ISSN 1936-5330

kcFED Research Working Papers

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Johannes Matschke and Jun Nie

September 2022; updated April 2023
RWP 22-10
http://doi.org/10.18651/RWP2022-10

Federal Reserve Bank of Kansas City

# Downward Wage Rigidities and Recession Dynamics in Advanced and Emerging Economies*

Johannes Matschke†
Federal Reserve Bank of Kansas City

Jun Nie‡
Federal Reserve Bank of Kansas City

April 24, 2023

***Abstract***

Downward wage rigidity limits the downward adjustment of wages, especially during recessions. Although macroeconomic models generally suggest that wage rigidity exacerbates employment losses and generates asymmetric business cycles, direct empirical evidence for this effect is scarce. In this paper, we construct a data set covering 53 countries, including both emerging markets and advanced economies, to measure and compare downward wage rigidities across countries. We find that wage rigidities are widespread, but higher in emerging markets overall. In addition, we provide empirical evidence that countries with higher downward wage rigidities are subject to more sizable contractions in employment and real GDP per capita during recessions. We also explore possible determinants of downward wage rigidity and show that our measure is tied to minimum wage growth and de jure labor market rigidity.

**Keywords**: Downward Wage Rigidities; Recession Dynamics; Unemployment

**JEL: F41, E23, E24, E32, J31, J50**

*We thank Cooper Howes, Matthew Notowidigdo, Matthias Rottner, Benjamin Schoefer, and Martín Uribe for valuable feedback on the paper. We are also grateful for helpful comments by seminar participants at the Bundesbank, Federal Reserve Bank of Kansas City, University of Oklahoma, and the University of Nebraska, Omaha. The views expressed in this paper are those of the authors and do not necessarily represent those of the Federal Reserve Bank of Kansas City or the Federal Reserve System. Declarations of interest: none.

†Corresponding author, E-mail:Johannes.Matschke@kc.frb.org

‡E-mail:Jun.Nie@kc.frb.org

# 1. Introduction

The widespread theory of "sticky wages" emphasizes that wages are sluggish to respond to economic shocks. Particularly harmful and empirically more relevant are downward wage rigidities, in which employers are unable to cut wages to adverse shocks and instead primarily reduce employment. This effect has stirred a large literature documenting the presence of downward wage rigidities based on micro-level data (see, for example, Gottschalk, 2005; Dickens et al., 2007; Messina et al., 2010; Sigurdsson and Sigurdardottir, 2016; Elsby and Solon, 2019; Kaur, 2019; Grigsby et al., 2021; Jo, 2021). Several studies have also analyzed the macroeconomic consequences of downward wage rigidities using both quantitative and theoretical macroeconomic models (see, for example, Hall, 2005; Gertler and Trigari, 2009; Kim and Ruge-Murcia, 2009; Benigno and Ricci, 2011; Schmitt-Grohe and Uribe, 2016; Dupraz et al., 2019).

However, no research has yet produced prima facie empirical evidence on how downward wage rigidities impact business cycles, especially recession dynamics during which these constraints possibly bind. As recessions are relatively rare events, it is paramount to assemble a large dataset and construct consistent downward wage rigidity estimates across countries. Unfortunately, cross-country evidence on wage rigidities is limited, and due to various definitions, existing estimates are difficult to compare. In this paper, we aim to close these gaps in the literature while also highlighting forces that drive downward wage rigidities.

We make three contributions. First, we calculate downward wage rigidities based on widely available aggregate data for 53 countries, including both major advanced economies (AEs) and emerging markets (EMs). To do so, we use an intuitive algorithm that exploits wage growth rates when downward wage constraints are more likely to bind. Our findings suggest both AEs and EMs experience substantial downward wage rigidity. Furthermore, since we estimate wage rigidities in line with the structural literature, our estimates can guide the calibration of wage rigidities in quantitative models.

Second, we provide empirical evidence that downward wage rigidities have detrimental effects on output and employment during recessions. These effects are both statistically and economically significant: countries with sizable downward rigidities experience a 9 percentage points (pp) greater decline in the employment share during a recession than countries with few or no wage rigidities. Further, these countries also experience a 2.5 pp greater decline in real GDP per capita.

Third, we relate our wage rigidity measure to key labor market features. On one hand, we show that our measure extracts information from minimum wage changes as well as de jure labor laws which capture regulations that protect employment. We find a positive correlation between minimum wage gains and aggregate wage growth, which in turn drives changes in our wage rigidity measure. This finding corroborates micro-level evidence based on individual-country studies on the importance of minimum wages in driving wage rigidities (Castellanos et al., 2004; Ahn et al., 2022). In addition, we show that de jure labor laws have similar effects on employment and GDP during recessions as our wage rigidity measure, though the effects of de jure labor laws are much less significant. On the other hand, we find that our downward wage measure is not correlated with the presence of unions or collective bargaining agreements. Our wage rigidity measure exacerbates employment losses in recessions. In contrast, a higher union density tends to stabilize the labor market during a downturn, while the effect of collective bargaining agreements on employment is insignificant. This provides insights into the role of labor unions and wage setting processes in driving wage rigidities, which is an unsettled question in the literature (Dickens et al., 2007; Holden and Wulfsberg, 2009; Babecký et al., 2010).

In more detail, we define downward wage rigidities according to the recent structural literature as a one-sided constraint (see, for example, Schmitt-Grohe and Uribe, 2016): hourly real earnings in any year must be no less than a fraction of last year's real earnings. The magnitude of that fraction therefore captures the degree of downward wage rigidities, with a larger fraction referring to stronger rigidities. Just to be clear, our approach to measuring real wage growth does not imply that we take a stance as to whether underlying downward wage rigidities are *real* or *nominal* (reluctance to accept real (nominal) wage cuts). Either would ceteris paribus increase real wage growth. Instead we focus on real wages to normalize wage rigidities across countries with different inflationary environments.[1] The challenge with the aforementioned definition is that it is impossible to empirically determine whether this constraint binds or not. Our key identification assumption is that downward wage rigidities likely materialize during periods of rising unemployment ('unemployment cycles'), in which labor markets exert downward pressure on wages or at least moderate wage growth. In other words, wage growth during unemployment cycles is informative about downward rigidities – either the constraint binds and thus we can

[1] Advanced economies are generally thought to be subject to nominal wage rigidities (Tobin, 1972), even though this distinction is difficult to make when inflation is low. When inflation is higher, as in many emerging markets, wage indexation becomes more prominent, which may induce real wage rigidities (see, for example, Goette et al., 2007; Messina and Sanz-de Galdeano, 2014). In contrast, Kaur (2019) finds widespread evidence for downward nominal wage rigidities in India, a country will relatively high inflation.

directly estimate the extent of downward wage rigidities, or the constraint does not bind, in which case wage growth is likely lower or negative and we observe no/minor downward wage rigidities.

A cross-country comparison of downward wage rigidities based on this procedure reveals two findings. First, downward wage rigidities are on average higher in emerging markets, yet nonetheless substantial in advanced economies. This ranking prevails even after we account for labor productivity differentials. Second, downward wage rigidities show substantial heterogeneity across emerging markets, but less so among advanced economies.

Next, we empirically examine the macroeconomic implications of downward wage rigidities using Local Projections (Jordà, 2005). As downward wage rigidities are more likely to bind during downturns, we focus on recession dynamics. We first extract recession episodes from 53 countries over a 25 year period (1995-2020), which generates a sample of 107 recession cycles. Then, we examine whether countries with severe downward wage rigidities experience more pronounced contractions in employment and real GDP per capita during recessions. We find striking differences: the employment share of countries with high downward wage rigidities declines nearly 10 percentage points over three years, more than five times the employment decline in countries with low wage rigidities. We observe smaller, but nevertheless significant differences for real GDP per capita: countries with high wage rigidities have roughly 2.5 pp lower real GDP per capita after three years.

Our approach distinguishes us from the literature in two ways. First, we look for empirical evidence on the aggregate relevance of downward wage rigidities in the data and do not draw our conclusions based on calibrated structural models. Our results therefore serve as an empirical test for a broad class of models featuring downward wage rigidity constraints as in Schmitt-Grohe and Uribe (2016). In this regard, our empirical analysis delivers qualitatively similar impulse response functions as those from structural models and hence provide strong support for these models. Second, in contrast to previous applied work which mainly focuses on micro data and indirect evidence based on aggregated data, we provide direct evidence of downward wage rigidities driving aggregate dynamics. Related to the applied macro literature, Abbritti and Fahr (2013), for example, highlight sticky wages and sizable employment declines during recessions. Such patterns are consistent with downward wage rigidities, but they may also result from compositional biases since unskilled workers are usually the first to loose their jobs during downturns (Solon et al., 1994; Abraham and Haltiwanger, 1995). Related, Calvo et al. (2012) show that financial crises with high inflation tend to feature wageless recoveries while crises with low inflation are associated with jobless recovers. This is in line with the predictions of downward nominal wage rigidities, where high inflation is able to reduce real wages. Further, Devicienti et al. (2007) find that downward wage rigidities are conducive both to higher turnover flows and to higher unemployment rates at the provincial level in Italy. Relative to these papers, we directly estimate downward wage rigidities in the data, argue that our estimation procedure mitigates the compositional bias, and show that wage rigidities directly drive recession dynamics using a large panel of countries.

We resort to country-level data to determine wage rigidities, owing to the lack of consistent micro-level data across countries.[2] A natural question is whether it is feasible to uncover wage rigidities based on this level of aggregation. We tackle this issue on three fronts. First, we design an estimation procedure that is likely not sensitive to a compositional bias – a common argument against using aggregate data. We determine wage rigidities only based on episodes with adverse labor market conditions and not by comparing wage growth between booms and busts. We also average estimates across unemployment cycles for each country. This mutes the effect of particularly severe or benign cycles, which could induce different compositional adjustments in the workforce. Second, we perform numerous robustness checks and explore the implications of our measure on various labor market related outcomes, like volatility in wages and employment, the zero impact of wage rigidities during expansions, or the sensitivity of wage growth to the unemployment rate. We find that countries with high downward wage rigidities perform in a way that is consistent with theories on wage rigidities. Third, we directly contrast our measure with micro-level estimates on downward wage rigidities based on payroll and pay slip data for a subset of overlapping countries (Elsby and Solon, 2019). We find similarities, which makes it plausible to conjecture a similar relationship for countries without available micro-level data.

We structure the remaining paper as follows: Section 2 defines downward wage rigidities in a simple structural model. Section 3 estimates downward wage rigidities for a large panel of advanced economies and emerging markets. Section 4 analyzes the implications of wage rigidities on business cycle dynamics. Section 5 provides insights into the determinants of downward wage rigidities. Section 6 concludes.

[2]Micro-level data, for example based on payroll records, is only available for small set of countries and usually confined to a limited amount of periods. We examine a large set of 53 countries over 25 years to analyze the macro implications of downward wage rigidities on recession dynamics. Thus, while micro-level data is superior to aggregated data, it is not available for the research questions we address in this paper.

# 2. Structural Framework

We start with a simple structural model which explicitly defines downward wage rigidities. This definition guides our empirical identification strategy in the next section. In addition, the model emphasizes the role of downward wage rigidities in driving recession dynamics, a feature that is empirically matched in Section 4.

We consider an economy in which households supply labor inelastically and firms produce output by hiring workers at competitive wages unless downward wage rigidities bind. Labor is the only input in the production process. With this setup, wages ($w_t$), labor ($l_t$), and output ($y_t = A_t F(l_t)$) are entirely pinned down by labor demand and the wage constraint. Because we do not analyze consumption, the specification of the household sector and whether we analyze an open or closed economy are nuisance. Instead, we can focus on characterizing the labor market.

**Labor Market:** Competitive firms choose labor to maximize profits. If the wage constraint does not bind, real wages equal the marginal product of labor,

$$w_t = A_t F'(l_t).$$

The function $F$ is strictly increasing and concave. The variable $A_t$ represents an exogenous technology process. However, real wages must at least equal $\gamma$ times the real wage in the previous period, which puts a floor on wages. Formally,

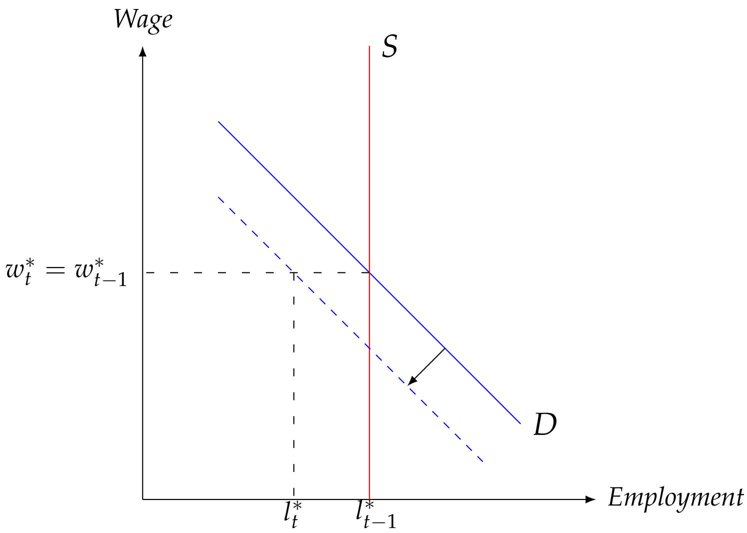
$$w_t \geq \gamma w_{t-1}.$$

The parameter $\gamma$ captures the strength of the wage rigidity. If $\gamma = 0$, wages are fully flexible. The equation hence does not impose any restrictions per se.[3]

**Equilibrium:** We illustrate the labor market equilibrium in Figure 1 during two arbitrary periods. The solid red line represents labor supply, the solid blue line initial labor demand. The slopes are determined by the inelastic labor supply and the diminishing returns to labor as encapsulated in $F$. The intersection between both lines determines the initial labor market equilibrium. Now suppose a negative technology shock hits the economy driving down labor demand (dashed line). With flexible wages, firms would respond by cutting wages to accommodate the inelastic labor supply, but with rigid wages, firms have to cut down employment, which also reduces production.

[3] We define wage rigidities in terms of real rather than nominal wages. This contrasts with, for example, Schmitt-Grohe and Uribe (2016), or Ottonello (2021). The different approach is motivated by empirical regularities as explained in Section 3. For a structural model where wage rigidities are defined based on real wages, see Blanchard and Gali (2007).

*Figure 1:* Labor Market




***Notes:*** *The red line represents labor supply, the blue line labor demand. The chart highlights the consequences of a negative shock to $A_t$ when $\gamma = 1$. The negative shock reduces labor demand. Because wages cannot adjust, firms hire fewer workers generating involuntary unemployment and output losses.*

**Recession Paths:** To illustrate the importance of downward wage rigidities in driving aggregate dynamics, we analyze an economy that is initially in steady state and subsequently hit by an unanticipated negative technology shock. Figure 2 visualizes the theoretical impulse response functions for employment (Panel (a)) and output (Panel (b)). In each plot, we consider two experiments. In the first experiment (black solid line), we set $\gamma = 0$. The wage constraint therefore never binds. In the second scenario (blue dashed line), we choose $\gamma = 0.95$. The size of the shock implies that the wage constraint binds from periods 1 to 7.

We see no response in employment when $\gamma = 0$. In contrast, employment contracts when the wage constraint binds. The response of GDP depends on the persistence of the technology process and the wage constraint. The recession worsens considerably when the wage constraint binds. As we will show later, we can qualitatively match these responses using a large panel of 53 advanced and emerging markets.

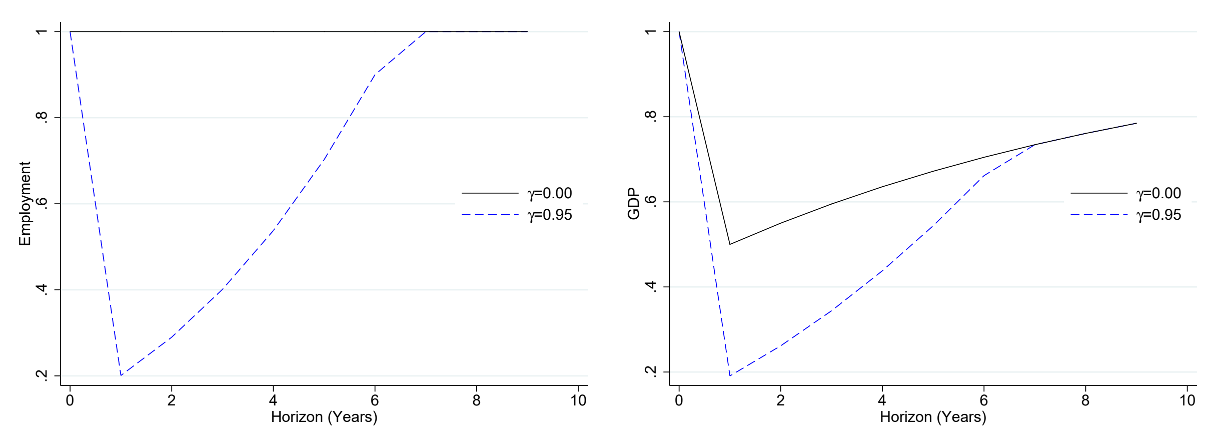
## 3. Determining Downward Wage Rigidities

This section details how we measure downward wage rigidity in the data. Just to reiterate, we define downward wage rigidities implicitly based on the real wage constraint

$$w_{i,t} \geq \gamma_i w_{i,t-1}, \tag{1}$$

***Figure 2:*** *Theoretical Recession Paths*

***(a)*** *Employment* ***(b)*** *GDP*




***Notes:*** *Impulse response functions due to a shock to $A_t$ on employment and GDP as a function of $\gamma$. Functional forms: $F(l_t) = l_t^{\alpha}$, $A_t = \rho_0 + \rho_1 A_{t-1} + \epsilon_t$. $\epsilon_t$ is a white noise process. Calibration: $l^{max} = 1$, $\alpha = 0.6$, $\rho_0 = 0.1$, $\rho_1 = 0.9$, $A_1 = 0.5$.*

where $w_{i,t}$ refers to the real wage in country $i$ and year $t$. $\gamma_i$ determines the country-specific severity of the downward wage constraint. A higher value reflects stronger downward wage rigidities. Two remarks are in order: First, we view $\gamma_i$ as country-specific, but not time-varying. The latter implies that we can average over multiple country-specific estimates to receive a more precise signal. Thus intuitively, we interpret $\gamma_i$ as a latent country-specific population parameter for which we obtain multiple sample estimates, which we then average. We think this approach is justified because wage rigidities appear to only slowly change over time. Second, and in line with structural work by, for example, Hall (2005) or Schmitt-Grohe and Uribe (2016), we are agnostic on the underlying frictions causing the wage constraint. We defer a thorough analysis on possible determinants to Section 5.

**Real Versus Nominal Downward Wage Rigidities:** To be very clear, we do not take a stance on whether underlying wage frictions are *real* or *nominal*. Indeed, higher nominal wages due to a heightened reluctance to accept nominal wage cuts would, just like real wage rigidities, also lead to higher real wage growth rates everything else equal. So, why do we analyze real instead of nominal wages? The reason is simple: The focus on real wages allows us to normalize wage rigidities across countries with heterogeneous inflation environments. When inflation is high, nominal wages naturally grow at a higher rate, as inflation puts upwards pressure on nominal wages.[4] But this inflationary effect is distinct from downward wage rigidities, and by focusing on real

[4] In a macro model without nominal frictions only real variables like the real wage are pinned down. As a consequence, goods inflation equals wage inflation absent shocks that alter real wages.

wages we can control for it.

**Data:** It is important to recognize that real wages in equation (1) refer to per-unit labor wages (see, also Section 2). We collect annual data on hourly earnings from the International Labor Organization (ILO) and the OECD.[5] We rely on the OECD series for advanced economies, because of their limited coverage in the ILO dataset. Both measures include overtime pay and regularly recurring cash supplements, but exclude benefits.[6] Hourly earnings are expressed in local currency, hence we deflate the series by the local consumer price index. The unbalanced sample contains 53 countries, 21 of which are advanced economies, from 1995-2020. Table A1 in the appendix provides an overview. Additional variables are described in the appendix.

## 3.1. Identification

We could in principle estimate $\gamma_i$ in equation (1) by calculating gross real hourly wage growth between two periods, in our case two consecutive years. However, this approach is only legitimate if the constraint happens to hold with equality, which we cannot ascertain empirically. Hence we start with a simple algorithm to select periods in which this wage constraint *plausibly* binds.

Based on the structural framework in Section 2, equation (1) binds whenever unemployment is positive. However, the model abstracts from important real world features, most notably frictional and structural unemployment. Positive unemployment per-se therefore provides no guidance on whether the wage constraint binds or not. High unemployment rates of course could coincide with a binding wage constraint. However, it appears daunting to determine the relevant unemployment rate threshold, which is also plausibly varying by country. Hence we do not pursue this route.

[5]The ILO hourly earnings' time coverage differs across 'vintages'. For example, a new vintage can start at a later date than the previous one or even exclude certain countries. We took great caution in combining different vintages in order to maximise time series coverage. Specifically, we only merged observations from two vintages when (i) overlapping periods indicate identical values, or (ii) when a country is only featured in one vintage. We also cross-checked individual outliers for consistency with historic accounts. Our analysis excludes Egypt and Venezuela because of at times extremely high and possibly unanchored inflation.

[6]Wage rigidities could be mitigated by benefits (Babecký et al., 2010). As a consequence, total labor compensation might be less rigid. This feature is likely less relevant. Otherwise, we would not see the large impact of downward wage rigidities as portrayed in the next sections. Another caveat with this measure is that wage rigidities for individual job stayers need not imply the same rigidity for average wages, as job switchers or entrants to to the labor force may not be subject to this constraint (Barattieri et al., 2014). This effect would once dampen the significance of our downward wage rigidity measure in driving business cycles. Given the large effects that we observe, this feature is likely not too important, in line with Elsby and Solon (2019) and Bewley (1999), who argue that new employees' wages are tied to the wages of existing employees.

Similarly, the constraint probably does not bind during favorable economic conditions which tend to put upward pressure on wages. In line with this argument, periods with declining unemployment likely provide no information on downward wage rigidities. This leaves us with one other option: Periods of rising unemployment induce downward pressure on wages (or at least wage growth) so the constraint may bind. If real wages continue to grow at an elevated pace, it is at least plausible to argue that wages are downward rigid. We proceed as follows:

First, we identify unemployment cycles in the dataset. A cycle is defined by consecutive years with a rising unemployment rate. Each cycle lasts at least one year, but a cycle can also last multiple years in case a country experiences prolonged adverse effects on labor markets. Table D1 in the appendix lists the year prior to each individual cycle. Each year therefore indicates a local minimum in the unemployment rate. Overall, we classify 198 unemployment cycles, 113 for emerging markets and 85 for advanced economies.

Second, we back out one estimate for downward wage rigidity per unemployment cycle. At this point we need to introduce notation. Individual cycles in country $i$ are indexed by $c(i) \in \mathbb{Z}$ for $c(i) = 1, \ldots, C(i)$, that is, there are $C(i)$ unemployment cycles in country $i$. Related, we index the last calendar year of cycle $c(i)$ by $T(c_i)$, and the year preceding the cycle by $0(c_i)$. The duration of each cycle is characterized by $H(c_i)$. With these conventions, the downward wage rigidity estimate of cycle $c(i)$ can be calculated as

$$\widehat{\gamma_{c(i)}} = \left( \frac{w_{i,T(c_i)}}{w_{i,0(c_i)}} \right)^{\frac{1}{H(c_i)}} \tag{2}$$

The statistic simply measures the annualized average gross real wage growth during cycle $c$ for country $i$. Equation (2) is closely linked to equation (1): If equation (1) binds, $\gamma_i$ corresponds to the gross real wage growth during one year of an unemployment cycle. We could therefore obtain one estimate per year and cycle, and subsequently average all estimates for each cycle to back out one estimate per cycle. This is exactly what equation (2) does. We portray the distribution of $\widehat{\gamma_{c(i)}}$ split by AEs and EMs in Figure C1. Individual estimates for each country are available in Table D2.[7]

[7] Two outliers are visible. During the 2019 unemployment cycle Honduras' real wage growth exceeded 50% annualized. In contrast, Ecuador witnessed real wage declines of more than 50% annualized during the 2001 cycle. The former is associated with sharp minimum wage increases, while wage declines in Ecuador may be related to the consequences of the Ecuadorian financial crisis. However, even considering these events, the two observed wage growth rates appear extreme. We decided to include these two outliers in the analysis. Our results regarding the macro implications of wage rigidities in Section 4 are not sensitive to this choice.

Third, we average over the cycle-specific wage rigidity measures of country $i$. At this point we utilize that $\gamma_i$ is assumed to be constant for each country during the sample period of 25 years. As a consequence, we can interpret each cycle-specific estimate as a somewhat noisy signal for underlying wage rigidities and average cycle-specific estimates to improve accuracy. There are two pieces of evidence supporting this approach: First, as apparent from Table D2, we do not observe a consistent upward or downward trend among cycle-specific estimates for individual countries. Second, wage rigidity estimates from preceding unemployment cycles predict the subsequent estimate. Figure C3 points to a sizable positive correlation, suggesting that estimates are persistent across unemployment cycles for the same country. Averaging over individual cycles for each country subsequently delivers the country-specific wage rigidity estimate $\widehat{\gamma}_i$:

$$\widehat{\gamma}_i = \frac{\sum_{c(i)=1}^{C(i)} \widehat{\gamma_{c(i)}}}{C(i)} \tag{3}$$

## 3.2. Estimation Results

We provide insights on the prevalence of downward wage rigidities across our sample of 53 countries in Table 1 for emerging markets and Table 2 for advanced economies. Column 2 portrays estimates for $\gamma_i$. A value above one points to real wage growth, despite rising unemployment. Just to reiterate, this does not necessarily imply that downward wage rigidities actually bind. Rather we conclude that countries with a high $\widehat{\gamma}_i$ are more likely subject to economically meaningful downward wage rigidities. Overall, estimates vary widely among emerging markets. Six countries experience real wage declines ($\widehat{\gamma}_i < 1$). Real wages in these countries are hence not particularly downward rigid. The majority of emerging markets, however, face real wage growth when unemployment rises. Estimates for advanced economies are less dispersed. Japan is the only developed economy with negative real wage growth. On average, real wage growth during unemployment cycles is higher in emerging markets (3.8%) than in advanced economies (1.8%), which may suggest more pronounced rigidities in emerging markets.

The third column in Tables 1 and 2 displays a labor productivity adjusted variant of $\widehat{\gamma}_i$, which we simply denote as $\tilde{\gamma}_i$. We follow the same steps as detailed in the previous section. However, in addition to normalizing nominal earnings by the price index, we also adjust earnings by long-run labor productivity growth. The latter is calculated as the country-specific sample average of real GDP per capita growth. Because of positive

***Table 1:*** *Rigidities Emerging Markets*

| Country | $\widehat{\gamma}_i$ | $\tilde{\gamma}_i$ | #Estimates |
|---|---|---|---|
| Argentina | 1.15 | 1.144 | 2 |
| Cambodia | 1.124 | 1.069 | 3 |
| Chile | 1.108 | 1.083 | 2 |
| Honduras | 1.098 | 1.088 | 5 |
| Mauritius | 1.094 | 1.063 | 4 |
| Thailand | 1.094 | 1.07 | 1 |
| Peru | 1.088 | 1.062 | 5 |
| Mongolia | 1.086 | 1.043 | 2 |
| Vietnam | 1.078 | 1.025 | 4 |
| Sri Lanka | 1.066 | 1.027 | 2 |
| Panama | 1.057 | 1.028 | 4 |
| Philippines | 1.054 | 1.027 | 3 |
| Malaysia | 1.045 | 1.02 | 3 |
| Bolivia | 1.039 | 1.021 | 5 |
| Armenia | 1.036 | .98 | 3 |
| Hungary | 1.034 | 1.009 | 3 |
| Turkey | 1.034 | 1.005 | 3 |
| Costa Rica | 1.031 | 1.008 | 6 |
| Pakistan | 1.03 | 1.015 | 2 |
| Poland | 1.03 | .992 | 4 |
| Bosnia and Herzegovina | 1.022 | .948 | 2 |
| Indonesia | 1.019 | .993 | 2 |
| Uruguay | 1.019 | .999 | 2 |
| Paraguay | 1.005 | .994 | 8 |
| Mexico | 1.004 | .997 | 3 |
| Brazil | 1.002 | .993 | 6 |
| South Africa | .997 | .99 | 3 |
| Dominican Republic | .983 | .952 | 7 |
| El Salvador | .981 | .972 | 5 |
| Guatemala | .98 | .968 | 4 |
| Colombia | .976 | .963 | 2 |
| Ecuador | .85 | .843 | 4 |
| Average | 1.038 | 1.012 | |

***Notes***: *Column 2 displays downward wage rigidities for each country ($\widehat{\gamma}_i$). A higher value signals more pronounced rigidities. A value greater than one, suggests on average positive real wage growth during unemployment cycles. $\widehat{\gamma}_i$ is defined in equation (3). The estimates in Column 3 adjust $\widehat{\gamma}_i$ for long run productivity growth ($\tilde{\gamma}_i$). Column 4 presents the number of cycle-specific estimates in each country.*

average real GDP per capita growth, adjusted real wages grow less and $\tilde{\gamma}_i$ is smaller than $\widehat{\gamma}_i$. Why do we present productivity adjusted rigidity estimates? Most macro models abstract from trend growth in productivity and impose a zero inflation steady state. The estimates in column 3 could therefore guide the calibration of models with downward nominal wage rigidities without trend inflation or productivity growth like Schmitt-Grohe and Uribe (2016), or in real models that abstract from trend growth. Even with this adjustment, wage rigidities appear more prevalent in EMs rather than

AEs (1.2% versus 0.1% productivity adjusted real wage growth).[8] Last but not least, column 4 portrays the number of cycle-specific estimates for each country. The United States for example experienced three periods of rising unemployment between 1995 and 2020.

***Table 2:*** *Rigidities Advanced Economies*

| Country | $\widehat{\gamma}_i$ | $\tilde{\gamma}_i$ | #Estimates |
|---|---|---|---|
| Lithuania | 1.087 | 1.035 | 2 |
| Latvia | 1.041 | .995 | 3 |
| Czech Republic | 1.026 | 1.005 | 1 |
| Portugal | 1.023 | 1.014 | 3 |
| United States | 1.02 | 1.006 | 3 |
| Finland | 1.019 | 1.003 | 4 |
| Spain | 1.019 | 1.01 | 3 |
| Slovak Republic | 1.016 | .984 | 5 |
| Germany | 1.015 | 1.005 | 3 |
| Iceland | 1.015 | .997 | 5 |
| New Zealand | 1.015 | 1.001 | 5 |
| Sweden | 1.015 | .999 | 4 |
| Austria | 1.014 | 1.004 | 6 |
| France | 1.013 | 1.006 | 5 |
| Korea, Republic of | 1.013 | .98 | 6 |
| Denmark | 1.012 | 1.001 | 4 |
| Belgium | 1.01 | 1 | 6 |
| Italy | 1.009 | 1.009 | 2 |
| Luxembourg | 1.008 | .995 | 7 |
| United Kingdom | 1.008 | .998 | 4 |
| Japan | .986 | .981 | 4 |
| Average | 1.018 | 1.001 | |

***Notes***: *Column 2 displays downward wage rigidities for each country ($\widehat{\gamma}_i$). A higher value signals more pronounced rigidities. A value greater than one, suggests on average positive real wage growth during unemployment cycles. $\widehat{\gamma}_i$ is defined in equation (3). The estimates in Column 3 adjust $\widehat{\gamma}_i$ for long run productivity growth ($\tilde{\gamma}_i$). Column 4 presents the number of cycle-specific estimates in each country.*

## 3.3. Plausibility of Ranking: Initial Evidence and a Road Map

We compute wage rigidities based on aggregate hourly real wage growth during unemployment cycles. Just to be upfront, we resort to aggregate data due to the lack of consistent micro-level data across a large set of countries. But, how accurate is our

[8] As apparent, some productivity adjusted downward wage rigidity estimates in column 3 are larger than one. If someone wants to directly apply these estimates to a macroeconomic model with a stationary steady state, we suggest to choose a value slightly less than one. This additional step is necessary, as it is not possible to solve for a stationary steady state when technology adjusted real wage growth is growing over time. Further, a value equal to one would prevent any downward adjustment after wages grow initially after a favorable shock. The original steady state is not stable. The empirical observation points to additional factors driving real wage growth beyond productivity growth which we, due to a lack of comprehensive cross-sectional data, cannot account for.

ranking? And more fundamentally, is it even possible to determine wage rigidities based on aggregate data?

**Compositional Bias:** A well known concern related to using aggregate data is that low-skilled workers are more likely to lose their jobs during recessions. This counter-cyclical compositional bias dampens fluctuations in aggregate wage growth rates between recessions and expansions even absent wage rigidities (Solon et al., 1994; Abraham and Haltiwanger, 1995). Our measure is likely not sensitive to this concern, despite using aggregate data, as we define wage rigidities as more prevalent if a country experiences higher wage growth during an unemployment cycle relative to other countries facing similar pressures on labor markets. In other words, we do not compare wage growth during booms relative to busts to calculate our downward wage rigidity measure. Instead, we compare wage growth rates during adverse labor market conditions both within and across countries. Each estimate is further an average of individual country-specific estimates. We therefore effectively compare average unemployment cycles across countries, and not, for example, a severe unemployment cycle in one country, with a benign upward trend in unemployment in another country, which could introduce distinctive compositional effects. Our country rankings of downward wage rigidity based on $\widehat{\gamma}_i$ are thus likely robust to this concern, and so are our regression results in Section 4.3 that evaluate the consequences of wage rigidities on recession dynamics.

**Micro-level Estimates:** We can also compare our measure with micro-level estimates of downward wage rigidities. Elsby and Solon (2019) survey this literature and collect estimates from various country-specific studies based on individual payroll and pay slip data.[9] Importantly, their review contains 12 countries, most of which are advanced economies and also part of our sample. We can thus compare our measure directly with micro-level evidence for a subset of countries. Of course this is not without a caveat: countries have different reporting standards for payroll data, the definition of wage freezes as a measure for downward wage rigidities also varies slightly by study, and, last but not least, the country-specific studies also consider a distinctive workforce. That said, we find some resemblance between our measure and a payroll based measure as evident from Figure B1, Panel (b), and Table B1. We defer a thorough discussion, including how we construct payroll-based wage rigidities based on wage freezes, to the appendix, but highlight the main takeaways: First, among the advanced economies with overlapping data, Portugal stands out as subject to the highest level of downward wage rigidities based on both approaches. Second, many advanced

[9]We thank Mike Elsby for generously sharing this data.

economies have wage rigidities that are not too far apart as discussed earlier. This is also mirrored in the payroll based measure. Third, because of this homogeneity the precise ranking between both measures differs somewhat, but countries tend to appear in the same bracket across both rankings with the exception of Italy.

**Road Map:** Subsequent sections provide further insights into the plausibility of our wage rigidity measure along two dimensions.

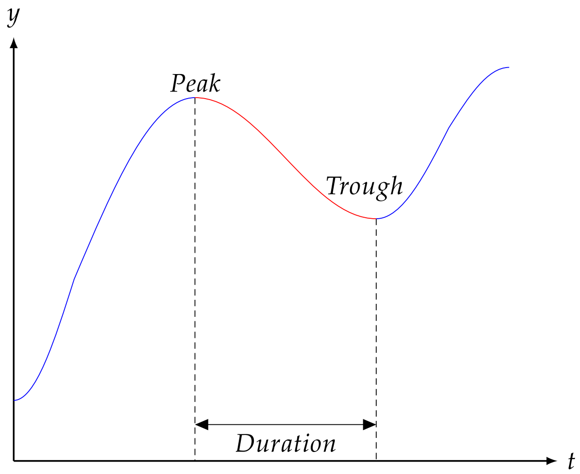
In Section 4, we derive, test, and verify predictions based on the structural wage rigidity literature: Countries with higher downward wage rigidity exhibit more pronounced recession dynamics; on the contrary, downward wage rigidities do not impact the employment path during economic booms; countries with high downward wage rigidities exhibit more volatility in employment and unemployment, but less volatility in wage growth; the wage (employment) change distributions suggest larger wage growth and employment losses across the entire distribution for high wage rigidity relative to low wage rigidity countries during recessions (first order stochastic dominance), but the difference vanishes during expansions; wage growth rates in high downward wage rigidity countries are less sensitive to the unemployment rate, but only when unemployment is high and the wage constraint therefore likely binding.

In Section 5, we discuss how our measure relates to labor market characteristics. In particular, we establish a positive relationship with two variables at the micro-level that plausibly introduce wage rigidities: minimum wage policies and de jure labor market restrictions. These myriad of exercises suggest that our measure indeed captures downward wage rigidities *and* that downward wage rigidities have macroeconomic implications across a large set of advanced economies and emerging markets.

## 4. Downward Wage Rigidities and Recession Dynamics

In this section, we empirically examine how downward wage rigidities influence business cycles, focusing on recession periods. Specifically, we investigate if countries that are subject to more pronounced wage rigidities (higher $\widehat{\gamma}_i$) experience more severe recessions in terms of employment and GDP losses. We also provide a series of descriptive statistics on the interplay between our wage rigidity measure and labor market dynamics. First though, we have to define and extract recessionary periods for our sample of 53 countries.

***Figure 3:*** *Filtering Turning Points*




***Notes:*** *The solid line represents a hypothetical upward trending path in real GDP per capita (y). The blue sections represent expansions and the red sections contractions. The Bry and Boschan (1971) algorithm filters out contractions, defined by peak, trough and duration.*

## 4.1. Turning Points in Economic Activity

Downward wage rigidities represent a one-sided constraint. If these rigidities have macroeconomic consequences, they should materialize during a downturn. It is therefore necessary to distinguish recessions from expansions and focus on the former. Though it may be surprising, most countries do not have agencies that determine turning points in economic activity. We hence cannot resort to official statistics. Instead, we implement the Bry and Boschan (1971) algorithm, the closest algorithmic interpretation of the NBER's definition of recessions (Jorda et al., 2011). We use real GDP per capita as the defining variable for business cycles. The algorithm then essentially searches for local minima and maxima in business cycle activity. We label each maximum as a peak and the subsequent minimum as the corresponding trough. A recession is subsequently defined as the period between peak and trough. Figure 3 illustrates the approach.

The algorithm extracts 107 recessions from 53 countries. Table D3 lists all individual peaks. Most recessions are related to the Asian Financial Crisis, the Global Financial Crisis, and the European Debt Crisis. One may also wonder about the Covid-19 Pandemic. We do not include pandemic related recessions: The pandemic provoked unprecedented monetary and fiscal intervention. Recession paths are therefore dominated by the policy response and the spread of the virus. It is unlikely to observe significant effects from wage rigidities. Figure C2 provides insights on the duration of the 107 recessions. Most recessions last between one and three years.

## 4.2. Descriptive Evidence

**Business Cycle Facts:** We begin with a series of descriptive statistics on the employment share and real GDP per capita during recessions stratified by the degree of wage rigidity in Table 3. The table provides the average cumulative decline in pp (employment share) or % (GDP per capita) ('amplitude'), the average duration of a recession in years and the annualized decline ('rate') defined as 'amplitude' over 'duration'. A country is subject to high (low) downward wage rigidities if $\widehat{\gamma}_i$ is above (below) the sample median. We also list the number of observations, characterized by the number of recessions, in each bin. Some emerging markets have limited data on employment, hence the imbalance in observations for the employment to population ratio.

***Table 3:*** *Business Cycle Facts*

| | Amplitude | | Duration | | Rate | |
|---|---|---|---|---|---|---|
| | High $\widehat{\gamma}_i$ | Low $\widehat{\gamma}_i$ | High $\widehat{\gamma}_i$ | Low $\widehat{\gamma}_i$ | High $\widehat{\gamma}_i$ | Low $\widehat{\gamma}_i$ |
| **Employment Population Ratio** | | | | | | |
| Mean | 1.486 | .853 | 1.474 | 1.6 | .864 | .567 |
| Observations | 38 | 45 | 38 | 45 | 38 | 45 |
| **Real GDP Per Capita** | | | | | | |
| Mean | 4.386 | 3.773 | 1.426 | 1.642 | 3.163 | 2.07 |
| Observations | 54 | 53 | 54 | 53 | 54 | 53 |

***Notes***: *Amplitude is the peak to trough cumulative decline in pp (employment) or % (GDP per capita). Duration is the peak to trough time in years. Rate is the annualized decline from peak to trough computed as Amplitude/Duration. The sample is split by the degree of wage rigidities. High $\widehat{\gamma}_i$ (low $\widehat{\gamma}_i$) refers to subsamples with wage rigidities above (below) the sample median, which we define separately for AEs and EMs.*

The employment share drops by 1.5 pp during a recession if the country is subject to more pronounced downward wage rigidities, but only by 0.9 pp if subject to no/muted rigidities. This difference persists on an annualized basis with 0.9 pp versus 0.6 pp. With regard to real GDP per capita, it appears that economies experience more severe contractions if subject to higher wage rigidities (4.4% versus 3.8%). The annualized decline is roughly 1.1 pp larger.

**Labor Market Volatility:** We subsequently characterize the volatility (standard deviation) of the employment to population ratio, the unemployment rate and real wage growth relative to the extent of downward wage rigidities. As visible in Table 4, countries with high downward wage rigidity (based on median threshold) experience much more volatile changes in employment and unemployment, but less volatility in wage growth. In more detail, the standard deviation of changes in the employment ratio is about 2 for high wage rigidity countries but only 1.4 for countries with low downward rigidities. A similar pattern emerges for changes in the unemployment rate. However, the standard deviation of wage growth is 18 for low wage rigidity countries but only 6.5 for high wage rigidity economies. Overall, all of these numbers suggest that countries with a high wage rigidity estimate (high $\widehat{\gamma}_i$) are more likely to have binding wage constraints. Hence employment adjusts more forcefully, while wages are less volatile.

***Table 4:*** *Wage Rigidities and Volatility*

| | sd(Δ Employment) | | sd(Δ Unemployment) | | sd(Δln Wage) | |
|---|---|---|---|---|---|---|
| | High $\widehat{\gamma}_i$ | Low $\widehat{\gamma}_i$ | High $\widehat{\gamma}_i$ | Low $\widehat{\gamma}_i$ | High $\widehat{\gamma}_i$ | Low $\widehat{\gamma}_i$ |
| Mean | 2.063 | 1.393 | 1.281 | 1.088 | 6.471 | 18.025 |
| Observations | 497 | 554 | 675 | 650 | 437 | 523 |

***Notes**: The table portrays the standard deviation of changes in the employment to population ratio, the unemployment rate (both in pp) and real wage growth (in %). The sample is split by the degree of wage rigidities. High $\widehat{\gamma}_i$ (low $\widehat{\gamma}_i$) refers to subsamples with wage rigidities above (below) the sample median, which we define separately for AEs and EMs.*

**Wage and Employment Distributions:** We next analyze the annual wage and employment change distributions for countries with high and low downward wage rigidity (threshold based on median) stratified by the business cycle phase. The idea is that countries with higher downward wage rigidities should exhibit higher wage growth during recessions. Similarly, employment should decline by more. However, these features should vanish once countries enter expansionary territory. Figure 4 confirms the aforementioned predictions for recessions. In Panel (a), we plot annual real wage growth for countries with high downward wage rigidities (blue) and low wage rigidities (red). Solid lines represent kernel densities. Clearly, the distribution for countries with low wage rigidities exerts stochastic dominance over the distribution of high wage rigidity countries. In other words, we observe higher wage growth during recessions for countries with high downward wage rigidities. Panel (b) provides results from a similar exercise just for changes in the employment to population ratio rather than wage growth. As apparent, the employment change distribution of countries with high downward wage rigidities stochastically dominates the distribution of low downward wage rigidity countries, implying larger employment losses. Figure C4 provides corresponding distributions for expansions. We find no difference between countries with high/low downward wage rigidities. Downward wage rigidities as calculated based on our metric only matter during recessions, just as implied by the theory.

**Wage Growth and Unemployment:** According to the structural framework in Section 2, wage growth is entirely pinned down by $\gamma$ once the downward wage constraint

***Figure 4:*** *Wage Rigidities and Labor Markets during Recessions*

***(a)*** *Δln Wage* ***(b)*** *Δ Employment*


***Notes***: *Real wage growth (in %) and changes in the employment to population ratio (in pp) at annual frequency during recessions based on the degree of downward wage rigidity. Recessions are defined by negative real GDP growth. Solid lines represent kernel densities and bars the raw data. "Low (High) Wage Rigidity" refers to subsamples with wage rigidities below (above) the sample median, which we define separately for AEs and EMs.*

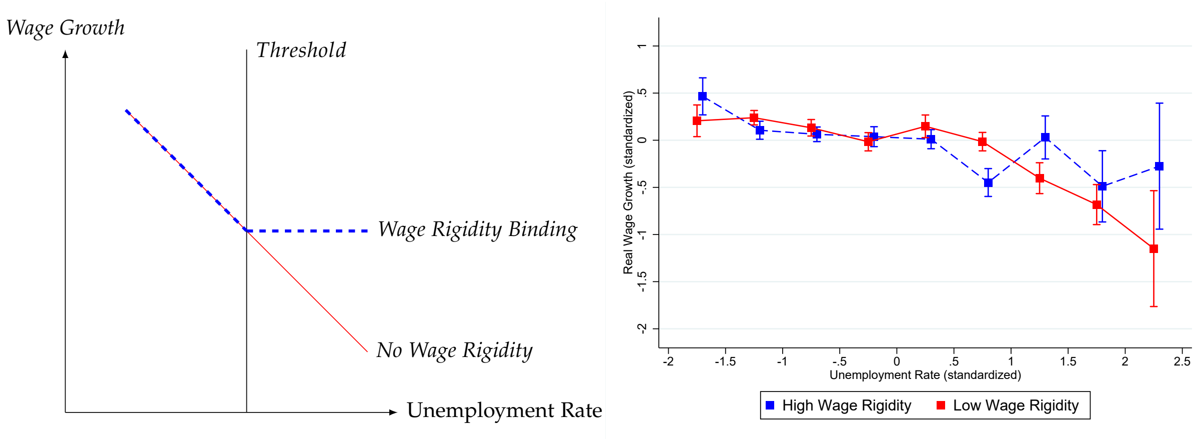
binds. Thus, a further increase in unemployment should not predict additional wage changes. We can empirically test this prediction. In particular, we subsequently show that wages in countries with high downward wage rigidities are indeed not sensitive to the unemployment rate once unemployment is elevated. We do not observe similar patterns when the unemployment rate is relatively low, or when a country is subject to low/no downward wage rigidities.

Figure 5, Panel (a), illustrates the above arguments graphically. Rising unemployment exerts downward pressure on wage growth as long as the one-sided downward wage constraint does not bind. However, once downward wage rigidities bind, as indicated by the black vertical line, wage growth is unrelated to the unemployment rate (dashed blue line). For a country that is not subject to wage rigidities, higher unemployment continues to push wage growth lower (red line).

Panel (b) provides matching empirical evidence. We standardize real wage growth and the unemployment rate to account for differences in level and volatility across countries. We further discretize the unemployment rate into bins of 0.5 standard deviations each. The blue (red) line and dots refer to countries with high (low) downward wage rigidities, defined relative to median wage rigidities as before. Two findings emerge. First, when the unemployment rate is low, we do not observe noticeable differences across countries with high or low downward wage rigidities. A higher unemployment rate does seem to lower real wage growth. Second, when the unemployment rate increases to relatively high levels, wage growth in countries

*Figure 5: Wage Growth and Unemployment: The Role of Downward Wage Rigidities*

*(a) Benchmark* *(b) Data*




***Notes***: *Panel (a) provides a theoretical benchmark for the relationship between wage growth and the unemployment rate depending on whether the downward wage constraint binds or not. Panel (b) adds empirical evidence. Real wage growth and the unemployment rate are standardized for each country. The unemployment rate is discretized into 0.5 standard deviation bins and 1 standard error bands around point estimates are added. A country is subject to high (low) downward wage rigidities if wage rigidities are above (below) the sample median, which we define separately for AEs and EMs.*

with high downward wage rigidities flattens, while wages in countries with low wage rigidities continue to decline.

Overall, our wage rigidity estimates provide theoretically consistent predictions on various dimensions. We also examined preliminary evidence on recession dynamics conditional on our downward wage rigidity measure. We subsequently, expand these insights by means of a formal regression analysis.

## 4.3. Formal Analysis based on Local Projections

In this section, we formally examine the effects of downward wage rigidities on employment and GDP during recessions via Local Projections (Jordà, 2005). Two results stand out in this analysis. First, countries with higher downward wage rigidities experience a significantly larger contraction in employment relative to countries with lower downward wage rigidities. This effect is also economically large. Three years into a recession, the employment to population share cumulatively drops by roughly 10 pp for countries with high downward wage rigidities, but less than 2 pp for countries with low downward wage rigidities. Second, the impact of downward wage rigidities on GDP is somewhat more muted but still significant at a horizon of three years, with real GDP per capita cumulatively declining roughly 8.5% in countries with high rigidities at the end of the third year since the beginning of a recession, relative to a

6% decline in countries with low rigidities.

To provide more details on the analysis, we track the effects of downward wage rigidity on the path of real GDP per capita and the employment to population ratio for up to three years since the last business cycle peak. There are few recessions in the data that last beyond three years, hence this particular threshold. Just to be upfront, our results should not be interpreted in a causal sense. We do not have exogenous sources of variation in wage rigidities, nor are there obvious natural experiments available. Wage rigidities are clearly endogenously determined. However, the impulse response functions shed light on how the path of the economy would be, if wage rigidities had deviated from its conditional mean.[10] To add context, we estimate

$$\Delta_{\tau(r)+h} y_i = \sum_{h=1}^{H(r)} \beta_h Pk_{i,\tau(r)+h} + \sum_{h=1}^{H(r)} \phi_h Pk_{i,\tau(r)+h} (\widehat{\gamma}_i - \overline{\gamma}) + \epsilon_{i,\tau(r)+h}, \tag{4}$$

which follows the general specification of Jordà et al. (2013). The dependent variable $y_i$ represents the logarithm real GDP per capita, or the employment share of country $i$. $\Delta_{\tau(r)+h} y_i = y_{i,\tau(r)+h} - y_{i,\tau(r)}$ is hence defined as the cumulative change in $y_i$ between years $\tau(r)$ and $\tau(r) + h$. We use the notation $\tau(r)$ to refer to the calendar year of the r-th business cycle peak and $h$ to indicate the number of years after the most recent peak.

The variable $Pk_{i,\tau(r)+h}$ is a binary indicator. The indicator equals one, if country $i$ experienced its last peak $h$ years ago. The coefficient vector $\{\beta_h\}_{h=1}^{H}$ characterizes the cumulative recession path of the dependent variable for a country with average wage rigidities. The second term in equation (4) captures the interaction between the recession response and prevailing downward wage rigidities. We standardize $\widehat{\gamma}_i$ in the regression analysis and subtract the mean $\overline{\gamma}$. Consequently, we can interpret the term $(\widehat{\gamma}_i - \overline{\gamma})$ as excess wage rigidity in units of standard deviations. The parameter $\phi_h$ represents the cumulative marginal effect of a one standard deviation treatment applied to the wage rigidity measure. The parameters $(\beta, \phi)$ are of chief interest, and provide the conditional path for the response of each dependent variable.

With this notation in mind, it is straightforward to derive impulse response functions. We are specifically interested in two responses, where we set excess wage rigidity to plus/minus $x$=0.5 standard deviations of the sample mean. The recession paths are:

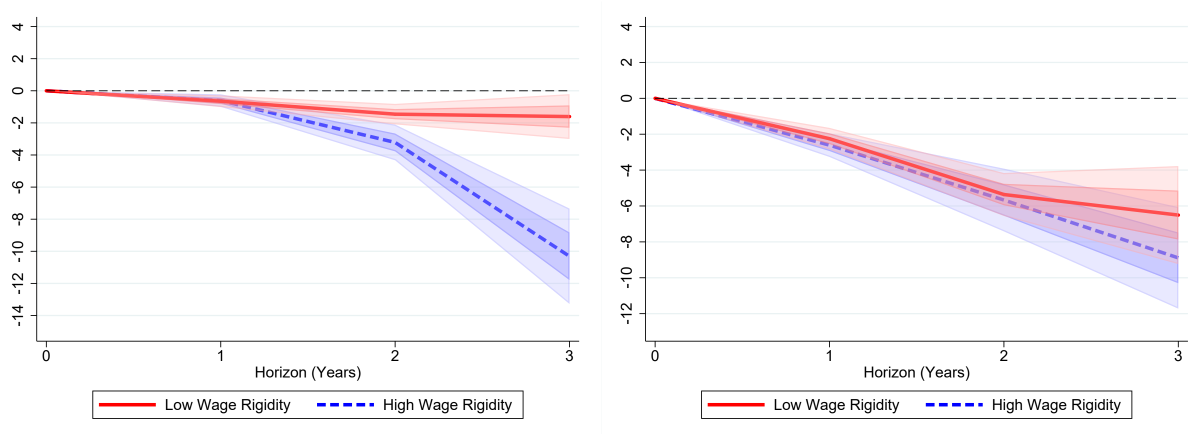
[10] A particular concern is reverse causality. As a prior it appears plausible to argue that more severe recessions induce more downward pressure on real wage growth. If so, our estimates are downward biased and therefore conservative. Further, wage rigidities are computed during unemployment cycles and not recessions. These episodes only partially overlap.

$$\{\beta_h + x\phi_h\}_{h=1}^{H}: \quad \text{Avg.+xStd.Dev.}$$
$$\{\beta_h - x\phi_h\}_{h=1}^{H}: \quad \text{Avg.-xStd.Dev.}$$

**Main Results:** We present our baseline results for the entire sample of advanced economies and emerging markets in Figure 6. The solid red line displays the typical path of a country with wage rigidities 0.5 standard deviations below the sample mean ($\beta_h - 0.5\phi_h$). The dashed blue line characterizes the path for a country with wage rigidities 0.5 standard deviations above the sample average ($\beta_h + 0.5\phi_h$). Shaded red and blue areas represent one and two standard error confidence bands. We estimate cluster robust standard errors. Each recession cycle represents one cluster.

***Figure 6:*** *Recession Paths: All Countries, Wage Rigidity Treatment +- 0.5 Standard Deviations*

***(a)*** *Employment* ***(b)*** *GDP*




***Notes**: Local Projections as specified in equation (4). Dependent variables: Cumulative change in the employment to population ratio (in pp) (Panel (a)), cumulative change in real GDP per capita (in %) (Panel (b)). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

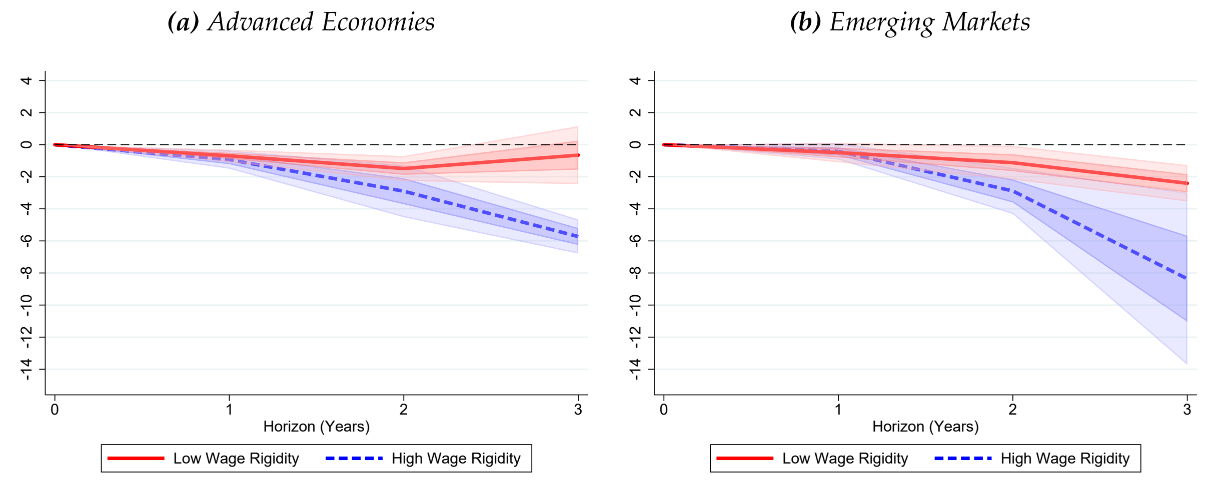
Focusing on Panel (a), the employment to population ratio declines by 0.6 pp during the first year of a recession. There are no noticeable differences across countries with high or low wage rigidities. This finding however dramatically changes during years 2 and 3. In year 2, the employment share for countries with high wage rigidities drops by 3.2 pp cumulatively, relative to 1.4 pp for countries with low downward wage rigidities. This gap widens in year 3, with 10.3 pp versus 1.6 pp. Figure C5 in the appendix plots the difference between both lines including confidence bands and confirms the statistically and economically significant difference between the two responses in years 2 and 3. Turning to output, we observe that real GDP per capita declines by roughly 2.4% in year 1 and 5.5% by year 2. Wage rigidities do not appear to drive the response until year 3. In year 3, we estimate a contraction of 8.9% for countries with high wage rigidities, but only 6.5% for countries with low rigidities. This difference is sizable, and significant as highlighted in Figure C5. Based on this evidence, we draw the following conclusions: Downward wage rigidities have a strong impact on employment during most of the recession cycle. However, the impact on real GDP is more muted and only observable in year 3, that is, only for recessions that actually lasted that long. The more pronounced impact on labor markets should however not surprise. Wage rigidity is a friction that foremost affects labor markets. Output in turn is driven by a host of factors, the labor market is only one of them.

Next, we explore if downward wage rigidities primarily matter for advanced economies or emerging markets. We separate the sample for two reasons: First, much of the literature around downward wage rigidities centers around advanced economies. Hence it is natural to ask if we can observe similar implications for employment and GDP for emerging markets as well. Second, a large share of the variation in $\widehat{\gamma}_i$ is due to the heterogeneity in emerging markets. Our results for the whole sample could therefore stem from the variation across emerging markets.

Figure 7 provides insights for employment and Figure 8 for output. The approach is very similar to our baseline analysis with one exception: We focus on subsamples, and as a consequence, also define "excess wage rigidity" relative to the specific subsample. As apparent from Figure 7, the responses for employment are quite similar: The contraction in employment is somewhat more pronounced for EMs with an additional roughly 2 pp drop, however the difference between countries with high and low wage rigidities remains stable. Thus, high wage rigidities negatively affect employment in both AEs and EMs. To confirm this, we plot the difference between the responses for high and low wage rigidities in Figure C6.

Wage rigidities influence output in advanced economies, but less so in emerging markets. Based on Figure 8, Panel (a), the recession path in AEs is somewhat more muted for countries with low wage rigidities during the first 2 years, but the difference is not significant as confirmed in Figure C7. The response gap between high and low wage rigidities in the third year is however sizable with 8.6 pp. Turning to emerging markets in Panel (b), wage rigidities once again do not influence output contractions during the first two years. The difference by year 3 equals 2.1 pp, which is noticeable and statistically significant as highlighted in the appendix. Overall though, from the perspective of the response gap, downward wage rigidities primarily affect output dynamics in AEs. The difference could be related to the large informal sector in EMs, which might absorb employment losses in the formal sector. The informal labor market is also plausibly less rigid. Due to a lack of data, we however cannot test this

**Figure 7:** *Recession Paths: Employment, Advanced Economies versus Emerging Markets*




***Notes***: *Local Projections as specified in equation (4). Dependent variable: Cumulative change in the employment to population ratio (in pp). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

hypothesis formally.

**Figure 8:** *Recession Paths: GDP, Advanced Economies versus Emerging Markets*


***Notes***: *Local Projections as specified in equation (4). Dependent variables: Cumulative change in real GDP per capita (in %). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

**Adding Control Variables:** To examine if our baseline results are robust, we include a variety of control variables in the local projection analysis. Specifically, we conduct the following local projection estimation

$$\Delta_{\tau(r)+h} y_i = \sum_{h=1}^{H(r)} \beta_h Pk_{i,\tau(r)+h} + \sum_{h=1}^{H(r)} \phi_h Pk_{i,\tau(r)+h} (\widehat{\gamma}_i - \overline{\gamma}) + \Gamma X_{i,\tau(r)+h} + \epsilon_{i,\tau(r)+h}, \quad (5)$$

where we add a vector of control variables, $X_{i,\tau(r)+h}$, with coefficient vector $\Gamma$ to the baseline specification in equation (4).

We consider two sets of control variables. First, we include control variables that are possibly related to our constructed wage rigidity measure, such as measures on collective bargaining between workers and firms, the union density, de jure labor market rigidities, and minimum wage growth. Due to limited data availability, we include country-specific averages of the union density, collective bargaining, and the de jure labor market measure. Minimum wage data is not available for 19 our of 53 countries. We therefore provide two sets of results, with and without minimum wage growth as a control variable. As these variables may contain information about wage rigidities, they may potentially weaken our estimated effects of the wage rigidity measure on employment and GDP. The results are summarized by Figures C10 and C11 (with minimum wage growth), and confirm this hypothesis. In particular, comparing the left panel of these figures with our benchmark (i.e., the left panel in Figure C5), we see that downward wage rigidities no longer exert a significant effect on employment during the first two years after controlling for variables that are related to our constructed rigidity measure. The effect of downward wage rigidities on GDP also weakens somewhat.

Second, we include control variables that are not directly related to our wage rigidity measure, but important in driving a country's employment and GDP dynamics during recessions. Specifically, we consider credit growth prior to a recession (annualized change in the credit-to-GDP ratio over three years prior to the recession). Ex-ante credit growth has been identified as a factor contributing to the severity of a (financial) recession (Jordà et al., 2013); we include the export-to-GDP ratio to control a country's vulnerability to external shocks; we add the bilateral exchange rate (relative to the U.S. dollar) to control for business cycle fluctuations due to currency variations. In particular open economies with a fixed exchange rate are more sensitive to conditions in international markets (see, for example, Obstfeld et al., 2019; Loipersberger and Matschke, 2022); we also include oil prices as some primarily emerging markets rely on oil exports, which in turn drives domestic developments. Overall, these variables capture country-specific factors and may isolate the impact of the wage rigidity measure on employment and GDP. As shown in Figure C12, including these variables keeps the results largely unchanged relative to the benchmark case (Figure C5). The effect of wage rigidities on employment decreases somewhat, but the results for GDP are more significant.

Finally, if we include both sets of control variables (excluding minimum wage), the results are similar to the results from only including the four variables that are potentially related to our wage rigidity measure. These results are displayed in Figure C13. The analysis in this subsection thus provides supporting evidence that our empirical results are robust.

**Placebo Regressions based on Expansions:** To assess the validity of the downward wage rigidity measure we now examine its effects on employment during expansions. The idea is that, if $\widehat{\gamma}_i$ in equation (3) picks up downward wage rigidities, it should not affect labor markets during an expansion when the wage constraint usually does not bind. We subsequently test and verify this hypothesis. The placebo regression reads

$$\Delta_{\tau(r)+h} y_i = \sum_{h=1}^{H(r)} \beta_h Tr_{i,\tau(r)+h} + \sum_{h=1}^{H(r)} \phi_h Tr_{i,\tau(r)+h} (\widehat{\gamma}_i - \overline{\gamma}) + \epsilon_{i,\tau(r)+h}. \tag{6}$$

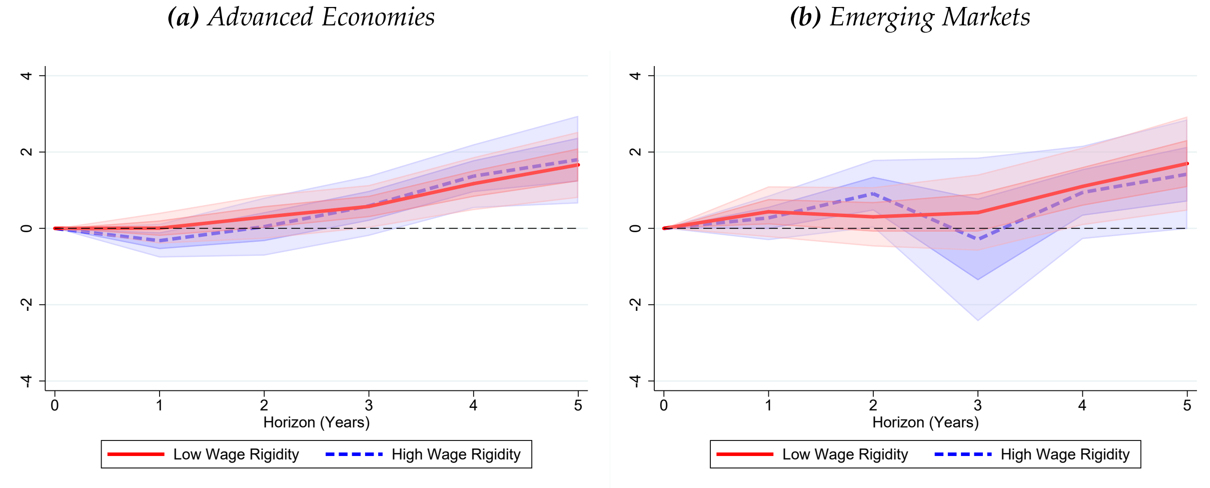
The equation is similar to the baseline recession projection (4) with one notable exception: We examine expansionary paths instead of recession dynamics and therefore replace the peak dummy $Pk_{i,\tau(r)+h}$ with a trough dummy $Tr_{i,\tau(r)+h}$. The dummy is one, if a country experienced its last trough $h$ years ago. Because expansions last longer than recessions, we are able to analyze up to five years from the most recent trough. The relevant null hypothesis is then whether the vector $\{\phi_h\}_{h=1}^{H}$ equals zero. We argue that $\phi$ is not statistically different from zero. This supports the notion that $\widehat{\gamma}_i$ only matters during recessions, just as predicted by the one-sided wage constraint.

Figure 9 plots the employment response path during expansions, depending on the degree of downward wage rigidities. We observe a general upward trend among AEs and EMs. This trend is delayed by one year for AEs, which is a well known business cycle fact (Stock and Watson, 1999). However, the important insight from these projections pertains to the indistinguishable difference between countries with high or low downward wage rigidities. Indeed, the solid red and blue dashed lines basically overlap. The employment path during expansions hence does not depend on downward wage rigidities.

## 5. Micro-level Frictions and Downward Wage Rigidity

The overarching conclusion from the last section is that downward wage rigidities matter for business cycle dynamics. We also compiled a host of evidence to verify that

***Figure 9:*** *Placebo: Employment Expansion Path*




***Notes****: Local Projections as specified in equation (6). Dependent variable: Cumulative change in the employment to population ratio (in pp). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

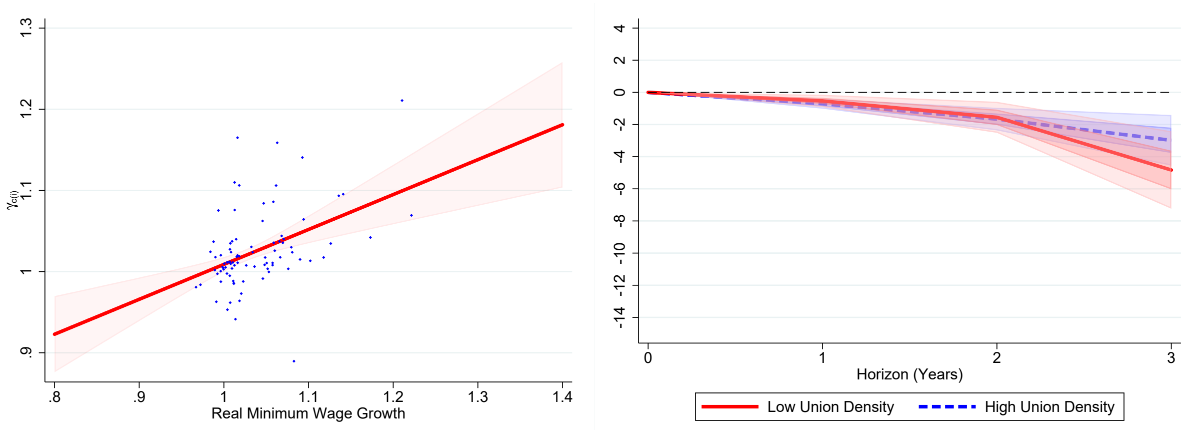
our downward wage rigidity measure confirms key predictions from the structural literature. However, we sidestepped a discussion on micro-level frictions/features that explain our measure. This section fills this gap. Most studies center around two themes: the bargaining power of workers and institutional features. We analyze four variables that highlight both aspects: worker unions, bargaining agreements, minimum wage policies and employment protection legislation. These variables are available for most countries in our sample and are prominently featured in the literature (see, for example, Dickens et al., 2007; Holden and Wulfsberg, 2009, 2014; Babecký et al., 2010). We subsequently relate our downward wage rigidity measure to minimum wage policies and de jure labor market legislation. Worker unions or collective bargaining agreements in contrast are not correlated with our measure. Though we do not claim causality, unions in fact tend to stabilize employment during recessions.

**Minimum Wages:** The narrative around minimum wages is straightforward: During recessions, firms would like to cut wages, but they may be unable if subject to a wage floor. Minimum wages can therefore introduce downward wage rigidities. Estimates on their prevalence generally vary widely across countries, but are sizable (Castellanos et al., 2004; Harasztosi and Lindner, 2019).

The downward wage rigidity measure calculated in Section 3 is associated with minimum wage growth. Figure 10, Panel (a), plots results from a simple bivariate regression where we regress the unemployment cycle-specific downward wage rigidity measure ($\widehat{\gamma_{c(i)}}$) on real minimum wage growth during the same period. We adjust minimum wage growth by inflation for consistency with the wage rigidity measure and exclude periods with zero nominal minimum wage growth. As apparent from the chart, minimum wage growth is associated with higher hourly earnings and, as a consequence, higher downward wage rigidities. However, minimum wage growth is not correlated with recession dynamics. We estimated Local Projections as in equation (4) where we replaced the wage rigidity measure with real minimum wage growth. Though countries with higher minimum wage growth performed slightly worse, the difference on employment or output is not significant. In sum, the wage rigidity measure extracts a signal from minimum wages, but other factors must play a role, too.

***Figure 10:*** *Explaining Wage Rigidities: Minimum Wages and Union Density*

***(a)*** *Minimum Wages and Downward Wage Rigidities* ***(b)*** *Union Density and Employment*




***Notes**: Panel (a): The panel presents results from a bivariate OLS regression. Dependent variable (y-axis): Downward wage rigidities ($\widehat{\gamma_{c(i)}}$). Independent variable: Gross real minimum wage growth (x-axis). Minimum wage growth is computed during unemployment cycles. 90% predictive margins and observations are added. unemployment cycles with zero nominal minimum wage growth are excluded, as well as episodes with real minimum wage growth exceeding 30 % or below -10 %. Panel (b): Local Projections as specified in equation (4) with downward wage rigidities replaced by union density. Union density for each country is averaged over the sample period 1995-2020. Dependent variable: Cumulative change in the employment to population ratio (in pp). "Low (High) Union Density" corresponds to the response of a country with -0.5(+0.5) standard deviations in union density from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

**Unions and Bargaining Agreements:** Unions and collective bargaining agreements are perceived to increase the bargaining power of employees (Horn and Wolinsky, 1988). Because workers are reluctant to wage cuts as demonstrated by the literature, workers organized in unions or included in collective bargaining agreements might have more leverage to actually enforce these sentiments.

Figure 10, Panel (b), plots the non-causal effect of a higher union density on employment during recessions. We once again estimate Local Projections as in equation (4), but this time we replace the wage rigidity indicator with a measure of union density.

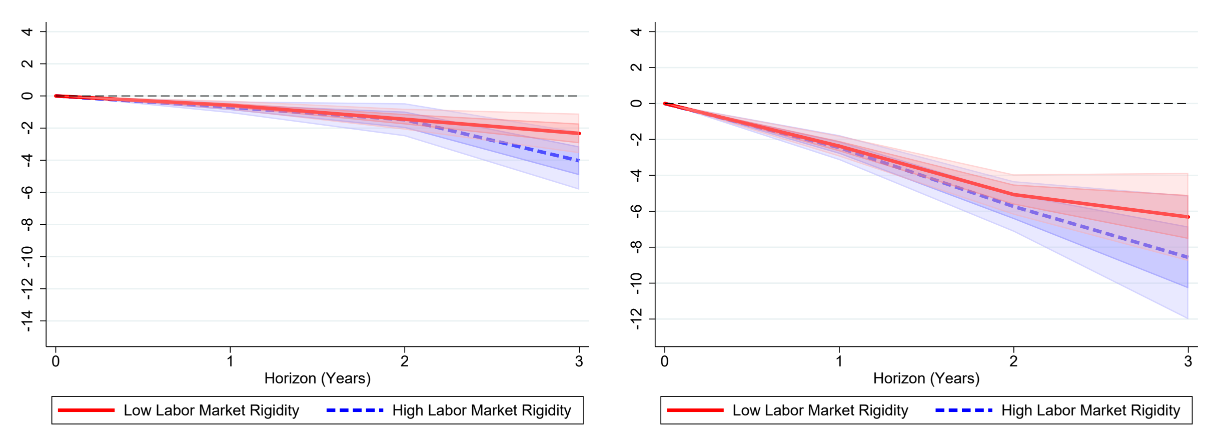
Union density for each country is averaged over the sample period 1995-2020. As one can see, if anything, a higher union density leads to a smaller contraction in employment. The difference by year 3 amounts to 1.9 pp and is borderline significant (Figure C8). The prevalence of unions therefore does not drive our baseline results regarding the significance of downward wage rigidities. In fact, union density and downward wage rigidities are negatively correlated. Our interpretation of these results is that unions primarily care about stabilizing employment and do not push for higher wages during a recession. Unions may also be associated with the presence of other policies that stabilize employment during recessions. The results for collective bargaining agreements are qualitatively similar, although not significant, and available in Figure C8. Once again we constructed this measure as a sample average for each country. The prevalence of domestic bargaining agreements does not correlate with the employment response during a recession and is in fact negatively correlated with the wage rigidity measure.

**De jure Employment Protection Legislation:** More rigid employment legislation could reduce the flexibility in labor markets and thus introduce persistence in the wage setting process (Simintzi et al., 2015). However, employment protection could also make it more difficult to reduce employment when firms need to do so, such as during economic downturns (Bentolila and Bertola, 1990; Messina and Vallanti, 2007).

We examine the de jure labor market rigidity measure of Campos and Nugent (2012). The index captures the de jure rigidity of employment protection legislation across more than 140 countries from 1960-2004 and is therefore widely available for the sample of countries in this study. Because data availability since 1995 is somewhat limited, we compute an average over the entire available time series for each country. Then, we estimate Local Projections as specified in equation (4). However, we replace the wage rigidity measure with de jure labor market rigidities. The impulse responses are available in Figure 11. The de jure measure yields a more muted response on employment and output. The employment share differs only 1.7 pp between high and low labor market rigidities by year 3. The difference is nevertheless significant (Figure C9). The paths for output appear similar to the paths based on wage rigidities, but are barely distinguishable from a statistical perspective. These weaker results could be driven by two opposing forces: Employment protection may generate downward wage rigidities, which is partially picked up by the regressions, but, at the same time, it may be more difficult to adjust employment during a recession.

***Figure 11:*** *Recession Paths: All Countries, De Jure Labor Market Restrictions*

***(a)*** *Employment* ***(b)*** *GDP*




***Notes***: *Local Projections as specified in equation (4) with one exception: The downward wage rigidity measure is replaced by a de jure labor market rigidity measure. Dependent variables: Cumulative change in the employment to population ratio (in pp) (Panel (a)), cumulative change in real GDP per capita (in %) (Panel (b)). "Low (High) Labor Market Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in labor market rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

## 6. Conclusion

In this paper, we provide a simple framework to calculate downward wage rigidities in aggregate data over a wide range of countries. The approach preserves consistency and shows widespread wage rigidities across advanced and emerging economies. As an additional benefit, our downward wage rigidity estimates are readily available as a reference when calibrating quantitative structural models. Furthermore, to the best of our knowledge, this paper is the first to provide direct cross-country empirical evidence on the relevance of downward wage rigidities in driving recession dynamics. We show that countries with noticeable downward wage rigidities perform worse in terms of employment and real GDP.

Our analysis also provides two important policy implications. First, we find that downward wage rigidities are related to minimum wage growth, suggesting that policymakers need to be cautious in raising minimum wages when labor markets are slack. Second, our results are supportive of worker unions in terms of stabilizing employment losses during recessions. The presence of labor unions also does not contribute to our downward wage rigidity measure. We hope this analysis stimulates further discussions on the relevance and determinants of wage rigidities and how to attenuate its negative effects.

# A. Appendix: Data

***Table A1:*** *Country List*

| | | | |
|---|---|---|---|
| **EMs** | | | |
| Argentina | Costa Rica | Malaysia | Philippines |
| Armenia | Dominican Republic | Mauritius | Poland |
| Bolivia | Ecuador | Mexico | South Africa |
| Bosnia and Herzegovina | El Salvador | Mongolia | Sri Lanka |
| Brazil | Guatemala | Pakistan | Thailand |
| Cambodia | Honduras | Panama | Turkey |
| Chile | Hungary | Paraguay | Uruguay |
| Colombia | Indonesia | Peru | Vietnam |
| **AEs** | | | |
| Austria | Germany | Lithuania | Sweden |
| Belgium | Iceland | Luxembourg | United Kingdom |
| Czech Republic | Italy | New Zealand | United States |
| Denmark | Japan | Portugal | . |
| Finland | Korea, Republic of | Slovak Republic | . |
| France | Latvia | Spain | . |

**Variables and Data Sources**

*Collective Bargaining Coverage Rate*: Number of employees whose pay/conditions of employment are determined by a collective agreements as a percentage of the total number of employees. (Source: ILO)

*CPI*: Consumer price index. We construct inflation as the log difference. (Source: IMF)

*Credit to GDP ratio*: Domestic credit to private sector as a percent of GDP. (Source: World Bank)

*De jure Labor Market Restrictions*: De jure rigidity of employment protection legislation. (Source: Campos and Nugent, 2012)

*Employment*: Employment to population ratio for ages 15+ in percent. (Source: ILO)

*Exchange Rate*: Local currency units per U.S. dollar. (Source: World Bank)

*Export-to-GDP ratio*: Exports of goods and services as a percent of GDP. (Source: World Bank)

*GDP*: Gross domestic product per capita in constant local currency. (Source: World Bank)

*Hourly Earnings*: Nominal hourly earnings data combined from the OECD MEI and ILOSTAT. (Source: OECD and ILO)

*Minimum Wage*: Nominal hourly minimum wage. (Source: ILO)

*Oil Prices*: U.S. dollars per barrel at year end. (Source: Bloomberg)

*Unemployment Rate*: Unemployment as a percent of the total labor force. (Source: ILO)

*Union Density*: Number of union members who are employees as a percentage of the total number of employees. (Source: ILO)

## B. Appendix: Evidence from Payroll Records and Pay Slips

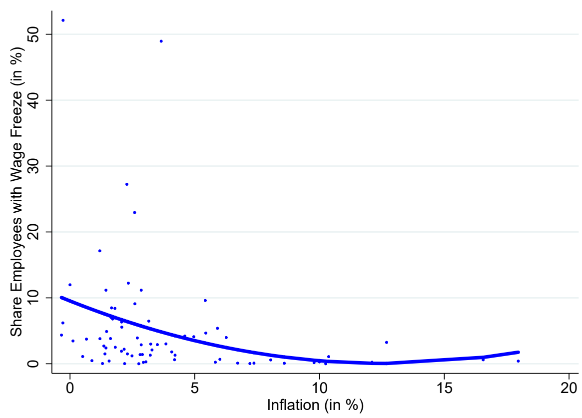
In this section, we compare our downward wage rigidity measure ($\widehat{\gamma}_i$) with micro-level estimates from payroll and pay slips data. Micro-level studies are usually country-specific, but Elsby and Solon, 2019 summarize and compare individual studies across 11 advanced economies and Mexico. We use their data to construct a measure on downward wage rigidities that proxies our procedure and document the resemblance between both measures for a group of overlapping advanced economies.

Figure B1, Panel (a) portrays the share of workers subject to nominal wage freezes and the level of inflation in a scatter plot. Nominal wage freezes are a common proxy for downward nominal wage rigidities, and derived based on payroll records. Each dot corresponds to a specific country (see Table B1) and year. Strikingly, the share of workers with nominal wage freezes decreases with inflation. This is not surprising, as nominal wage growth and inflation tend to correlate with each other. However, this relationship is not necessarily due to downward wage rigidities. For example, in a DSGE model without nominal frictions, wage inflation always equals goods inflation absent shocks that alter real wages. Put differently, inflation adds pressure on nominal wages. Given that countries have different inflation environments, we therefore normalize the share of wage freezes by inflation, to obtain a measure that measures wage freezes in excess of what would be predicted by inflation. This mirrors our approach to construct wage rigidities based on real rather than nominal wages. We thus estimate the following regression,

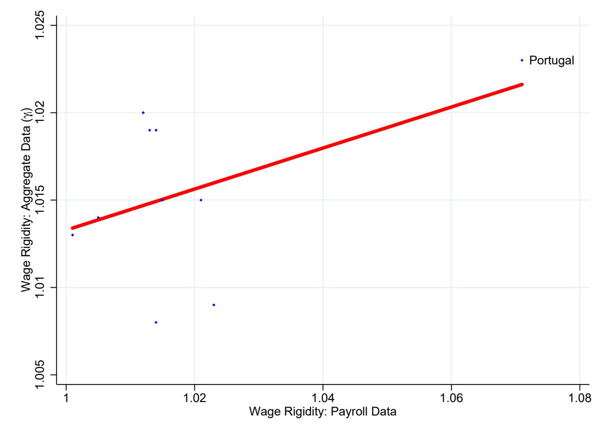
$$Freeze_{i,t} = \alpha + \beta_1 \pi_{i,t} + \beta_2 \pi_{i,t}^2 + \epsilon_{i,t},$$

which we also portray in Figure B1, Panel (a). Note that we choose a second order polynomial to account for the non-linearity between inflation and nominal wage freezes. All our subsequent results will go trough with alternative non-linear specifications such as third order polynomials or flexible splines. The error term $\epsilon_{i,t}$ in this regression measures excess downward wage rigidity normalized by inflation and thus in spirit resembles $\widehat{\gamma_{c(i)}}$, that is, our inflation adjusted measure of downward wage rigidity. Following our approach to calculate $\widehat{\gamma}_i$, we subsequently average estimated residuals for each country and normalize this measure to have the same mean and standard deviation as our downward wage rigidity measure for advanced economies.

***Figure B1:*** *Downward Wage Rigidities based on Payroll Data*




***(a)*** *Nominal Wage Freezes and Inflation*




***(b)*** *Our Wage Rigidity Measure versus Payroll Evidence*

***Notes***: *Panel (a): The panel presents results from a bivariate second order polynomial OLS regression. Dependent variable (y-axis): Share of employees receiving nominal wage freezes in %. Independent variable: Inflation in % (x-axis). Observations are added. We delete observations with more than 25 % annual inflation. Panel (b): Scatter plot with line of best fit representing the relationship between our downward wage rigidity measure ($\widehat{\gamma}_i$) and a measure based on payroll data. See text for details.*

Figure B1, Panel (b) plots the downward wage rigidity measure based on payroll data against our measure. As apparent, the correlation between both is positive. Particularly, Portugal is identified as the most rigid in the overlapping sample based on both measures. One might be worried that the positive slope is entirely driven by this one observation, but we obtain identical patterns when we plot ranks rather than the estimates themselves. Table B1 provides more details and tabulates both measures. In terms of outliers, we perfectly match Portugal and are close for the United Kingdom, which is identified as having less than average downward wage rigidities in the payroll data. The measures differ for Italy, which we classify as less rigid, but payroll data suggests more pronounced rigidities. Overall though, most advanced economies in this subsample have similar wage rigidities according to our measure. We find corresponding evidence based on payroll data.

Of course, this exercise is not without limitations. The overlap between both measures is imperfect even though they do resemble each other. However, even payroll data is subject to noise when comparing different countries: payroll reporting standards differ, and studies resort to different samples (e.g. blue-collar versus white-collar workers). Thus, while the results in this section support our downward wage rigidity

***Table B1:*** *Comparison: Our Measure versus Payroll Evidence*

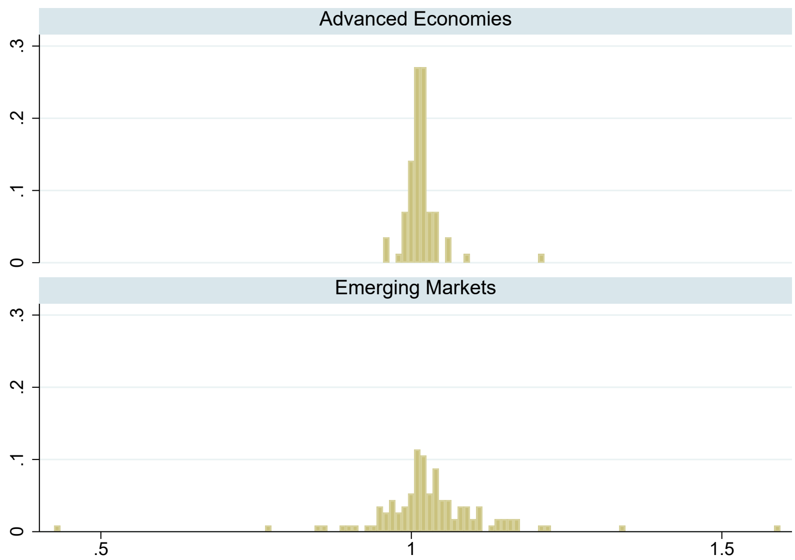
| Country | $\widehat{\gamma}_i$ | Payroll |
|---|---|---|
| Portugal | 1.023 | 1.071 |
| United States | 1.02 | 1.012 |
| Finland | 1.019 | 1.013 |
| Spain | 1.019 | 1.014 |
| Germany | 1.015 | 1.021 |
| Sweden | 1.015 | 1.015 |
| Austria | 1.014 | 1.005 |
| Korea, Republic of | 1.013 | 1.001 |
| Italy | 1.009 | 1.023 |
| United Kingdom | 1.008 | 1.014 |

***Notes****: This table compares our downward wage rigidity measure based on aggregate data with evidence from payroll records and pay slips (Elsby and Solon, 2019). Column 2 displays downward wage rigidities according to our measure from Table 2 ($\widehat{\gamma}_i$). A higher value signals more pronounced rigidities. The estimates in Column 3 are based on payroll data. A higher value signals more pronounced rigidities. The payroll estimates are normalized to feature the same mean and standard deviation as our measure. See text for details.*

measure, it should be complemented with additional evidence. This motivates our extensive robustness checks and extensions in Sections 4 and 5.

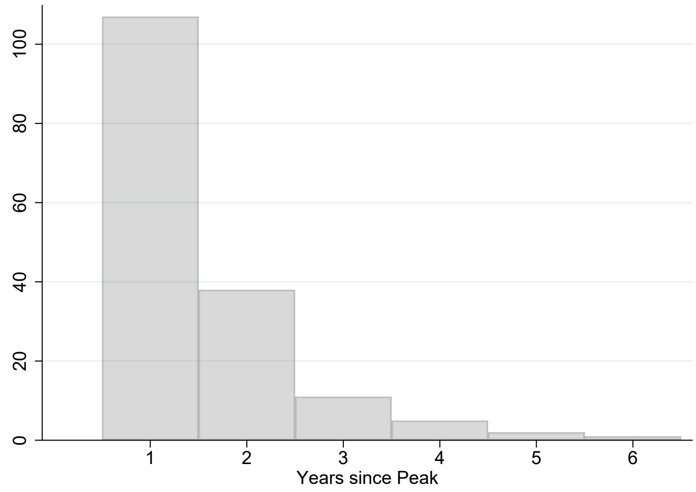
# C. Appendix: Figures

***Figure C1:*** *Cycle-specific Downward Wage Rigidity Estimates ($\widehat{\gamma_{c(i)}}$)*



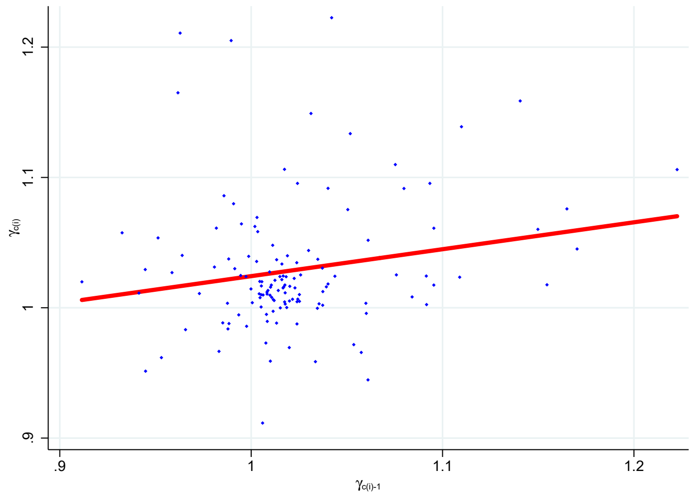

***Notes****: Distribution for $\widehat{\gamma_{c(i)}}$ as specified by equation (2) split by advanced and emerging markets.*

***Figure C2:*** *Duration of Recessions*




***Notes****: Each bar represents the number of ongoing recessions h years after the peak for the entire sample. Each recession by construction lasts at least one year.*

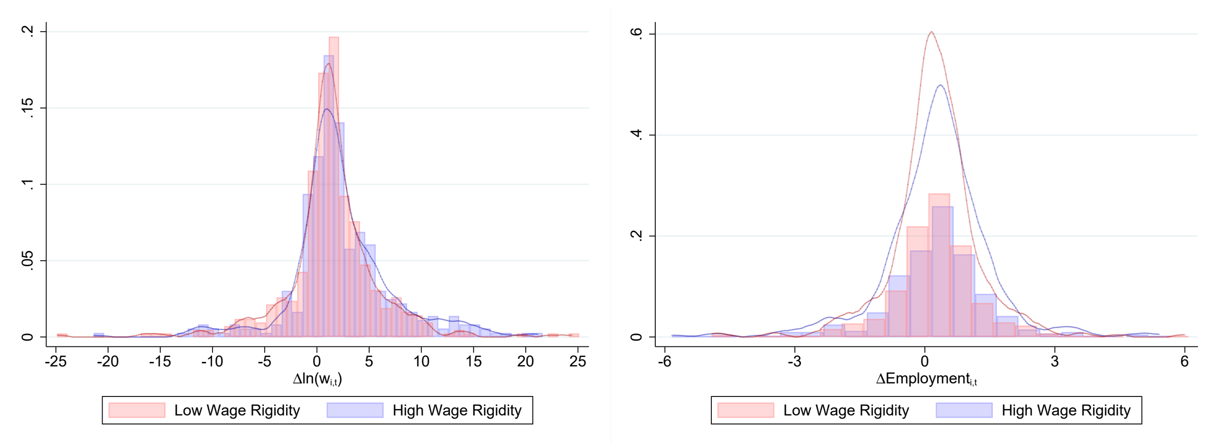
***Figure C3:*** *Within-Country Correlation of Downward Wage Rigidities*




***Notes****: The figure portrays the relationship between country-specific downward wage rigidity estimates based on a bivariate OLS regression. Dependent variable (y-axis):* $\widehat{\gamma_{c(i)}}$. *Independent variable:* $\widehat{\gamma_{c(i)-1}}$. *Observations are added. The chart excludes outliers defined as* $\widehat{\gamma_{c(i)}} > 1.3$ *or* $\widehat{\gamma_{c(i)}} < 0.9$.

***Figure C4:*** *Wage Rigidities and Labor Markets during Expansions*

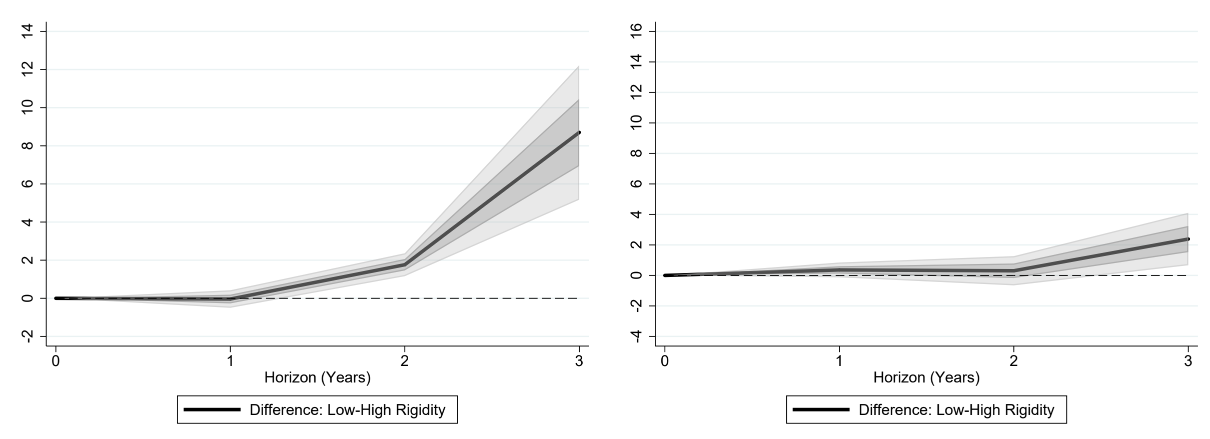
***(a)*** *Δln Wage* ***(b)*** *Δ Employment*




***Notes***: *Real wage growth (in %) and changes in the employment to population ratio (in pp) at annual frequency during expansions based on the degree of downward wage rigidity. Expansions are defined by positive real GDP growth. Solid lines represent kernel densities and bars the raw data. "Low (High) Wage Rigidity" refers to subsamples with wage rigidities below (above) the sample median, which we define separately for AEs and EMs.*

***Figure C5:*** *Recession Paths: All Countries, Low minus High Downward Wage Rigidity*

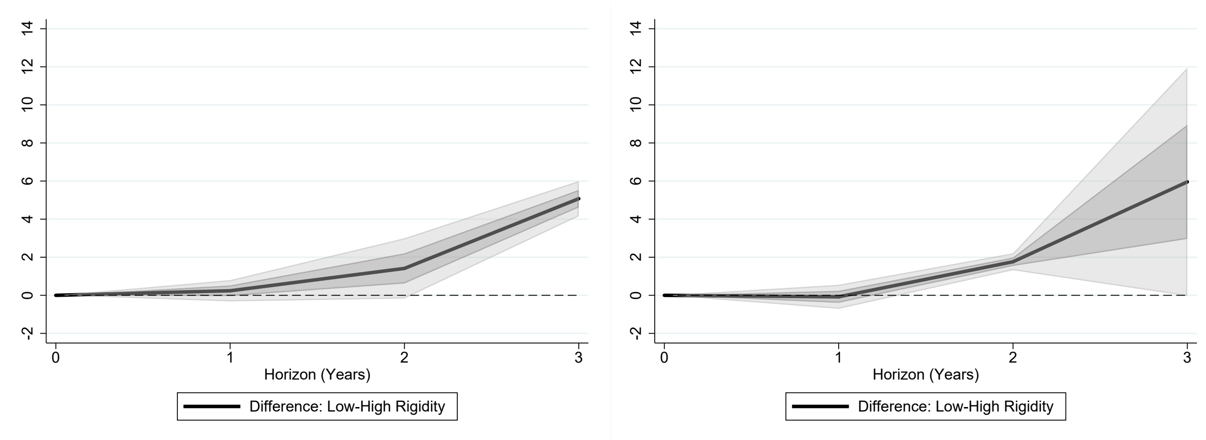
***(a)*** *Employment* ***(b)*** *GDP*




***Notes***: *Local Projections as specified in equation (4). The charts plot the cumulative difference (in pp) between the low and high rigidity response for the employment to population ratio (Panel (a)) and real GDP per capita (Panel (b)). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

***Figure C6:*** *Recession Paths: Employment, AEs versus EMs, Low minus High Downward Wage Rigidity*

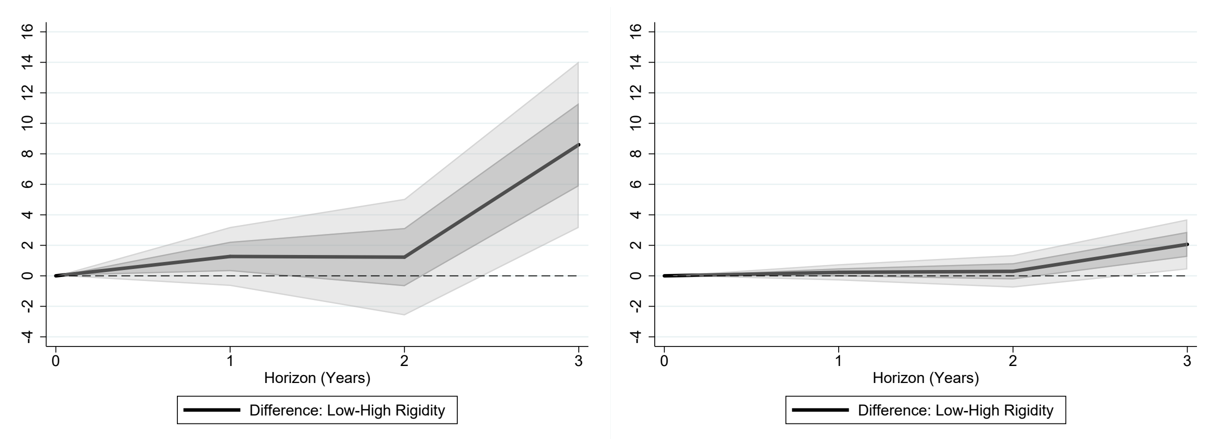
***(a)*** *Advanced Economies* ***(b)*** *Emerging Markets*




***Notes***: *Local Projections as specified in equation (4). The charts plot the cumulative difference (in pp) between the low and high rigidity response for the employment to population ratio among advanced economies (Panel (a)) and emerging markets (Panel (b)). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

***Figure C7:*** *Recession Paths: GDP, AEs versus EMs, Low minus High Downward Wage Rigidity*

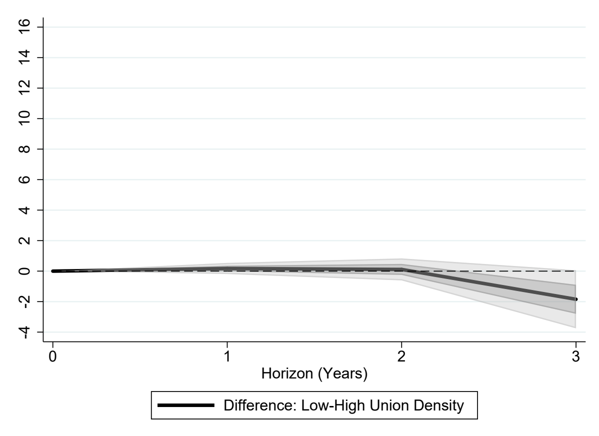
***(a)*** *Advanced Economies* ***(b)*** *Emerging Markets*



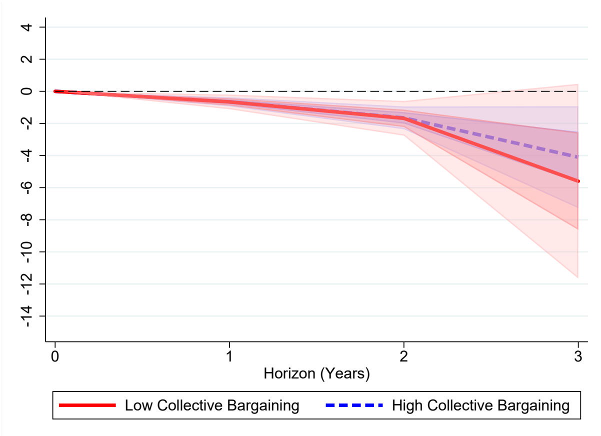

***Notes***: *Local Projections as specified in equation (4). The charts plot the cumulative difference (in pp) between the low and high rigidity response for real GDP per capita among advanced economies (Panel (a)) and emerging markets (Panel (b)) "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

**Figure C8:** *Union Density, Collective Bargaining and Employment*

***(a)*** *Union Density*



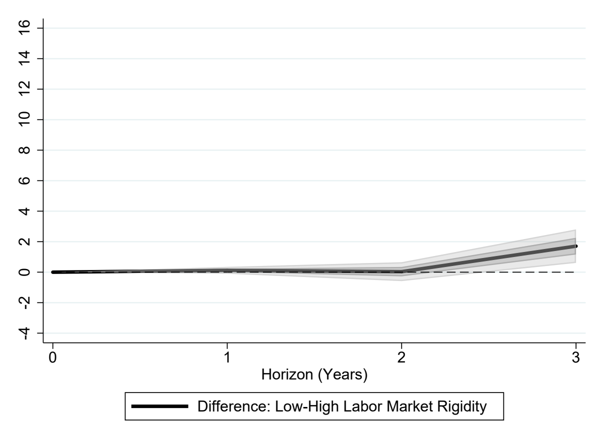

***(b)*** *Collective Bargaining*



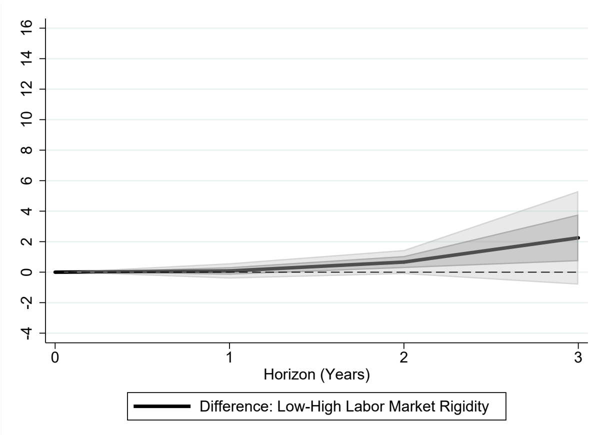

***Notes***: *Panel (a): Local Projections as specified in equation (4) with downward wage rigidities replaced by union density. Union density for each country is averaged over the sample period 1995-2020. The charts plot the cumulative difference between the low and high union density response for the employment to population ratio (in pp). "Low (High) Union Density" corresponds to the response of a country with -0.5(+0.5) standard deviations in union density from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates. Panel (b): Local Projections as specified in equation (4) with downward wage rigidities replaced by prevalence of collective bargaining. Collective bargaining for each country is averaged over the sample period 1995-2020. Dependent variable: Cumulative change in the employment to population ratio (in pp). "Low (High) Collective Bargaining" corresponds to the response of a country with -0.5(+0.5) standard deviations in collective bargaining from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

**Figure C9:** *Recession Paths: All Countries, Low minus High De Jure Labor Market Rigidity*

***(a)*** *Employment*



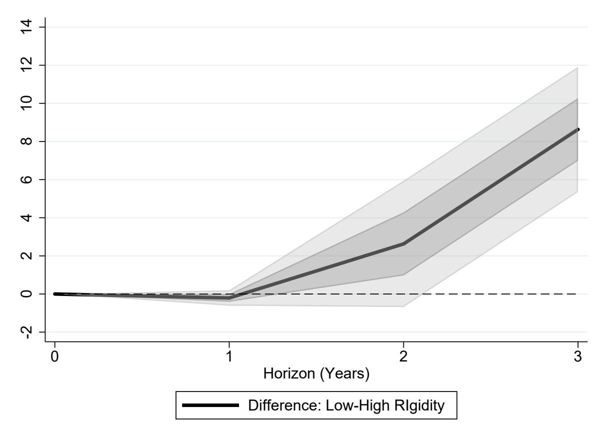

***(b)*** *GDP*



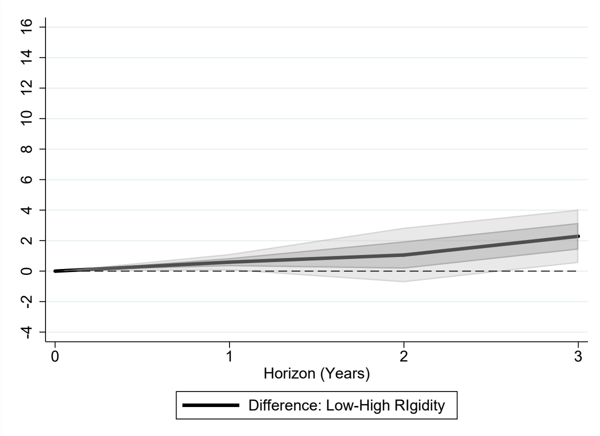

***Notes***: *Local Projections as specified in equation (4). The wage rigidity indicator is replaced by de jure labor market restrictions as defined in Campos and Nugent (2012). The charts plot the cumulative difference (in pp) between the low and high rigidities response for the employment to population ratio (Panel (a)) and real GDP per capita (Panel (b)). "Low (High) Labor Market Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in de jure labor market restrictions from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

*Figure C10:* *Robustness Check: Including Variables Related to the Rigidity Measure (All Countries)*

***(a)*** *Employment*



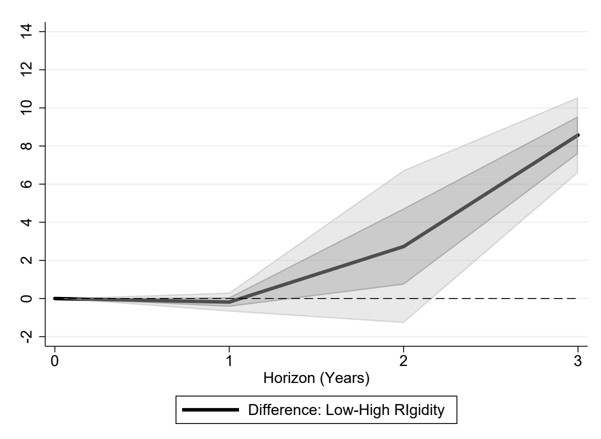

***(b)*** *GDP*



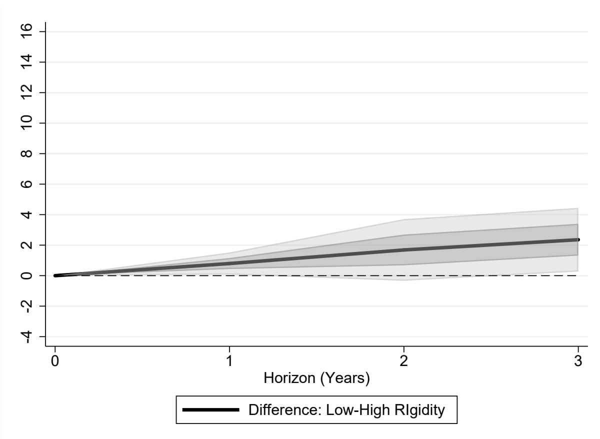

***Notes***: *Local Projections as specified in equation (5), which include three control variables that are possibly related to our downward wage rigidity measure: collective bargaining, union density, and de jure labor market rigidities. The charts plot the cumulative difference (in pp) between the low and high rigidity response for the employment to population ratio (Panel (a)) and real GDP per capita (Panel (b)). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

*Figure C11:* *Robustness Check: Including Minimum Wage Growth (All Countries)*

***(a)*** *Employment*



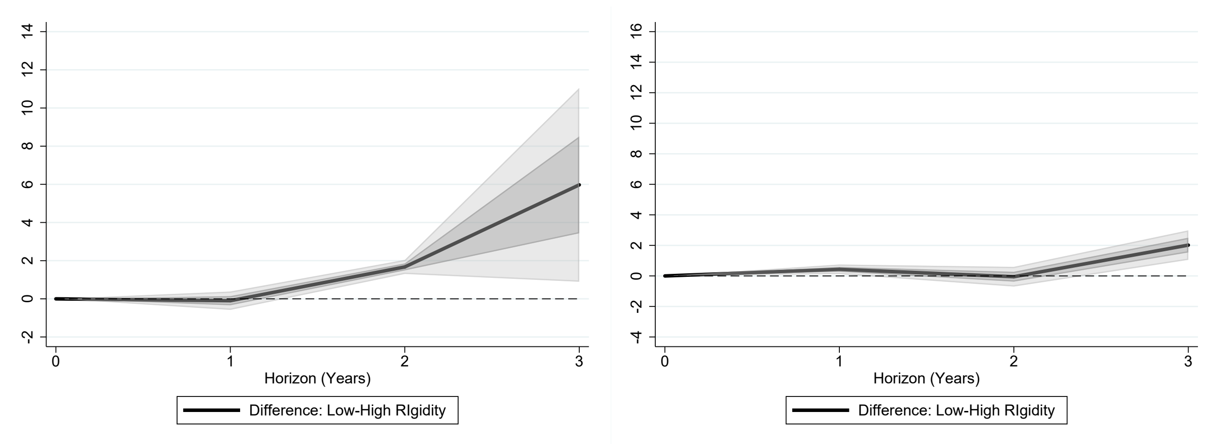

***(b)*** *GDP*




***Notes***: *Local Projections as specified in equation (5), which add minimum wage growth to the three remaining labor market related control variables (collective bargaining, union density, and de jure labor market rigidities). The charts plot the cumulative difference (in pp) between the low and high rigidity response for the employment to population ratio (Panel (a)) and real GDP per capita (Panel (b)). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

**Figure C12:** *Robustness Check: Including Other Variables (All Countries)*

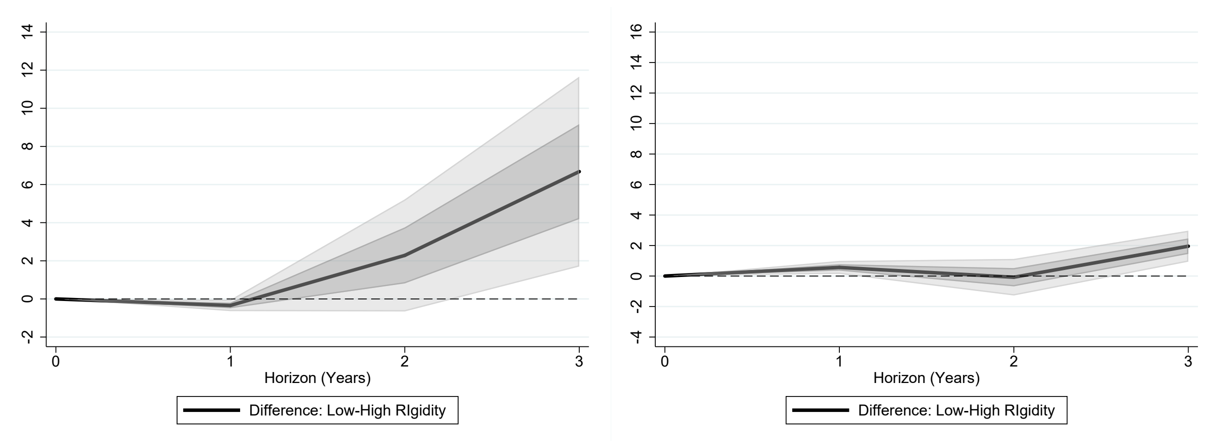
***(a)*** *Employment* ***(b)*** *GDP*




***Notes***: *Local Projections as specified in equation (5), which include four control variables that are not directly related to our downward wage rigidity measure, but may influence recession dynamics: credit-to-GDP ratios prior to recessions, export-to-GDP ratios, oil prices, and the bilateral exchange rate relative to the U.S. dollar. The charts plot the cumulative difference (in pp) between the low and high rigidity response for the employment to population ratio (Panel (a)) and real GDP per capita (Panel (b)). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

**Figure C13:** *Robustness Check: Including All Variables (All Countries)*

***(a)*** *Employment* ***(b)*** *GDP*




***Notes***: *Local Projections as specified in equation (5) which include all control variables, i.e., the two sets of variables included in Figures C10 and C12. The charts plot the cumulative difference (in pp) between the low and high rigidity response for the employment to population ratio (Panel (a)) and real GDP per capita (Panel (b)). "Low (High) Wage Rigidity" corresponds to the response of a country with -0.5(+0.5) standard deviations in downward wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

# D. Appendix: Tables

***Table D1:*** *Unemployment - Trough Preceding Cycle*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **EMs** | | | | | | | | |
| Argentina | 2008 | 2011 | | | | | | |
| Armenia | 2013 | 2016 | 2019 | | | | | |
| Bolivia | 2001 | 2008 | 2012 | 2014 | 2019 | | | |
| Bosnia and Herzegovina | 2008 | 2013 | | | | | | |
| Brazil | 2002 | 2004 | 2008 | 2011 | 2014 | 2019 | | |
| Cambodia | 2009 | 2013 | 2015 | | | | | |
| Chile | 2013 | 2015 | | | | | | |
| Colombia | 2007 | 2015 | | | | | | |
| Costa Rica | 2000 | 2004 | 2007 | 2010 | 2013 | 2017 | | |
| Dominican Republic | 2000 | 2002 | 2004 | 2008 | 2010 | 2014 | 2017 | |
| Ecuador | 2001 | 2007 | 2013 | 2018 | | | | |
| El Salvador | 2002 | 2004 | 2008 | 2013 | 2015 | | | |
| Guatemala | 2006 | 2012 | 2015 | | | | | |
| Honduras | 2008 | 2012 | 2015 | 2017 | 2019 | | | |
| Hungary | 2002 | 2007 | 2019 | | | | | |
| Indonesia | 2014 | 2019 | | | | | | |
| Malaysia | 2012 | 2014 | 2018 | | | | | |
| Mauritius | 2002 | 2008 | 2011 | 2013 | | | | |
| Mexico | 2005 | 2012 | 2018 | | | | | |
| Mongolia | 2008 | 2012 | | | | | | |
| Pakistan | 2007 | 2014 | | | | | | |
| Panama | 2001 | 2011 | 2013 | 2018 | | | | |
| Paraguay | 1998 | 2001 | 2005 | 2008 | 2010 | 2012 | 2015 | 2017 |
| Peru | 2001 | 2003 | 2012 | 2014 | 2019 | | | |
| Philippines | 2007 | 2013 | 2019 | | | | | |
| Poland | 1998 | 2008 | 2011 | 2019 | | | | |
| South Africa | 2011 | 2013 | 2018 | | | | | |
| Sri Lanka | 2014 | 2017 | | | | | | |
| Thailand | 2019 | | | | | | | |
| Turkey | 2006 | 2012 | 2017 | | | | | |
| Uruguay | 2011 | 2013 | | | | | | |
| Vietnam | 2011 | 2014 | 2016 | 2018 | | | | |
| **AEs** | | | | | | | | |
| Austria | 1997 | 2001 | 2003 | 2008 | 2011 | 2019 | | |
| Belgium | 1997 | 2001 | 2004 | 2008 | 2011 | 2019 | | |
| Czech Republic | 2019 | | | | | | | |
| Denmark | 1998 | 2001 | 2008 | 2019 | | | | |
| Finland | 2001 | 2008 | 2012 | 2019 | | | | |
| France | 2001 | 2003 | 2008 | 2011 | 2019 | | | |
| Germany | 2001 | 2008 | 2019 | | | | | |
| Iceland | 1996 | 2001 | 2005 | 2007 | 2018 | | | |
| Italy | 2007 | 2011 | | | | | | |
| Japan | 1997 | 2000 | 2007 | 2019 | | | | |
| Korea, Republic of | 1996 | 2002 | 2008 | 2013 | 2017 | 2019 | | |
| Latvia | 2001 | 2007 | 2019 | | | | | |
| Lithuania | 2007 | 2018 | | | | | | |
| Luxembourg | 1997 | 2001 | 2005 | 2007 | 2010 | 2014 | 2017 | |
| New Zealand | 1996 | 2005 | 2007 | 2011 | 2019 | | | |
| Portugal | 2000 | 2008 | 2019 | | | | | |
| Slovak Republic | 1996 | 2003 | 2008 | 2011 | 2019 | | | |
| Spain | 2001 | 2007 | 2019 | | | | | |
| Sweden | 2001 | 2007 | 2011 | 2018 | | | | |
| United Kingdom | 2001 | 2004 | 2007 | 2019 | | | | |
| United States | 2000 | 2007 | 2019 | | | | | |

***Notes****: The table displays the year prior to each unemployment cycle, that is, the local minimum in the unemployment rate. We only include cycles with data on real wages.*

*__Table D2:__ Cycle-specific Downward Wage Rigidity Estimates*

| EMs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Argentina | 1.141 | 1.159 | | | | | | |
| Armenia | 1.035 | 1.003 | 1.069 | | | | | |
| Bolivia | .991 | 1.08 | 1.092 | 1.024 | 1.007 | | | |
| Bosnia and Herzegovina | 1.022 | 1.023 | | | | | | |
| Brazil | .991 | 1.03 | 1.044 | .89 | 1.019 | 1.04 | | |
| Cambodia | 1.042 | 1.223 | 1.106 | | | | | |
| Chile | 1.17 | 1.045 | | | | | | |
| Colombia | .941 | 1.011 | | | | | | |
| Costa Rica | .953 | .962 | 1.165 | 1.076 | 1.025 | 1.005 | | |
| Dominican Republic | 1.012 | .859 | 1.15 | 1.06 | .996 | .847 | .959 | |
| Ecuador | .424 | 1.005 | 1.01 | .959 | | | | |
| El Salvador | .933 | 1.058 | .966 | .983 | .967 | | | |
| Guatemala | .951 | 1.054 | .972 | | | | | |
| Honduras | 1.006 | .912 | 1.02 | .969 | 1.586 | | | |
| Hungary | 1.037 | 1.002 | 1.062 | | | | | |
| Indonesia | .999 | 1.039 | | | | | | |
| Malaysia | 1.04 | 1.092 | 1.002 | | | | | |
| Mauritius | 1.05 | 1.075 | 1.11 | 1.139 | | | | |
| Mexico | .994 | .995 | 1.025 | | | | | |
| Mongolia | 1.155 | 1.018 | | | | | | |
| Pakistan | 1.011 | 1.048 | | | | | | |
| Panama | .982 | 1.061 | 1.052 | 1.134 | | | | |
| Paraguay | 1.069 | .772 | 1.044 | 1.024 | 1.095 | 1.061 | .945 | 1.029 |
| Peru | 1.338 | .897 | 1.008 | .99 | 1.205 | | | |
| Philippines | .981 | 1.031 | 1.149 | | | | | |
| Poland | 1.084 | 1.008 | 1.011 | 1.017 | | | | |
| South Africa | 1.008 | .973 | 1.011 | | | | | |
| Sri Lanka | 1.109 | 1.023 | | | | | | |
| Thailand | 1.094 | | | | | | | |
| Turkey | 1.035 | 1.037 | 1.03 | | | | | |
| Uruguay | 1.023 | 1.015 | | | | | | |
| Vietnam | 1.093 | 1.095 | 1.017 | 1.106 | | | | |
| **AEs** | | | | | | | | |
| Austria | 1.014 | 1.013 | .988 | 1.037 | 1.012 | 1.021 | | |
| Belgium | 1.018 | 1.011 | .997 | 1.024 | 1.005 | 1.008 | | |
| Czech Republic | 1.026 | | | | | | | |
| Denmark | 1.017 | 1.015 | 1 | 1.014 | | | | |
| Finland | 1.026 | 1.025 | 1.01 | 1.016 | | | | |
| France | 1.012 | 1.006 | 1.01 | 1.01 | 1.028 | | | |
| Germany | 1.005 | 1.017 | 1.024 | | | | | |
| Iceland | 1.039 | 1.016 | 1.034 | .959 | 1.027 | | | |
| Italy | 1.019 | 1 | | | | | | |
| Japan | .985 | .988 | .988 | .984 | | | | |
| Korea, Republic of | .964 | 1.04 | 1.018 | 1.024 | 1.035 | 1 | | |
| Latvia | 1.06 | 1.003 | 1.058 | | | | | |
| Lithuania | .963 | 1.211 | | | | | | |
| Luxembourg | 1.008 | 1.012 | 1.006 | 1.02 | 1.005 | 1.001 | 1.004 | |
| New Zealand | 1.018 | 1.017 | 1.004 | 1.02 | 1.016 | | | |
| Portugal | .998 | .986 | 1.086 | | | | | |
| Slovak Republic | 1.004 | 1.011 | 1.008 | .995 | 1.064 | | | |
| Spain | 1.018 | 1.003 | 1.036 | | | | | |
| Sweden | 1.017 | 1.016 | 1.022 | 1.007 | | | | |
| United Kingdom | 1.015 | 1.024 | .988 | 1.003 | | | | |
| United States | 1.009 | 1.013 | 1.037 | | | | | |

***Notes**: The table displays individual $\widehat{\gamma_{c(i)}}$ estimates. The ordering resembles the unemployment cycles in Table D1.*

***Table D3:*** *Business Cycle Peaks*

| EMs | | | | | |
|---|---|---|---|---|---|
| Argentina | 1998 | 2008 | 2011 | 2013 | 2015 |
| Armenia | 2008 | 2015 | | | |
| Bolivia | 1998 | 2000 | | | |
| Bosnia and Herzegovina | 2008 | | | | |
| Brazil | 1997 | 2002 | 2008 | 2013 | |
| Cambodia | 2008 | | | | |
| Chile | 1998 | 2008 | 2016 | | |
| Colombia | 1997 | 2016 | | | |
| Costa Rica | 2008 | | | | |
| Dominican Republic | 2002 | 2008 | | | |
| Ecuador | 1998 | 2008 | 2014 | | |
| El Salvador | 2008 | | | | |
| Guatemala | 2000 | 2008 | | | |
| Honduras | 1998 | 2008 | | | |
| Hungary | 2008 | 2011 | | | |
| Indonesia | 1997 | | | | |
| Malaysia | 1997 | 2000 | 2008 | | |
| Mexico | 2000 | 2007 | | | |
| Mongolia | 2008 | 2015 | | | |
| Pakistan | 1996 | 2007 | 2009 | | |
| Panama | 2000 | 2008 | | | |
| Paraguay | 1997 | 2008 | 2011 | | |
| Peru | 1997 | 2000 | | | |
| Philippines | 1997 | 2008 | | | |
| South Africa | 1997 | 2008 | 2013 | | |
| Sri Lanka | 2000 | | | | |
| Thailand | 1996 | 2008 | | | |
| Turkey | 1998 | 2000 | 2007 | 2018 | |
| Uruguay | 1998 | | | | |
| **AEs** | | | | | |
| Austria | 2008 | 2012 | | | |
| Belgium | 2007 | 2012 | | | |
| Czech Republic | 1996 | 2008 | 2011 | | |
| Denmark | 2007 | 2011 | | | |
| Finland | 2008 | 2011 | | | |
| France | 2007 | 2011 | | | |
| Germany | 2001 | 2008 | | | |
| Iceland | 2001 | 2008 | | | |
| Italy | 2002 | 2007 | 2011 | | |
| Japan | 1997 | 2001 | 2007 | | |
| Korea, Republic of | 1997 | | | | |
| Latvia | 2007 | | | | |
| Lithuania | 1998 | 2008 | | | |
| Luxembourg | 2007 | 2010 | 2014 | 2016 | |
| New Zealand | 1997 | 2007 | | | |
| Portugal | 2002 | 2008 | 2010 | | |
| Slovak Republic | 1998 | 2008 | | | |
| Spain | 2007 | | | | |
| Sweden | 2007 | 2011 | | | |
| United Kingdom | 2007 | | | | |
| United States | 2007 | | | | |

***Notes****: Business cycle peaks as identified with the Bry and Boschan (1971) algorithm.*

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