ISSN 1936-5330

kc FED Research Working Papers

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

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

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December 1, 2022

***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. Labor unions in contrast stabilize employment during recessions.

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

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

*We thank Cooper Howes, Matthew Notowidigdo, Matthias Rottner, 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. Alice E Von Ende-Becker provided excellent research assistance. 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.

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# 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). Several studies have also analyzed the macroeconomic consequences of downward wage rigidities using both quantitative and theoretical macroeconomic models (see, for example, Hall, 2005; Blanchard and Gali, 2007; Gertler and Trigari, 2009; Benigno and Ricci, 2011; Schmitt-Grohe and Uribe, 2016).

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 the forces driving downward wage rigidities.

We make three contributions. First, we calculate downward real wage rigidities – a constraint that impedes downward real wage adjustments – 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 real 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 real 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 show how our wage rigidity measure, which is based on aggregate

data, relates to micro-level data as well as other key labor market features. On one hand, we show that our wage rigidity 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 driven by 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 real 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 real wage rigidities, with a larger fraction referring to stronger rigidities.[1] Notice this fraction is usually greater than one, as hourly real earnings tend to grow even during adverse macroeconomic conditions. The challenge with this 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 spells'), in which labor markets exert downward pressure on wages or at least moderate wage growth. In other words, wage growth during unemployment spells is informative about downward rigidities – either the constraint binds and thus we can directly estimate the extent of downward real wage rigidities, or the constraint does not bind, in which case

[1]The different inflationary environments among EMs and between AEs and EMs explain why we focus on real rather than nominal wage rigidities, the latter refering to a tendency to oppose nominal wage declines. With higher inflation, workers are reluctant to accept real wage cuts and hence index nominal wages to inflation, which induces real wage rigidities (see, for example, Goette et al., 2007; Messina and Sanz-de Galdeano, 2014). In addition, real wage rigidities and nominal wage rigidities coincide when inflation is low.

wage growth is likely lower or negative and we observe no/minor downward wage rigidities.[2]

A cross-country comparison of downward real wage rigidities based on this procedure reveals two findings. First, downward real 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 real wage rigidities show substantial heterogeneity across emerging markets, but less so among advanced economies.

Next, we empirically examine the macroeconomic implications of downward real 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 than countries with low wage rigidities.

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 the 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, we provide direct evidence of downward wage rigidities driving aggregate dynamics. Abbritti and Fahr (2013) provide indirect evidence on the aggregate relevance of wage rigidities via asymmetric business cycle statistics and the behavior of wages versus employment during recessions. Related, 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.

[2] A third option is that wages could grow sizably even though the wage constraint does not bind. This is unlikely, however, as we focus on periods with adverse labor market conditions.

We conduct several exercises to help understand the labor market frictions that our measure captures. First, we examine its relationships with a wide range of labor market features and find that it extracts information from minimum wage growth and de jure labor market restrictions. Second, we conduct a placebo regression and verify that our measure has no effect on employment during expansions, consistent with the one-sided nature of the rigidity. Third, we show that our measure reflects realistic dynamics with respect to wage growth and unemployment. In particular, wage growth rates in countries with high downward wage rigidities are not sensitive to the unemployment rate – when unemployment is high and the downward wage constraint likely binding. All this evidence suggests that our rigidity measure captures important micro-level labor market frictions that prevent downward wage adjustments. Further support for the presence of downward wage rigidities in aggregated data is also articulated in Holden and Wulfsberg (2009), or Loipersberger and Matschke (2022).

We structure the remaining paper as follows: Section 2 defines downward real wage rigidities in a simple structural model. Section 3 estimates downward real 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 real wage rigidities and provides several robustness checks. Section 6 concludes.

## 2. Structural Framework

We start with a simple structural model which explicitly defines downward real 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 focus on 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,

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

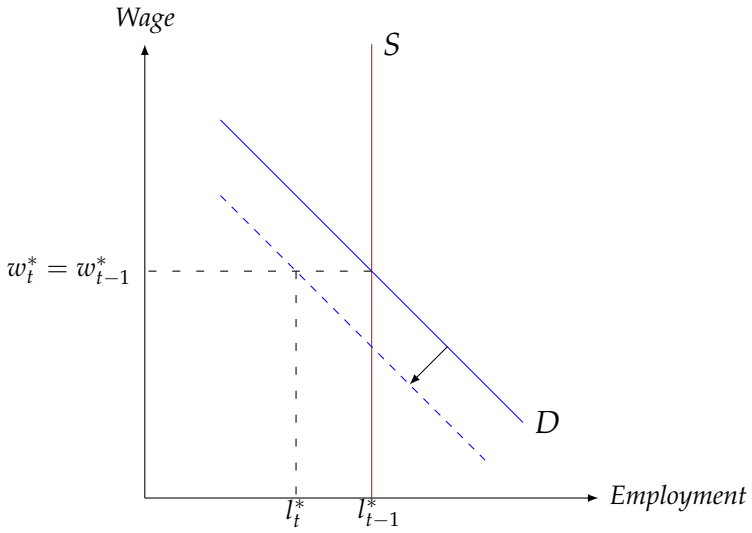
The function $F$ is strictly increasing and concave. The variable $A_t$ represents an exogenous technology process. However, real wages must at least equal $\gamma$ times the real wage in the previous period, which puts a floor on wages. Formally,

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

The parameter $\gamma$ captures the strength of the real 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.

***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.*

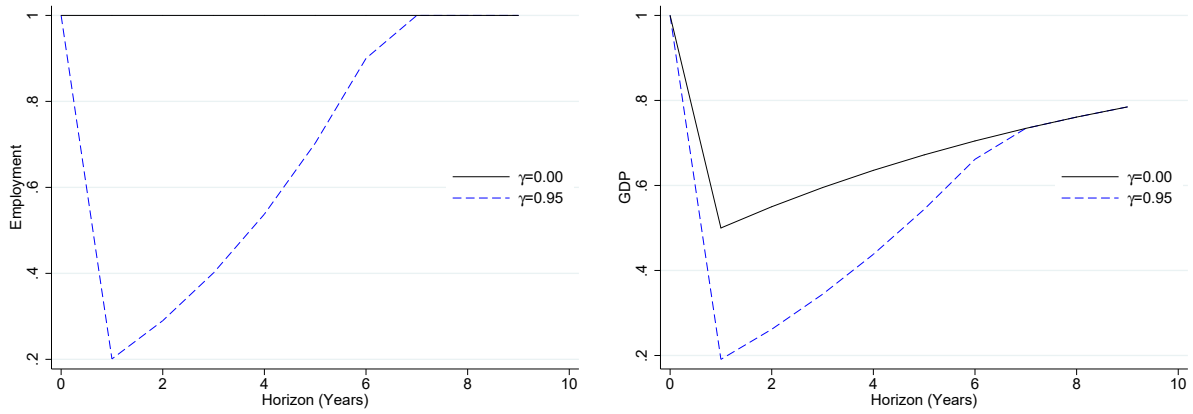
[3]We define wage rigidities in terms of real rather than nominal wages. This contrasts with, for example, Schmitt-Grohe and Uribe (2016), or Ottonello (2021). The different approach is motivated by empirical regularities as explained in Section 3.

**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.

Focusing on Panel (a), 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.

***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: $l^{max} = 1$, $\alpha = 0.6$, $\rho_0 = 0.1$, $\rho_1 = 0.9$, $A_1 = 0.5$.*

## 3. Determining Real Wage Rigidities

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

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

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. Though wage rigidities likely change over time, this process appears slow with no material effect over the sample period of 25 years. We are not aware of empirical studies that document sizable changes in wage rigidities 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.

We could in principle estimate $\gamma_i$ by calculating gross real wage growth between two periods, in our case two consecutive years. However, this approach is only legitimate if constraint (1) 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. Before, we describe why we focus on real instead of nominal wages and explain the data.

There are several reasons why we analyze real instead of nominal wages. First, when inflation is elevated, as is true for many emerging markets, workers are reluctant to accept wages that do not grow with the level of expected inflation. They hence condition on non-negative real rather than nominal wage growth, which induces real wage rigidity (Goette et al., 2007; Messina and Sanz-de Galdeano, 2014). Second, emerging markets experience heterogeneous inflation environments. Because workers condition on expected inflation, one could therefore conclude that wage rigidities are more severe in high inflation environments, even when this difference is driven by distinct inflation expectations. By adjusting for inflation, we circumvent this issue and essentially normalize wage rigidities. Third, for advanced economies with stable and low inflation, nominal and real wage rigidities tend to coincide and the distinction between nominal and real becomes less relevant.

It is important to recognize that real wages in equation (1) refer to per-unit labor wages (see, also Section 2). We collect data on hourly earnings from the International Labor Organization (ILO) and the OECD. We rely on the OECD series for advanced economies. Both measures include overtime pay and regularly recurring cash supplements, but exclude benefits. 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.[4] Additional variables are described in the appendix.

## 3.1. Identification

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 structural unemployment. Positive unemployment therefore provides little guidance on whether the wage constraint binds or not, although high unemployment rates may imply 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. 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 limited 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.[5] We proceed as follows:

First, we identify unemployment spells in the dataset. A spell is defined by consecutive years with a rising unemployment rate. Each spell lasts at least one year, but a spell can also last multiple years in case a country experiences prolonged adverse effects on labor markets. Table A2 in the appendix lists the year prior to each individual spell. Each year therefore indicates a local minimum in the unemployment rate. Overall, we classify 198 unemployment spells, 113 for emerging markets and 85 for advanced economies.

Second, we back out one estimate for downward real wage rigidity per unemployment spell. At this point we need to introduce notation. Individual spells

[4]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 and deleted abnormal values which are likely due to data errors. Our analysis excludes Egypt and Venezuela because of at times extremely high and possibly unanchored inflation.

[5]Although we estimate downward wage rigidities during rising unemployment rather than a high level of unemployment, we obtain realistic dynamics between wage growth and the unemployment rate. As explained in Section 5, wage growth in countries with high estimated downward wage rigidities is not sensitive to the unemployment rate when unemployment is high, unlike countries with low/no downward wage rigidities.

in country $i$ are indexed by $s(i) \in \mathbb{Z}$ for $s(i) = 1,..., S(i)$, that is, there are $S(i)$ unemployment spells in country $i$. Related, we index the last calendar year of spell $s(i)$ by $T(s_i)$, and the year preceding the spell by $0(s_i)$. Lastly, the duration of each spell is characterized by $H(s_i)$. With these conventions, the downward real wage rigidity estimate of spell $s(i)$ can be calculated as

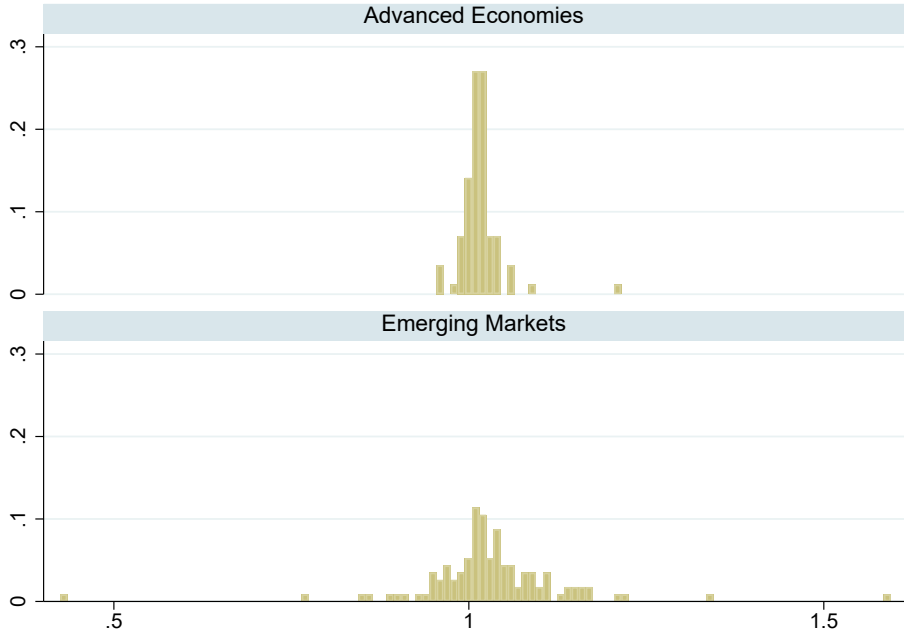
$$\widehat{\gamma_{s(i)}} = \left( \frac{w_{i,T(s_i)}}{w_{i,0(s_i)}} \right)^{\frac{1}{H(s_i)}} \tag{2}$$

The statistic simply measures annualized average real gross wage growth during spell $s$ for country $i$. We portray the distribution split by AEs and EMs in Figure 3. Individual estimates for each country are available in Table A3. As apparent, average annual real wage growth during periods of rising unemployment is generally positive ($\widehat{\gamma_{s(i)}} > 1$). However, there is considerable heterogeneity among emerging markets. Two outliers are visible. During the 2019 unemployment spell Honduras' real wage growth exceeded 50% annualized. In contrast, Ecuador witnessed real wage declines of more than 50% annualized during the 2001 spell. 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. This may be due to specific statistical procedures implemented by the ILO, which prevent a one-to-one mapping between policy actions, or the economic environment, and the hourly earnings series. We decided to include these two outliers in the analysis. Our results regarding the macro implications of wage rigidities in Section 4 are however not sensitive to this choice.

Third, we average over the spell-specific wage rigidity measures of country $i$. At this point we make use of the assumption that $\gamma_i$ is slow moving and hence constant for each country during the sample period of 25 years. As a consequence we can interpret each spell-specific estimate as a somewhat noisy signal for the underlying wage rigidity. By pooling these for each country, we therefore improve accuracy. There are two pieces of evidence supporting this approach: First, as apparent from Table A3, there is no consistent trend in the spell-specific estimates for individual countries. Second, the variation in $\widehat{\gamma_{s(i)}}$ between countries is larger than the variation within countries (not reported). Averaging over individual spells for each country subsequently delivers the country-specific wage rigidity estimate $\widehat{\gamma_i}$:

$$\widehat{\gamma_i} = \frac{\sum_{s(i)=1}^{S(i)} \widehat{\gamma_{s(i)}}}{S(i)} \tag{3}$$

***Figure 3:*** *Spell-specific Downward Real Wage Rigidity Estimates* ($\widehat{\gamma_{s(i)}}$)




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

## 3.2. Estimation Results

We provide insights on the prevalence of downward real wage rigidities across our sample of 53 countries in Tables 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 real 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 spells 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 display 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

***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 real 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 spells. $\widehat{\gamma}_i$ 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 spell-specific estimates in each country.*

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 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). Last but not least, column 4 in Tables 1 and 2 portray the number of spell specific estimates for each country. The United States for example experienced three periods of rising unemployment between 1995 and 2020.

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.[6] This 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.

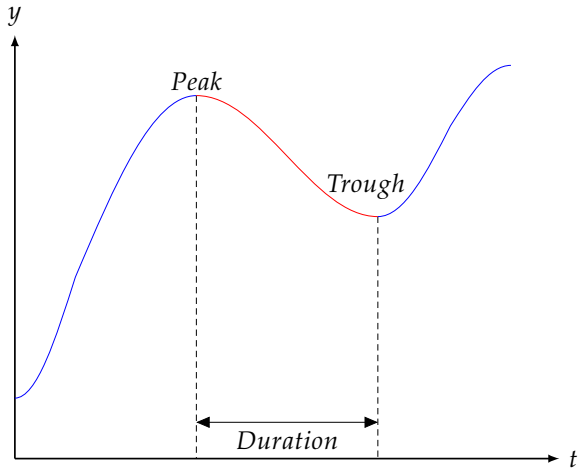
***Table 2:*** *Rigidities Advanced Economies*

| 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 real 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 spells. $\widehat{\gamma}_i$ 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 spell-specific estimates in each country.*

[6] 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.

***Figure 4:*** *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. Downward Wage Rigidities and Recession Dynamics

In this section, we empirically examine how downward real wage rigidities influence business cycles, focusing on recession periods. In particular, we investigate if countries that are subject to more pronounced real wage rigidities (higher $\widehat{\gamma}_i$) experience more severe recessions in terms of employment and GDP losses.

### 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 the remaining business cycles 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 4 illustrates the approach.

The algorithm extracts 107 recessions from 53 countries. Table A4 lists all individual

peaks. Most recessions are related to the Global Financial Crisis. A noticeable amount of recessions are also attributed to the European Debt Crisis and the Asian Financial 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 A1 provides insights on the duration of the 107 recessions. Most recessions last one year. Only very few recessions last more than three years.

## 4.2. Descriptive Evidence

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 % ('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 real 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.

***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 %). Duration is the peak to trough time in years. Rate is the annualized decline from peak to trough (in %) 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 real 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 real wage rigidities (4.4% versus 3.8%). The annualized decline is roughly 1.1 pp larger. We subsequently provide more nuanced insights from a formal regression analysis.

## 4.3. Formal Analysis Based on Local Projections

In this section, we formally examine the effects of downward real 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 real wage rigidities experience a significantly larger contraction in employment relative to countries with lower downward real 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 real wage rigidities, but less than 2 pp for countries with low downward real wage rigidities. Second, the impact of downward real 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 real 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 real wage rigidities had deviated from its conditional mean.[7] 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

[7] 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 spells and not recessions. These episodes only partially overlap.

$i$ 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 real 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 cumulated 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:

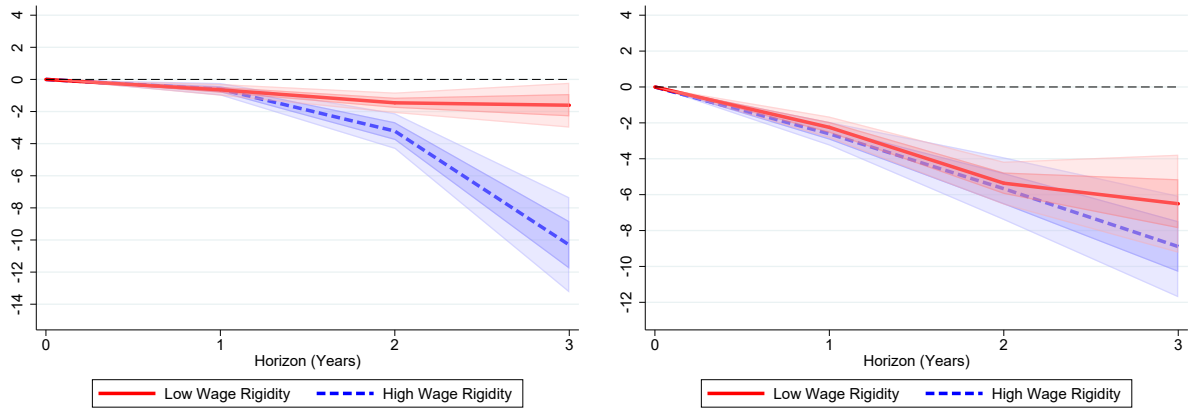
$$\begin{aligned} \{\beta_h + x\phi_h\}_{h=1}^{H}: &\quad \text{Avg.+xStd.Dev.} \\ \{\beta_h - x\phi_h\}_{h=1}^{H}: &\quad \text{Avg.-xStd.Dev.} \end{aligned}$$

We present our baseline results for the entire sample of advanced economies and emerging markets in Figure 5. The solid red line displays the typical path of a country with real 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.

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 year 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 A2 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.

***Figure 5:*** *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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

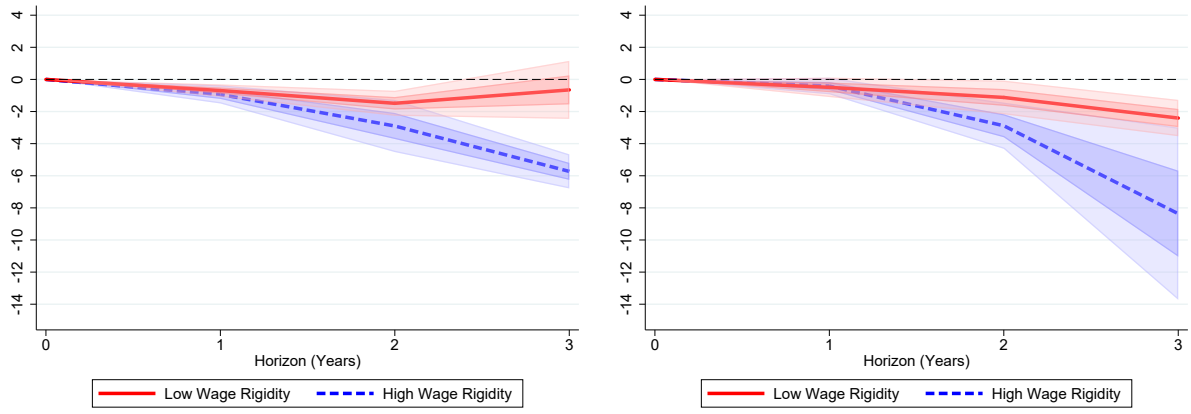
This difference is sizable, and significant as highlighted in Figure A2. Based on this evidence, we draw the following two conclusions: First, downward real wage rigidities have a strong impact on employment during most of the recession cycle. Second, the impact on real GDP is more muted and only observable 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 real wage rigidities primarily matter for advanced economies or emerging markets. Figure 6 provides insights for employment and Figure 7 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 6, 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 A3.

Wage rigidities influence output in advanced economies, but less so in emerging markets. Based on Panel (a), Figure 7, the recession path in AEs is somewhat more muted for countries with low wage rigidities during the first 2 years, but the difference

***Figure 6:*** *Recession Paths: Employment, Advanced Economies versus Emerging Markets*

***(a)*** *Advanced Economies* ***(b)*** *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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

is not significant as confirmed in Figure A4. 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 a quantitative point, downward real 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 hypothesis formally.

## 5. Robustness Checks and Discussion

The overarching conclusion from the last section is that downward real wage rigidities matter for business cycle dynamics. Accommodating the macro literature, we compute wage rigidities based on aggregate real wage growth rates during unemployment spells. In this section, we discuss how our measure is related to the evidence in the micro literature and also conduct robustness checks on our empirical results in the previous section.

Generally speaking, prevalent downward wage rigidities at the individual level will lead to higher average wage growth at the aggregate level. However, there are a

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

***(a)*** *Advanced Economies* ***(b)*** *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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

couple of caveats. First, wage rigidities could be mitigated by alternative adjustments through, for example, benefits (Babecký et al., 2010). As a consequence, total labor compensation might be less rigid. But if this mitigation fully compensates wage rigidities, we should not observe a larger decline in employment for countries with downward wage rigidities. Second, low-skilled workers are more likely to lose their jobs during recessions (Solon et al., 1994; Abraham and Haltiwanger, 1995). This counter-cyclical composition bias would likely dampen fluctuations in wage growth rates between recessions and expansions even absent wage rigidities. Our measure is likely not too sensitive to this concern as we define wage rigidities as more prevalent if a country experiences higher wage growth during an unemployment spell relative to other countries facing similar pressures on labor markets. Third, wage rigidities for individual job stayers need not imply the same rigidity for average wages, as new entrants into labor markets, or workers moving from one job to another, may not be subject to this constraint (Barattieri et al., 2014). This effect would dampen the significance of downward wage rigidities in driving business cycles.

In the subsequent sections, we show the following: (i) our wage rigidity measure aligns with minimum wage growth and a de jure measure of labor market rigidities, but differs from worker unions or collective bargaining agreements. All four factors are commonly cited as possible determinants for downward wage rigidities. Our evidence suggests that unions or bargaining agreements do not introduce downward wage rigidity and do not lead to employment losses during recessions; (ii) the downward

wage rigidity measure has no explanatory power during expansions and hence captures the one-sided constraint inherent to downward wage rigidity; (iii) wage growth rates in high downward wage rigidity countries are not sensitive to the unemployment rate, when unemployment is high and the wage constraint therefore likely binding. We do not observe such patterns in countries with low estimated downward wage rigidities; (iv) Our benchmark impulse response estimation on the importance of downward wage rigidities in shaping recession dynamics is robust to adding a variety of control variables; (v) the wage growth distribution during expansions closely resembles the distribution during recessions, providing reassurance that wages are sticky in aggregate data.

## 5.1. Downward Wage Rigidities and Other Labor Market Features

To provide more intuition about our downward wage rigidity measure, we discuss the relationship between this measure and several variables that could contribute to downward wage rigidities according to the applied micro literature. 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).

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). Unions and collective bargaining agreements in turn are perceived to increase the bargaining power of employees (Horn and Wolinsky, 1988). Because workers are reluctant to either nominal or real 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. Last but not least, 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).

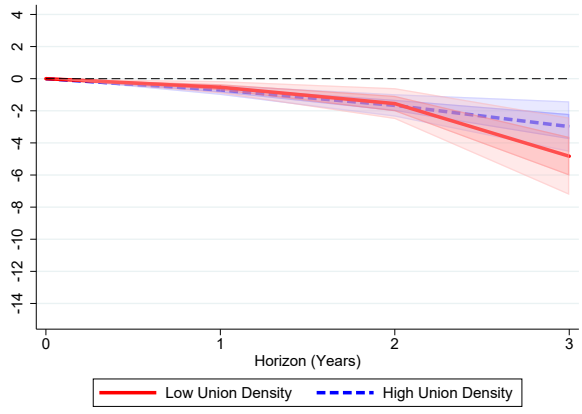
The downward real wage rigidity measure calculated in Section 3 is associated

with minimum wage growth. Figure 8, Panel (a), plots results from a simple bivariate regression where we regress the unemployment spell-specific downward real wage rigidity measure ($\widehat{\gamma_{s(i)}}$) 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 real wage rigidities. However, minimum wage growth does not adversely affect 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 (not reported). In sum, the wage rigidity measure extracts a signal from minimum wages, but other factors must play a role, too.

***Figure 8:*** *Explaining Wage Rigidities: Minimum Wages and Union Density*

***(a)*** *Minimum Wages and Downward Wage Rigidities*


***(b)*** *Union Density and Employment*

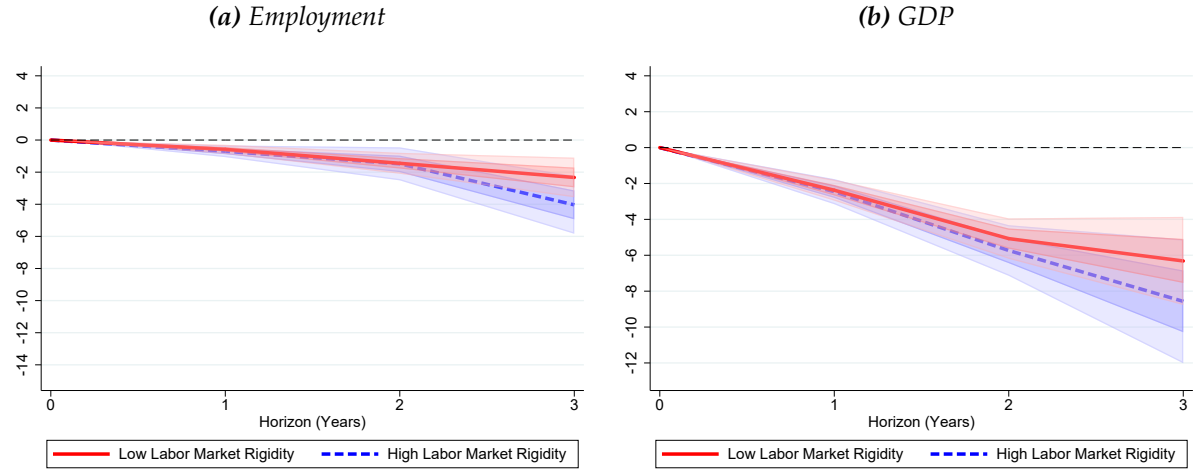



***Notes****: Panel (a): The panel presents results from a bivariate OLS regression. Dependent variable (y-axis): Downward real wage rigidities ($\widehat{\gamma_{s(i)}}$). Independent variable: Gross real minimum wage growth (x-axis). Minimum wage growth is computed during unemployment spells. 90% predictive margins and observations are added. Unemployment spells with zero nominal minimum wage growth are excluded. Panel (b): Local Projections as specified in equation (4) with downward real 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) Wage 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.*

Figure 8, Panel (b), plots the 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 A5). The prevalence of unions therefore does not drive our baseline results regarding the significance of downward real wage rigidities. In fact, union density and downward real wage rigidities are negatively correlated (not reported). Our interpretation of these results is that unions primarily care about stabilizing employment and do not push for higher wages during a recession. The results for collective bargaining agreements are qualitatively similar, although not significant, and available in Figure A5. Once again we constructed this measure as a sample average for each country. The prevalence of domestic bargaining agreements does not affect the employment response during a recession and is in fact negatively correlated with the wage rigidity measure (not reported).

***Figure 9:*** *Recession Paths: All Countries, De Jure Labor Market Restrictions*




***Notes****: Local Projections as specified in equation (4) with one exception: The downward real wage rigidity measure (γ) 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.*

We conclude this section by examining 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 9. The de jure measure yields a more muted response on employment and output relative to the downward wage rigidity

measure. The employment share differs only 1.7 pp between high and low labor market rigidities by year 3. The difference is nevertheless significant (Figure A6). 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.

## 5.2. Placebo Regressions Based on Expansions

This section assesses the validity of the downward real wage rigidity measure by examining its effects on employment during expansions. The idea is that, if $\widehat{\gamma}_i$ in equation (4) picks up downward real 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

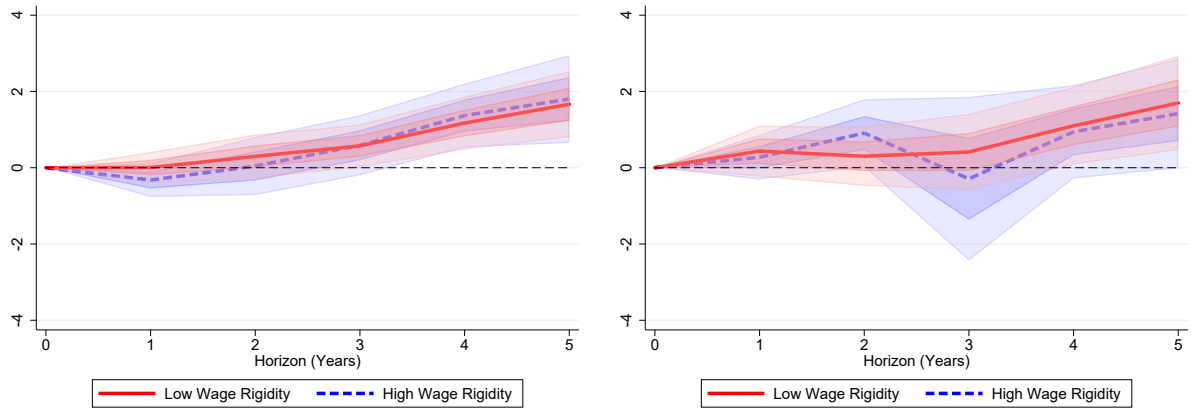
$$\Delta_{\tau(r)+h} y_i = \sum_{h=1}^{H(r)} \beta_h Tr_{i,\tau(r)+h} + \sum_{h=1}^{H(r)} \phi_h Tr_{i,\tau(r)+h} (\widehat{\gamma}_i - \overline{\gamma}) + \epsilon_{i,\tau(r)+h}. \tag{5}$$

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 significant from zero. This supports the notion that $\widehat{\gamma}_i$ only matters during recessions, just as predicted by the one-sided wage constraint.

Figure 10 plots the employment response path during expansions, depending on the degree of downward real 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 real wage rigidities.

***Figure 10:*** *Placebo: Employment Expansion Path*

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




***Notes:*** *Local Projections as specified in equation (5). 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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

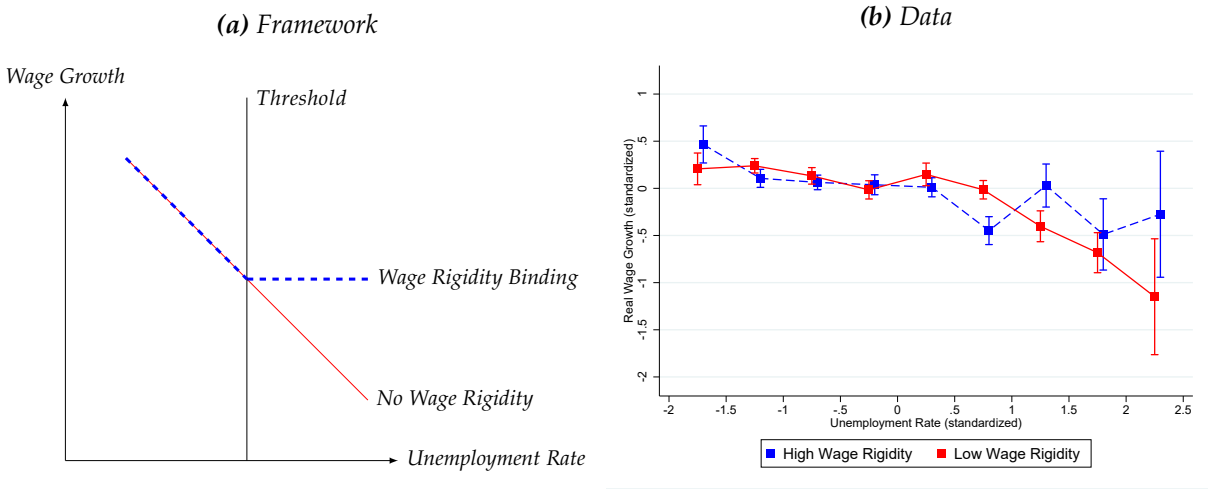
## 5.3. Wage Growth and Unemployment

According to the structural framework in Section 2, once the downward wage constraint binds, wage growth is entirely pinned down by $\gamma$. Thus, a further increase in unemployment should not predict additional wage changes. We can test this prediction in the data. In particular, we 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.

Panel (a) in Figure 11 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). However for a country that is not subject to wage rigidities, higher unemployment continues to push wage growth lower (red line).

Panel (b) provides evidence that a similar pattern also exists in the data. To facilitate the comparison, real wage growth and the unemployment rate are standardized for each country 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,

***Figure 11:*** *Wage Growth and Unemployment: The Role of Downward Wage Rigidities*




***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 hourly earnings 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.*

where we separate countries into these two groups based on their downward wage rigidity measure relative to the median estimate. 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. Second, when the unemployment rate increases to relatively high levels, wage growth in countries with high downward wage rigidities do not drop, while wages in countries with low wage rigidities tend to decline.

Overall, our wage rigidity estimates provide theoretically consistent predictions regarding the interplay between wages and the unemployment rate.

## 5.4. Adding Control Variables

To examine if our empirical results in 4.3 are robust, we include a variety of control variables in the local projection analysis. Specifically, we conduct the following local projection estimation

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

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 just as in the previous section. 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 A7 and A8 (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 A2), 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 a country's exports-to-GDP ratio to control a country's vulnerability to external shocks; we add a country's exchange rate (relative to the US dollar) to control for business cycle fluctuations due to currency variations. In particular open economies with a fixed exchange rate are more vulnerable to conditions on 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 A9, including these variables keeps the results largely unchanged relative to the benchmark case (Figure A2). The effect of wage rigidities on employment decreases somewhat, but the results for GDP are more significant.

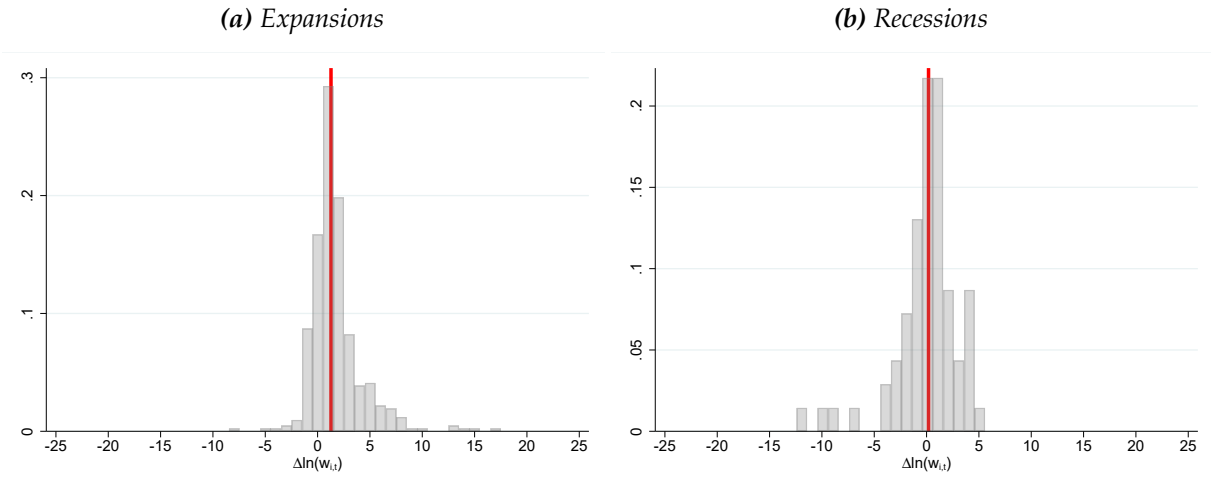
Finally, if we include both sets of control variables (excluding minimum wage), the results are similar to the results from only including the four variables that are

potentially related to our wage rigidity measure. These results are displayed in Figure A10. The analysis in this subsection thus provides supporting evidence that our empirical results in section 4.3 are robust.

## 5.5. Real Wages during Recessions and Expansions

Our approach to measuring downward wage rigidities mirrors the definition of downward wage rigidities in the structural literature (Schmitt-Grohe and Uribe, 2016). A country is subject to higher downward wage rigidities if real wages increase more (or decline less) relative to other countries during similar adverse conditions in domestic labor markets. As explained earlier, this mitigates the effect of a potential composition bias, as low-skilled workers are more likely to loose their job during a recession. Nevertheless, we can also compare wage growth distributions in recessions and expansions to emphasize that wages in aggregate data are sticky.

***Figure 12:*** *Real Wage Growth - Advanced Economies*

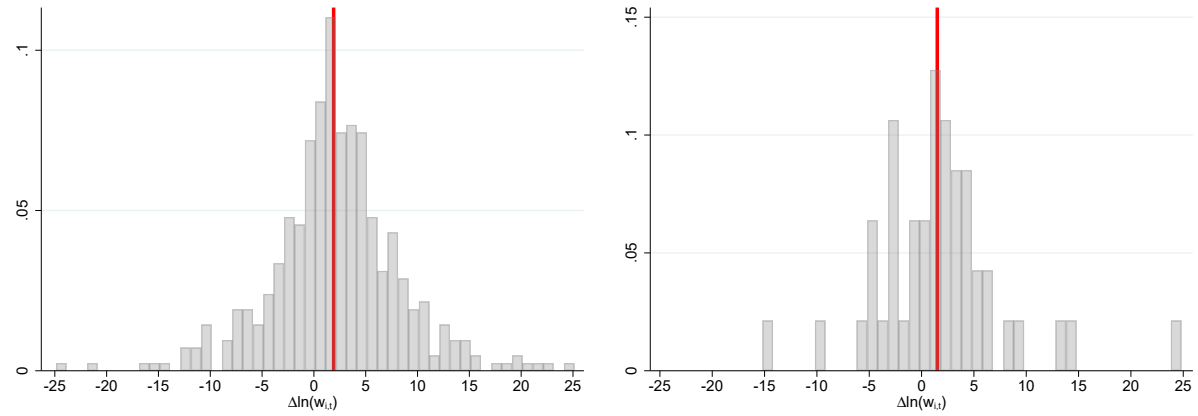



***Notes****: Hourly real wage growth distribution during expansions and recessions for AEs. Observations at annual frequency. Recessions are defined by negative real GDP growth. The red line represents the sample median.*

Specifically, Figures 12 and 13 plot the distribution of hourly real wage growth rates during expansions and recessions, separately for advanced economies and emerging markets. Recessions are defined by negative real GDP growth. Two findings emerge in these figures. First, real wage growth rates are quite similar during expansions and recessions, supporting the idea that wages are slow to adjust. In more detail, the median real wage growth rate for emerging markets during recession is similar to the real wage growth rate during expansions (1.5% versus 1.9%). The gap among advanced economies is somewhat larger (0.2% versus 1.3%). Second, real wage growth rates

***Figure 13:*** *Real Wage Growth - Emerging Markets*

***(a)*** *Expansions* ***(b)*** *Recessions*




***Notes****: Hourly real wage growth distribution during expansions and recessions for EMs. Observations at annual frequency. Recessions are defined by negative real GDP growth. The red line represents the sample median.*

among emerging markets are more heterogeneous than in advanced economies (see also Tables 1 and 2). This should not be surprising given that emerging markets tend to experience more volatile business cycle fluctuations. Overall, this analysis supports the notion that wage stickiness at the individual level translates into wage stickiness in aggregate data, which provides support for our country-level approach. Further, wage rigidities based on this alternative metric might be more prevalent among emerging markets just as with our preferred specification.

## 6. Conclusion

In this paper, we provide a simple framework to calculate downward real wage rigidities in aggregate data over a wide range of countries. The approach preserves consistency and shows widespread wage rigidities across countries. As an additional benefit, our downward real 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 empirical evidence on the relevance of downward wage rigidities in driving recession dynamics. We show that countries with noticeable downward real wage rigidities perform worse in terms of employment and real GDP.

Our analysis also provides two important policy implications. First, we find that downward real 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. Unions also do not contribute to downward wage rigidities. 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 US $, calculated as an annual average based on monthly averages (Source: World Bank)

*Exports 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)

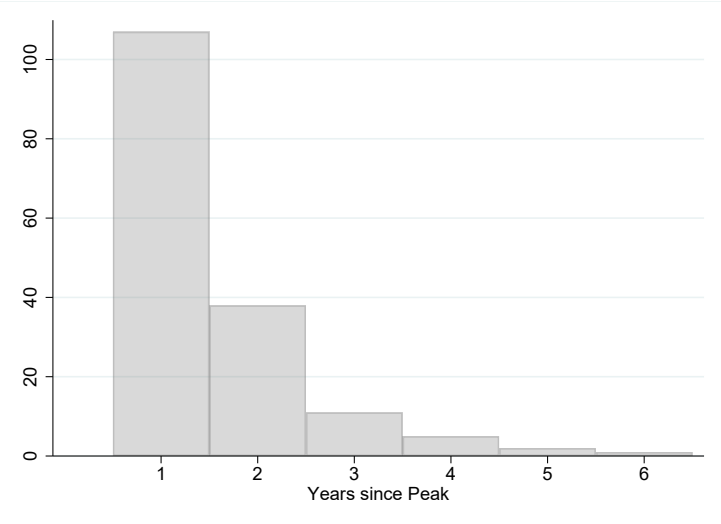
*Oil Prices*: US $ per barrel at end of period (Source: Bloomberg)

*Unemployment Rate*: Unemployment as percent of 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: Figures

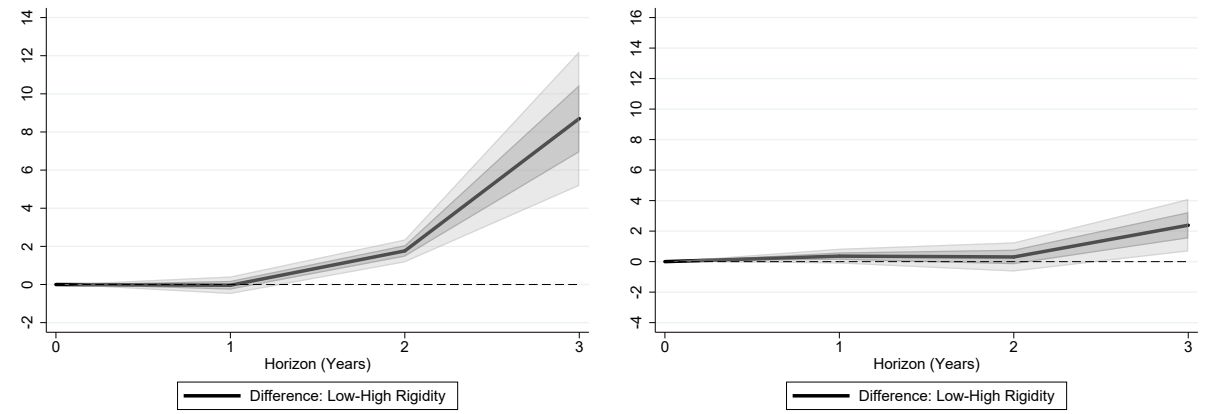
***Figure A1:*** *Duration of Recessions*




***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 A2:*** *Recession Paths: All Countries, Low minus High Real Wage Rigidity*

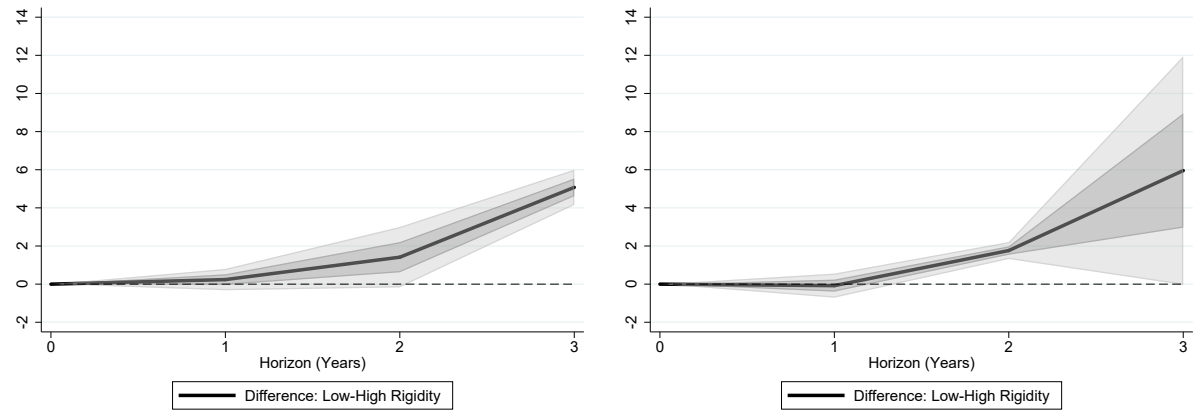
***(a)*** *Employment* ***(b)*** *GDP*




***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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

***Figure A3:*** *Recession Paths: Employment, AEs versus EMs, Low minus High Real Wage Rigidity*

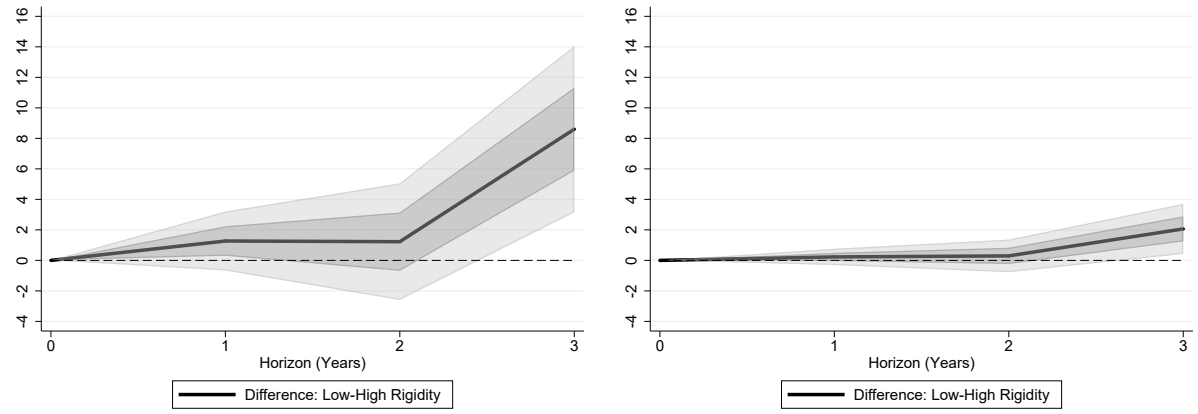
***(a)*** *Advanced Economies* ***(b)*** *Emerging Markets*




***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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

***Figure A4:*** *Recession Paths: GDP, AEs versus EMs, Low minus High Real Wage Rigidity*

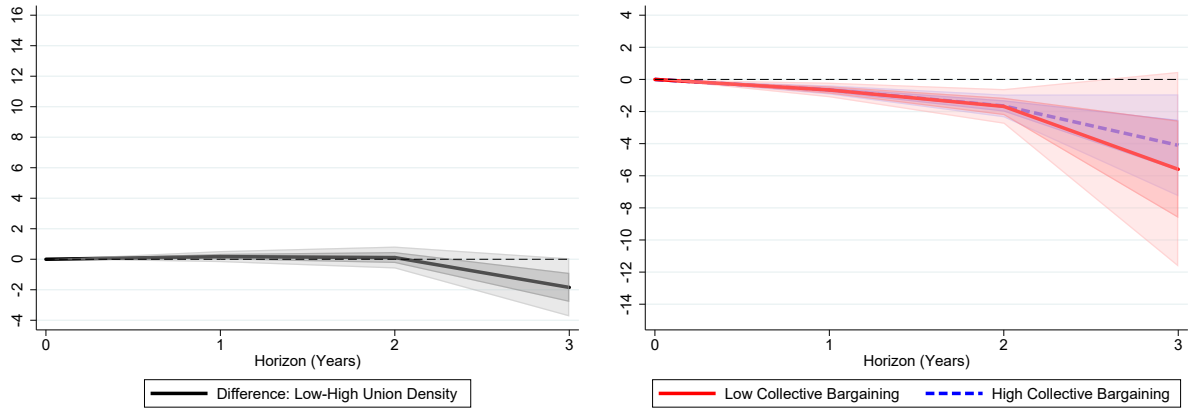
***(a)*** *Advanced Economies* ***(b)*** *Emerging Markets*




***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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

***Figure A5:*** *Union Density, Collective Bargaining and Employment*

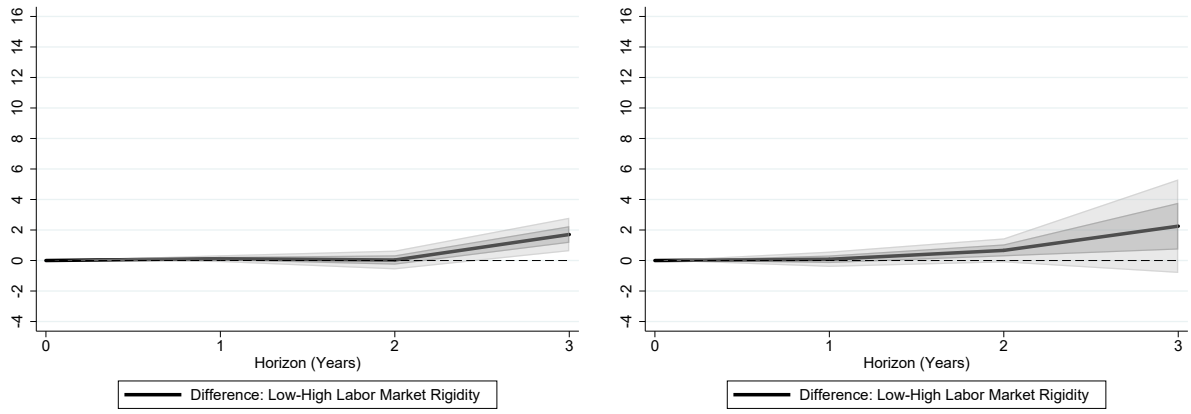
***(a)*** *Union Density* ***(b)*** *Collective Bargaining*




***Notes****: Panel (a): Local Projections as specified in equation (4) with downward real 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 rigidity response for the employment to population ratio (in pp). "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. Panel (b): Local Projections as specified in equation (4) with downward real 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 A6:*** *Recession Paths: All Countries, Low minus High De Jure Labor Market Rigidity*

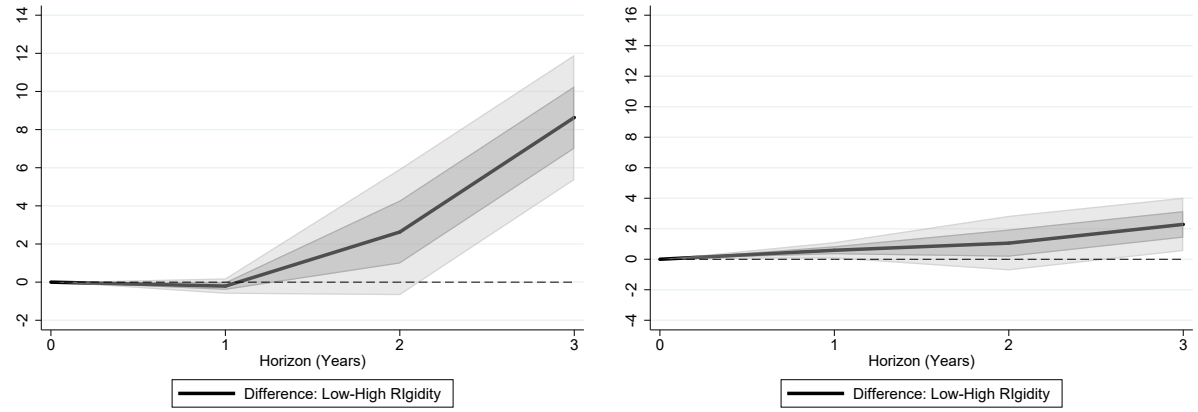
***(a)*** *Employment* ***(b)*** *GDP*




***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 A7:*** *Robustness Check: Including Variables Related to the Rigidity Measure (All Countries)*

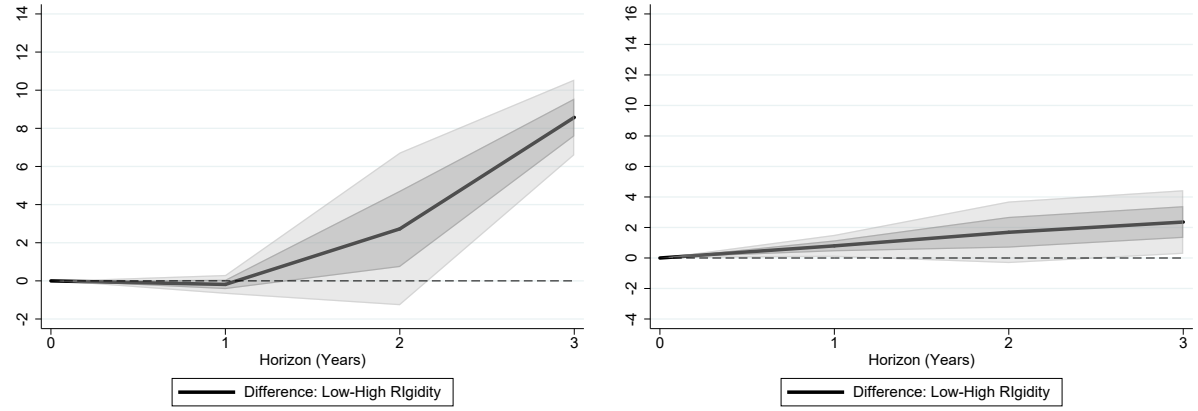
***(a)*** *Employment* ***(b)*** *GDP*




***Notes****: Local Projections as specified in equation (6), 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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

***Figure A8:*** *Robustness Check: Including Minimum Wage Growth (All Countries)*

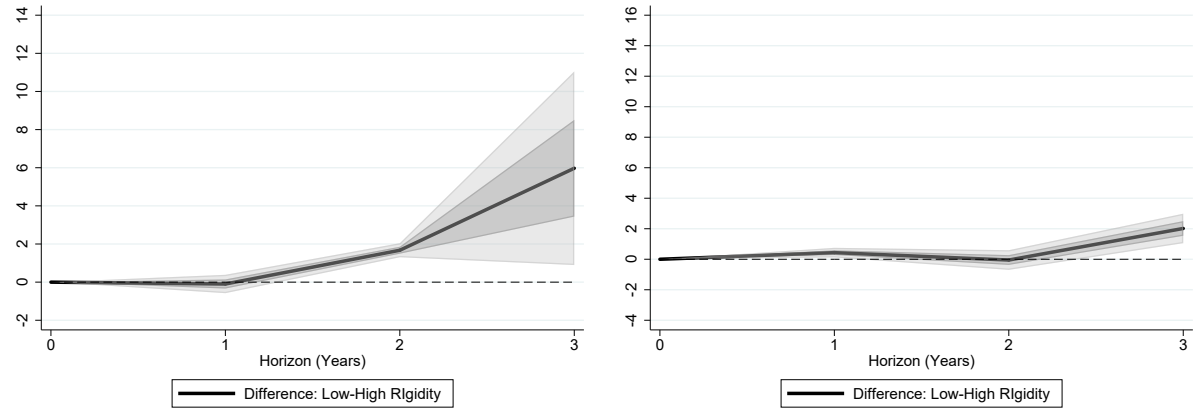
***(a)*** *Employment* ***(b)*** *GDP*




***Notes****: Local Projections as specified in equation (6), which adds 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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

***Figure A9:*** *Robustness Check: Including Other Variables (All Countries)*

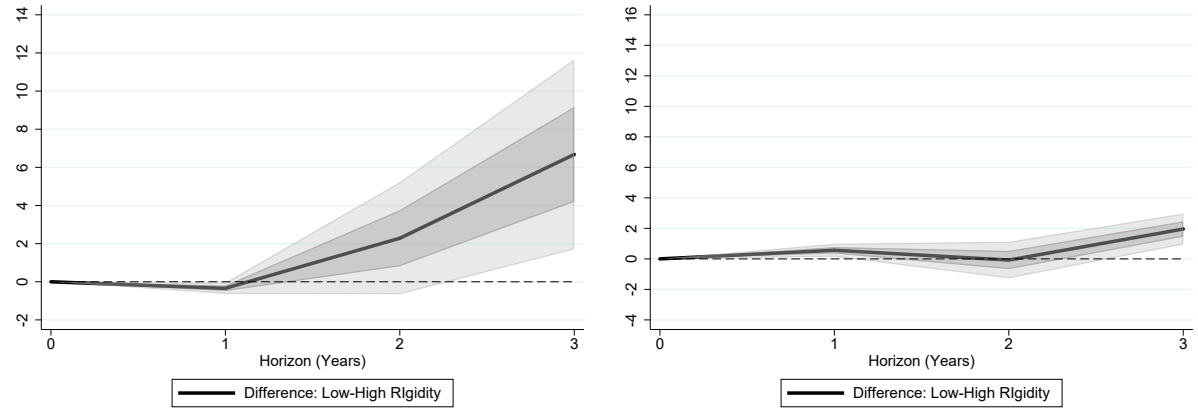
***(a)*** *Employment* ***(b)*** *GDP*




***Notes****: Local Projections as specified in equation (6), 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 US 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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

***Figure A10:*** *Robustness Check: Including All Variables (All Countries)*

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




***Notes****: Local Projections as specified in equation (6) which include all control variables, i.e., the two sets of variables included in Figures A7 and A9. 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 real wage rigidity from the mean. Shaded areas are 1 and 2 cluster robust s.e. bands around response estimates.*

# C. Appendix: Tables

***Table A2:*** *Unemployment - Trough Preceding Spell*

| **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 spell, that is, the local minimum in the unemployment rate. We only include spells with data on real wages.*

***Table A3:*** *Spell-specific Downward Real 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* $\widehat{\gamma_{s(i)}}$ *estimates. The ordering resembles the unemployment spells in Table A2.*

***Table A4:*** *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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