The sample period for the experiment using downward nominal wage rigidity spans from 1980:Q1 to 2007:Q4. The start date reflects the availability of state-level large-firm share data beginning in 1978:Q1, combined with the use of eight lags of the control variables. The end date corresponds to the availability of monetary policy shocks from Wieland and Yang (2020), which extends through 2007. For consistency and comparability, we use the same sample period in the analysis of tax shocks.

7.2 Estimation Results

This section discusses the estimation results. Section 7.2.1 presents the impulse responses to monetary policy shocks, while Section 7.2.2 presents those to tax shocks.

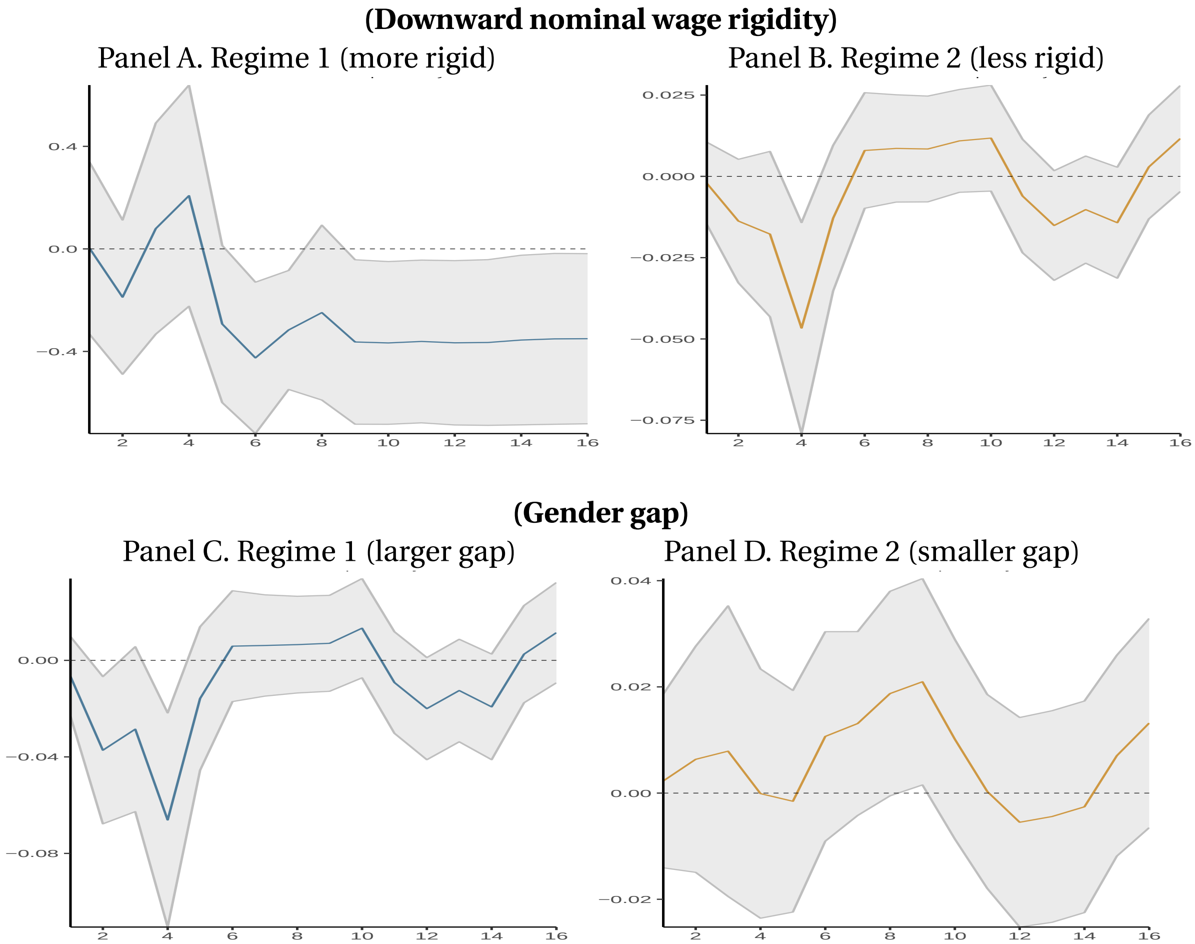
7.2.1 Monetary Policy

Figure 6 shows the response of the relative probability of an L-shaped recession compared to a U-shaped recession following a one-unit expansionary monetary policy shock. Negative values indicate that such a policy significantly reduces the likelihood of an L-shaped recession relative to a U-shaped one, thereby mitigating hysteresis, while positive values suggest the opposite. Panel A presents estimates under greater downward nominal wage rigidity, and Panel B under lower rigidity. In the regime of greater downward nominal wage rigidity, expansionary monetary policy significantly reduces the relative probability of an L-shaped recession about four quarters after the shock, with persistent effects.[32] In contrast, these hysteresis-mitigating effects are weaker and shorter-lived under weaker downward nominal wage rigidity, with a statistically significant impact only in the fourth quarter following the shock. This result confirms the long-run effectiveness of monetary policy in mitigating hysteresis and highlights that these effects are stronger when nominal wages are more downwardly rigid.

Finally, we examine the interaction between the gender employment gap and the hysteresis-mitigating effect of monetary policy. We find that expansionary monetary policy is more effective

[32] Using an alternative expansion probability threshold of 0.85 yields slightly weaker statistical significance for the hysteresis-reducing effects, but the main result remains robust.

Figure 6: EFFECTS OF MONETARY POLICY ON THE RELATIVE LIKELIHOOD OF U-SHAPED RECESSION

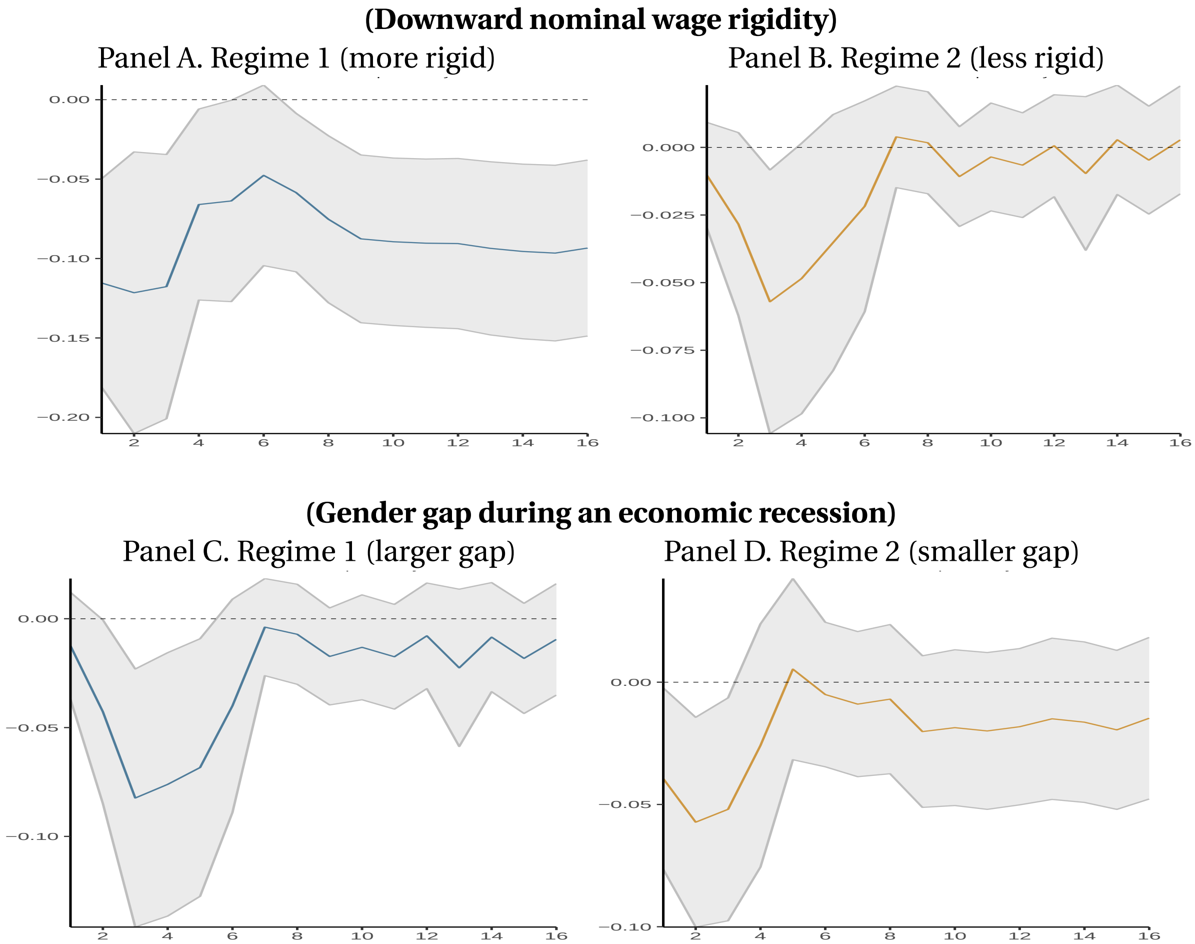


Notes to figure: This figure displays the estimated responses of relative risk of an L-shaped recession over a U-shaped recession to a one-unit increase in monetary policy shock. The state dependence is determined by the above/below average share of zero nominal wage changes in Panels A and B; the above/below average rate of gender convergence in Panels C and D. Monetary policy shock estimates are from Romer and Romer (2004) extended by Wieland and Yang (2020). The shaded area captures 95 percent confidence intervals based on Newey-West standard errors.

Source: Authors' calculation

in regimes with a larger gender employment gap (Panel C). This result reflects that men are more likely to have jobs in capital-intensive industries; hence, expansionary monetary policy increases capital spending, creating more jobs for men. Additionally, as shown in the previous section, men's employment is more cyclically sensitive than women's and more susceptible to hysteresis. In this sense, the hysteresis-mitigating effects of monetary policy are particularly strong for male employment and thus more pronounced in states with a larger gender employment gap.

Figure 7: EFFECTS OF TAX SHOCK ON THE RELATIVE LIKELIHOOD OF U-SHAPED RECESSION



Notes to figure: This figure displays the estimated responses of relative risk of an L-shaped recession over a U-shaped recession to a one-unit increase in tax shock. The state dependence is determined by the above/below average share of zero nominal wage changes in Panels A and B; the above/below average rate of gender convergence in Panels C and D. Tax shock estimates are from Romer and Romer (2007). The shaded area captures 95 percent confidence intervals based on Newey-West standard errors.

Source: Authors' calculation

7.2.2 Tax shocks

Next, we examine the effects of expansionary tax shocks in mitigating hysteresis (Figure 7). Tax cuts exhibit sizable hysteresis-reducing effects, as indicated by their statistically significant and negative pass-through to the relative probability of an L-shaped recession. Specifically, they lower the likelihood of an L-shaped recession relative to a U-shaped one when nominal wages are more downwardly rigid during a recession (Panel A). In contrast, the effect is smaller and shorter-lived under weaker downward nominal wage rigidity (Panel B). These findings suggest that tax cuts are more effective at mitigating hysteresis in environments with greater downward

Table 5: HYSTERESIS MITIGATING EFFECTS OF DEMAND POLICIES

	Monetary policy (expansionary)	Tax policy (tax cuts)
⇑ Downward nominal wage rigidity	+	+
⇑ Recession gender employment gap	+	0

Note to table: This summary presents the effects of the factors in the first column on the effectiveness of demand-side policies in mitigating hysteresis. The symbols '+' and '0' indicate effective mitigation and no effect, respectively.

nominal wage rigidity.

The bottom panels report how the gender employment gap interacts with the effectiveness of tax cuts in mitigating hysteresis. Unlike monetary policy shocks, the gender employment gap does not produce discernible differences in the transmission of tax cuts.

Table 5 summarizes the estimation results. Notably, both expansionary monetary policy and tax shocks are more effective at alleviating hysteresis in regimes with greater downward nominal wage rigidity. This finding is consistent with the conventional view that the real effects of monetary policy arise from nominal rigidity. In addition, tax cuts help reduce production costs when labor costs cannot adjust flexibly due to downward nominal wage rigidity or maintain aggregate demand, thereby sustaining labor demand and mitigating hysteresis.[33]

Gender employment gaps interact differently with the two policies. Monetary policy is more effective in the presence of a larger gender gap, likely because male employment is more capital-complementary and comoves more closely with capital investment. In contrast, the gender employment gap does not lead to noticeable differences in the transmission of tax shocks.

8 Conclusion

This paper empirically investigates the factors contributing to macroeconomic hysteresis. We define hysteresis as a phenomenon in which the level of economic activity fails to return to its pre-recession trajectory. To measure the likelihood of hysteresis, we estimate a Bayesian Markov-switching model that distinguishes between two types of recessions—U-shaped and L-shaped—as well as periods of expansion. In this framework, L-shaped recessions represent

[33]This result aligns with Lee (2025), who finds that macroeconomic variables respond nearly twice as strongly and more persistently in states with higher wage rigidity compared to those with more flexible wages. Our analysis differs from Lee's in that we focus specifically on the response of hysteresis, whereas Lee examines the effects on general macroeconomic variables generally following a marginal tax shock.

episodes of macroeconomic hysteresis, characterized by prolonged weakness in economic activity, while U-shaped recessions indicate swift recoveries without lasting damage. The model is estimated using state-level private payroll employment data, allowing us to classify regional business cycles accordingly. Our findings reveal substantial variation in the timing and severity of recessions and recoveries across U.S. states, driven by differences in sensitivity to aggregate shocks and by state-specific factors that generate localized, asynchronous business cycles.

Leveraging rich heterogeneity in state-level recession experiences, we examine the factors that contribute to or mitigate hysteresis, with particular emphasis on downward nominal wage rigidity and the gender employment gap. This analysis controls for a comprehensive range of state-level characteristics. We find that greater downward nominal wage rigidity and a larger gender employment gap both increase the likelihood of hysteresis.

Finally, we assess the extent to which demand-side policies interact with these two hysteresis-related factors. We find that expansionary monetary policy and tax shocks are more effective at mitigating hysteresis in environments with greater downward nominal wage rigidity. Gender employment gaps, however, affect the transmission of the two policies differently. Monetary policy is more effective when the gender gap is larger, likely because male employment is more capital-complementary and tends to comove with capital investment. In contrast, the gender gap does not significantly affect the transmission of expansionary tax shocks.

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Appendix A Data

A.1 Data sources

Data were amalgamated from a variety of sources including HAVER, FRED, BLS, and Census. For several variables, data were collected from one source for the earlier part of the sample (1960s, 70s, 80s) and from another for more recent years.

1. State-level private payroll employment (1960:M1 - 2023:M12): retrieved from HAVER. See Figures A1 and A2.

2. Employment share of manufacturing, finance, and professional services (1969-2023, yearly): Haver (BEAEMPL) 1969-2001; BLS State employment and unemployment (retrieved from FRED, ALFRED) 2002-2023. Employment shares for the three industries are available in FRED starting in 1990. However, to ensure consistency in industrial classification, we use data from HAVER through 2001 and switch to FRED/ALFRED data from 2002 onward. The employment share for the finance industry is unavailable in ALFRED for New Mexico and South Dakota, so we exclude these two states from the finance series starting in 2002.

3. Unemployment rate and labor force participation rate by gender and by state : BLS. The employment-to-population ratio is calculated based on the unemployment rate and the labor force participation rate. (https://www.bls.gov/lau/ex14tables.htm; https://www.bls.gov/opub/geographic-profile/.)

4. Employment share by firm size (1978-2021, yearly): Census Bureau's Business Dynamics Statistics (BDS)

5. Total tax and total income (yearly, 1960-2022), Annual Survey of State Govt Tax Collections (Census) and Personal Income By State (BEA) data, respectively.

Beyond publicly available data provided by the statistical agencies, some series are sourced from websites maintained by individual researchers or non-profit institutions.

1. Oil production by state (1960-2022 yearly): EIA and Hamilton (2011)[34]

2. Union membership (1964-2021, yearly): Barry Hirsch (http://www.unionstats.com/)

3. Fraction of wage cuts, no wage changes, and wage increases: Yoon Joo Jo (https://sites.google.com/view/yoonjoojo/rsearch).

4. Minimum wage data (by state, and of the federal level): Vaghul and Zipperer (2016)(https://equitablegrowth.org/working-papers/historical-state-and-sub-state-minimum-wage-da

5. Monetary policy shocks of Romer and Romer (2004) extended by Wieland and Yang (2020) (https://www.openicpsr.org/openicpsr/project/135741/version/V1/view?path=/openicpsr/135741/fcr:versions/V1/Monetary_shocks.zip&type=file)

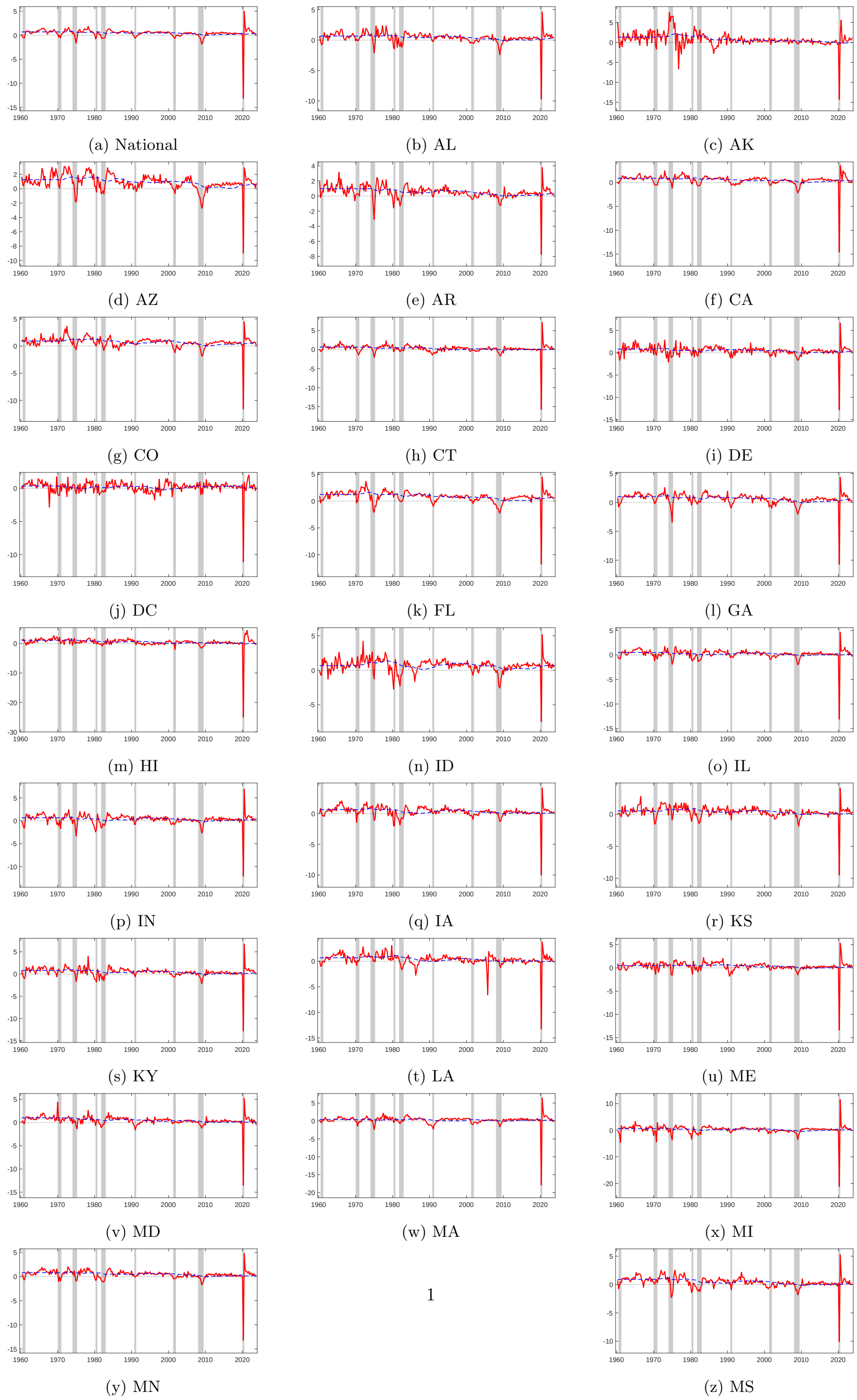
6. Military spending news shock of Ramey and Zubairy (2018) (https://www.openicpsr.org/openicpsr/project/135741/version/V1/view)

A.2 Industry Variables

To measure the share of workers in each state by industry, we used the Standard Industrial Classification (SIC) system from 1969-1989 and the North American Industry Classification System from 1990-2023. The wage and salary state SIC data are stored in HAVER under the BEAEMPL database. As the data are state level, each state has its own mnemonics; this is denoted by '##' which stands in for each two-letter abbreviation for states. Manufacturing and finance services data were mined from HAVER under mnemonics ##SM@BEAEMPL and ##SFI@BEAEMPL. For professional and business services, we added ##SSB@BEAEMPL and ##SSL@BEAEMPL - business services and legal services - as the best possible proxy to match NAICS professional and business services used in the later part of the sample. To obtain ratios of these industries in each state, the number of employees per industry was divided by the total nonfarm employee base of each state, as captured by the SIC with ##SNF@BEAEMPL.

[34] We thank professor James Hamilton for sharing the dataset used in Hamilton (2011).

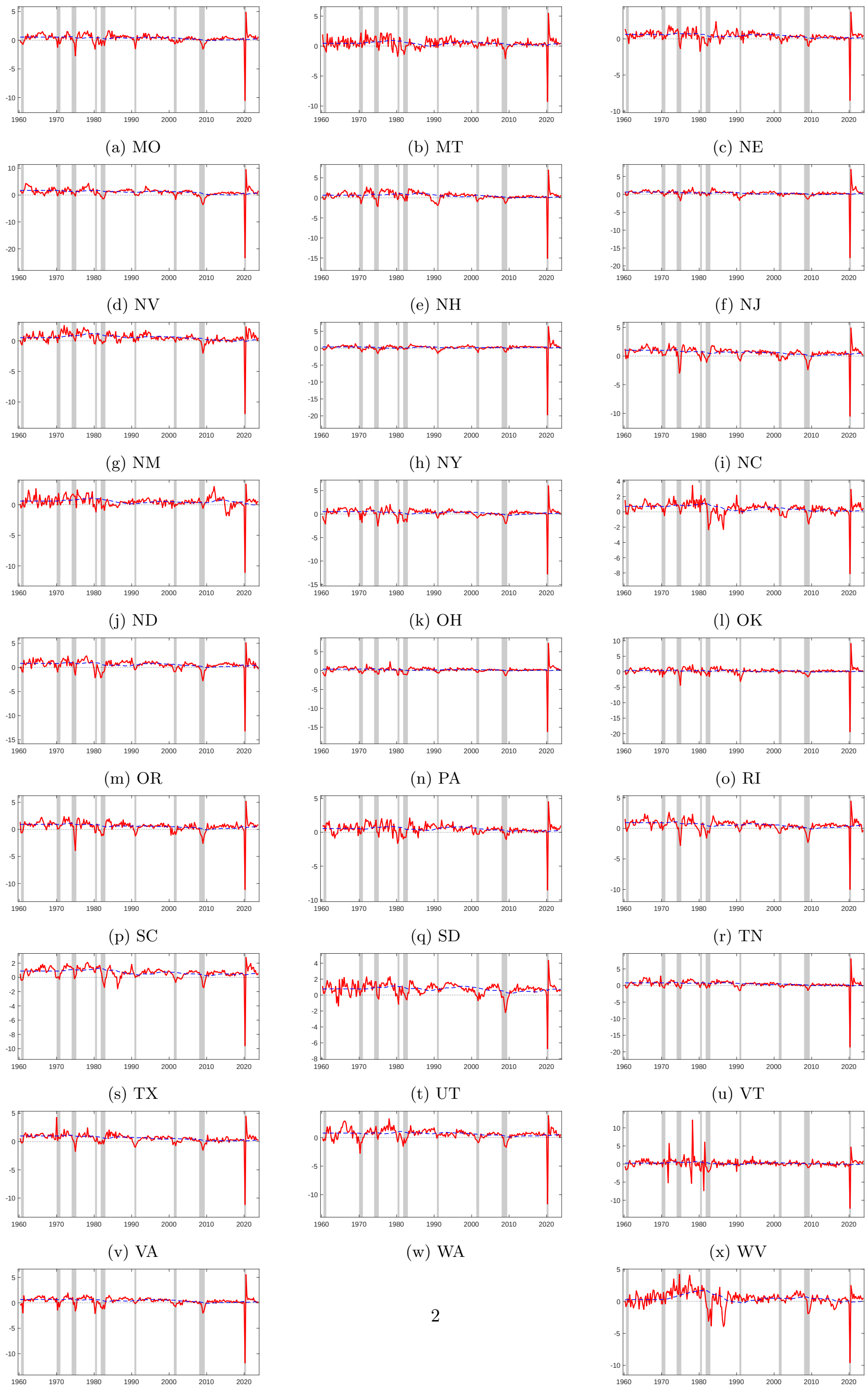
Figure A1: EMPLOYMENT GROWTH BY STATE (1)



Notes to figure: The figures show employment growth by state, with the blue dashed line representing the 40-quarter moving average of employment growth for each state. The shaded areas denote the NBER recessions.

Sources: BLS and authors' calculation

Figure A2: EMPLOYMENT GROWTH BY STATE (2)



(a) MO (b) MT (c) NE (d) NV (e) NH (f) NJ (g) NM (h) NY (i) NC (j) ND (k) OH (l) OK (m) OR (n) PA (o) RI (p) SC (q) SD (r) TN (s) TX (t) UT (u) VT (v) VA (w) WA (x) WV (y) WI (z) WY

2

Notes to figure: The figures show employment growth by state, with the blue dashed line representing the 40-quarter moving average of employment growth for each state. The shaded areas denote the NBER recessions.

Sources: BLS and authors' calculation

For 1990-2023, data were collected from the BLS State Employment and Unemployment reports in FRED. The FRED mnemonics used for manufacturing, finance and insurance, and professional and business services were ##MFG, SMU##000005552000001A, and ##PBSVN, respectively. Note that for finance and insurance, the state FIPS code is used instead of the two-letter abbreviation. Additionally, data for New Mexico and South Dakota are missing in that series.

The data were then converted into a ratio for each state by dividing by the employees in each industry by the total nonfarm employees in each state, a metric that was also collected from BLS State Employment and Unemployment records through FRED using ##NAN.

Table B1: POSTERIOR ESTIMATES FOR THE REGIME-SWITCHING MODEL AT THE NATIONAL LEVEL

Parameter	Posterior Mean	90% Credible Interval
p_{00}	0.93	[0.85, 0.95]
p_{01}	0.04	[0.00, 0.06]
p_{02}	0.03	[0.00, 0.04]
p_{11}	0.73	[0.28, 0.86]
p_{22}	0.77	[0.24, 0.92]
μ_0	0.05	[–0.17, 0.12]
μ_1	–1.30	[–4.34, –1.06]
μ_2	–1.56	[–5.27, –1.18]
σ^2	0.18	[0.11, 0.23]
c_0	7.22	[4.27, 8.50]
ρ	0.61	[0.37, 0.72]
Acceptance Rate	0.35	

Note to table: The posterior estimates are based on the regime-switching model in (4.1) for employment growth at the national level. **Source**: Authors' calculation.

Appendix B Additional Results

B.1 National Level

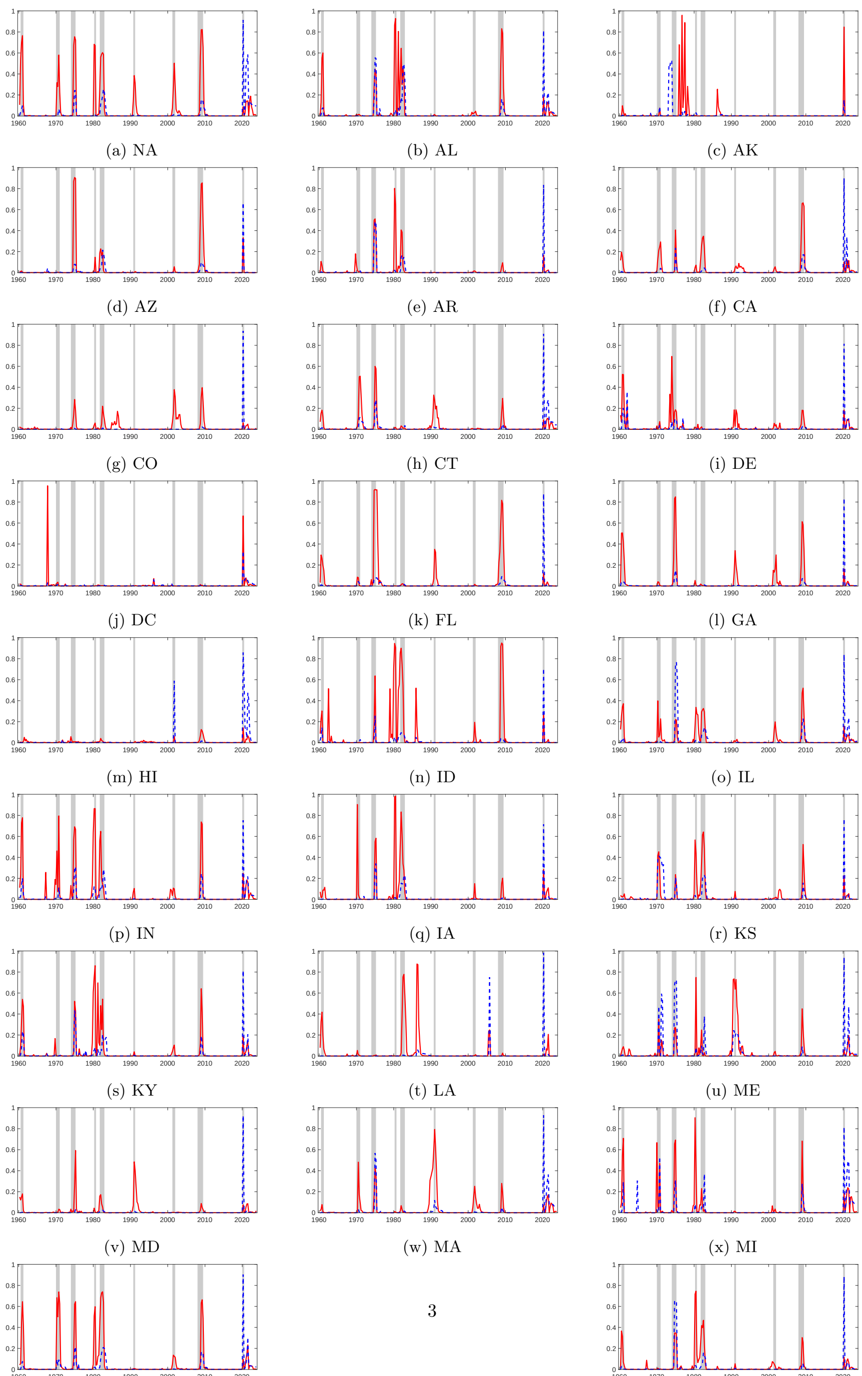
While our primary focus is not on the specific recovery shapes at the national level, we present the estimation results to shed light on the cyclical characteristics of employment growth. Table B1 provides the posterior estimates for the regime-switching model at the national level. The transition probabilities from an expansion regime to L-shaped and U-shaped recession regimes, p_{01} and p_{02}, are 0.04 and 0.03, respectively. This indicates that L-shaped and U-shaped recessions are almost equally likely to occur in employment growth at the national level. The posterior means for the recession shocks, μ_1 and μ_2, are estimated at -1.30 and -1.56 for the L-shaped and U-shaped regimes, respectively, suggesting that the magnitude of the recession shocks is quite similar. The COVID-19 scaling parameter, c_0, is 7.22, indicating that COVID-19 had approximately seven times the recessionary impact on U.S. employment compared to conventional recessions.

The decay parameter, ρ, is estimated at 0.61, suggesting that the unusually large impact of COVID-19 diminished rapidly. The acceptance rate of the Metropolis-Hastings sampling is approximately 0.35, which falls within our target range of 0.2 to 0.4.

B.2 State Level

Figures B3 – B4 report the state-level estimates of recession probabilities.

Figure B3: STATE-LEVEL RESULT (1)



(a) NA (b) AL (c) AK

(d) AZ (e) AR (f) CA

(g) CO (h) CT (i) DE

(j) DC (k) FL (l) GA

(m) HI (n) ID (o) IL

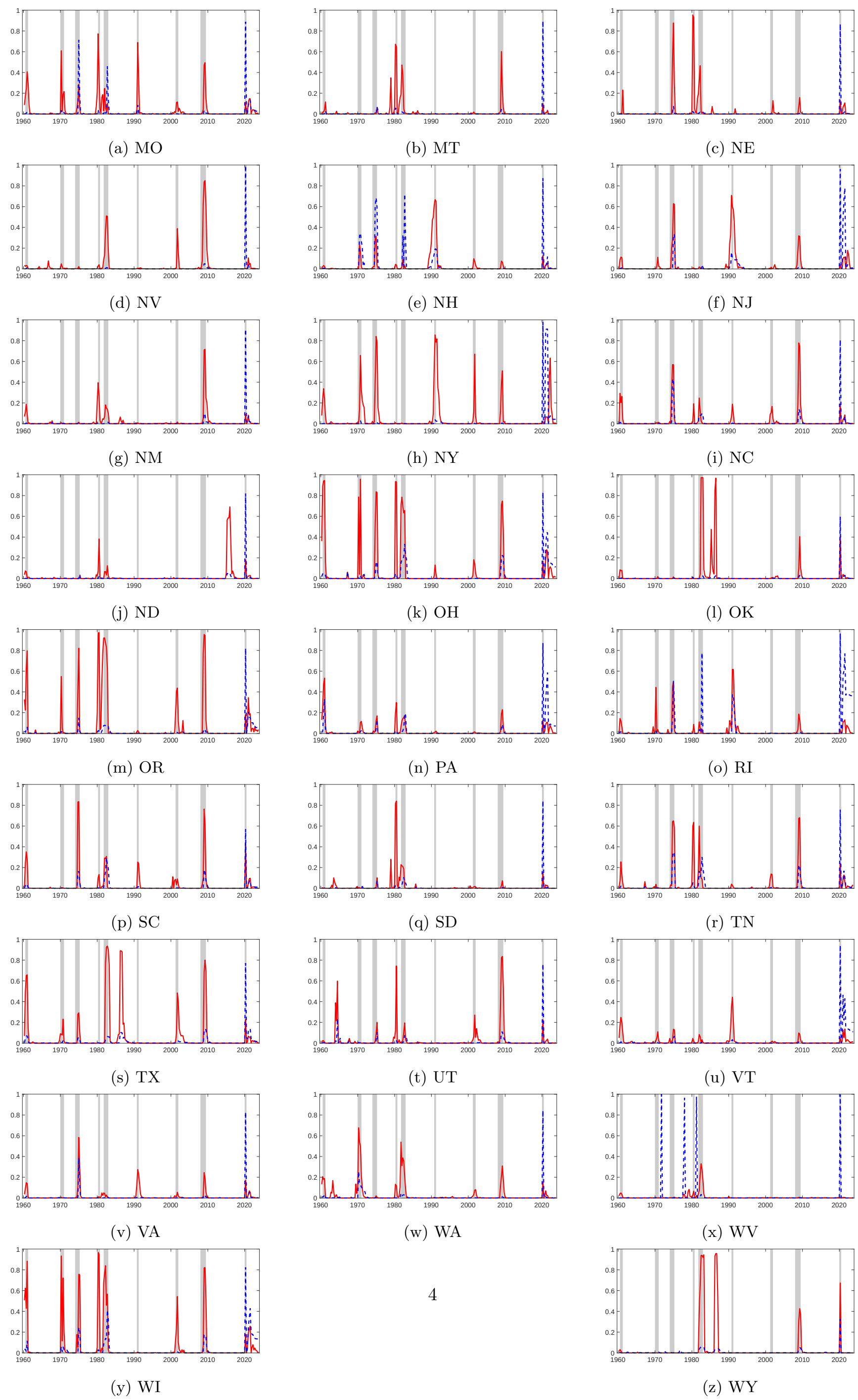
(p) IN (q) IA (r) KS

(s) KY (t) LA (u) ME

(v) MD (w) MA (x) MI

(y) MN 3 (z) MS

Figure B4: STATE-LEVEL RESULT (2)



Notes to figure: The figures display the estimated probabilities of L-shaped and U-shaped recessions. The blue lines represent the probability of a U-shaped recession, while the red lines represent the probability of an L-shaped recession. The Y-axis indicates the probability, and the X-axis represents calendar time in quarter. The shaded areas denote the NBER recessions.

Source: Authors' calculation