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HETEROGENEITY IN REAL WAGE CYCLICALITY: EVIDENCE FOR THE PORTUGUESE LABOUR MARKET

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Abstract

This work revisits the study of Carneiro et al. (2012) which measured the real wage cyclicality in the Portuguese labour market, with the aim of extending the period of analysis to include the 2008-2021 years. Additionally, this study further explores real wage cyclicality by taking into account individuals' sociodemographic characteristics and firm characteristics. Finally, this study evaluates to what extent wage cyclicality varies according to the phase of the business cycle. To evaluate the cyclical behaviour of real average total hourly earnings, a level wage equation that simultaneously controls for firm, worker and job title heterogeneity with three high-dimensional fixed effects is estimated. This methodology is applied to administrative linked employer-employee data that allows for the control of compositional effects as well as specification bias. This study presents six main novel findings. First, it confirms that the most extreme phases of the business cycle are the ones that lead to the highest wage cyclicality. Second, it shows that more education tends to lead to less wage cyclicality and less cyclical job upgrading/downgrading. Third, it shows that wage cyclicality tends to increase with a worker's age. Fourth, it shows that larger firms seem to adjust more hiring wages than the wages of more-tenured workers. Fifth, it reveals that workers of the two autonomous regions of "Açores" and "Madeira" experience less real wage procyclicality than workers of Mainland Portugal. And, finally, it provides evidence that wage cyclicality is much more correlated with labour market conditions than with other aggregate economic indicators.

JEL codes: E24, E32, J64

Keywords: Real wage cyclicality, heterogeneity, fixed effects

Resumo

Este trabalho revisita o estudo de Carneiro et al. (2012) que mediu a ciclicidade dos salários reais no mercado de trabalho português, com o objetivo de estender o período de análise para incluir os anos 2008-2021. Adicionalmente, este estudo explora a ciclicidade dos salários tendo em conta as características sociodemográficas dos indivíduos e as características das empresas. Finalmente, este estudo avalia em que medida a ciclicidade salarial varia de acordo com a fase do ciclo económico. O comportamento cíclico dos salários totais horários foi estimado através de uma equação salarial com três efeitos fixos- trabalhador, empresa e categoria profissional. Esta metodologia foi aplicada a dados administrativos que cruzam a identificação do trabalhador com a da respetiva empresa e que permitem o controlo de efeitos de composição, bem como de enviesamento de especificação. Este estudo apresenta seis principais resultados. Primeiro, confirma que as fases mais extremas do ciclo económico são as que conduzem a uma maior ciclicidade salarial. Segundo, demonstra que mais educação leva a menos ciclicidade salarial e *cyclical job upgrading/downgrading*. Terceiro, mostra que a ciclicidade salarial aumenta com a idade dos trabalhadores. Quarto, mostra que empresas maiores ajustam mais os salários de entrada do que os salários dos trabalhadores com mais antiguidade. Quinto, revela que trabalhadores empregados nas regiões autónomas dos Açores e da Madeira experienciam menos ciclicidade salarial do que trabalhadores empregados em Portugal Continental. E, finalmente, fornece evidencia de que a ciclicidade salarial está muito mais correlacionada com as condições do mercado laboral do que com outros indicadores macroeconómicos agregados.

Códigos JEL: E24, E32, J64

Palavras-Chave: Ciclicidade dos salários reais, heterogeneidade, efeitos fixos

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GDP – Gross Domestic Product

UK – United Kingdom

US – United States

1. Introduction

Understanding how real wages evolve over the business cycle has long been an object of interest of economists since it is of the utmost importance for the development of meaningful macroeconomic models (Devereux, 2001). On the one hand, some labour market models like that of Mortensen and Pissarides (1994) rely on the cyclical volatility of real wages of new jobs to explain unemployment fluctuations. On the other hand, some business cycle models like the extended New Keynesian model proposed by Blanchard and Galí (2007) rely on real wage rigidities to explain the role of monetary policy. Establishing a "stylized fact" about the cyclicality of real wages would, thus, offer a criterion of evaluation of macroeconomic models (Brandolini, 1995).

However, extensive research on the existence of a cyclical pattern for real wages has found conflicting evidence, failing to establish such a stylized fact. A first branch of studies making use of macro data found a multitude of patterns of real wage behaviour- procyclicality, countercyclicality and acyclicality. Later analysis justified those discrepancies between the results of various studies with the vulnerability of such studies to the choice of deflator, data-detrending method, and cyclical stance indicator, as well as natural limitations of aggregate data that bias the results. One of those limitations is composition bias, which consists in the fact that the impossibility to control for a change in the composition of the labour force during the cycle due to the nature of aggregate data will bias the results if different groups of workers with different wage levels experience different cyclicality in employment. Another problem that plagues studies based on aggregate data is specification bias, or in other words, the impossibility to control for heterogeneity between workers with different characteristics which hides inequalities in the wage cyclicality exhibited by different groups of workers. A more recent branch of studies focusing on micro panel data seems to be more consistent in finding real wages procyclical, but some authors have proven that real wage behaviour can vary across time and be different across countries as well as across sociodemographic groups and, thus, no global pattern can be pinned down.

Using the innovative approach put forth by Carneiro et al. (2012), this study aims to measure the semi-elasticity of real average hourly earnings with regard to the unemployment rate in the Portuguese labour market in a context of low inflation rates. This approach consists of a level wage equation containing controls for three types of heterogeneity: observed and unobserved worker, job title and firm permanent heterogeneity. To simultaneously control

for the three types of heterogeneity, three high-dimensional fixed effects are included in the estimation which is obtained through an iterative strategy suggested by Correia (2016) that yields the exact results of a least squares estimation without the need to deal with the dimensionality of the matrix of fixed effects.

This methodology is applied to a data set called 'Quadros de Pessoal' which contains matched employer-employee data of prime quality and is very comprehensive of the Portuguese labour market since it includes annual information reported by firms to the Portuguese Ministery of Labour and Social Solidarity through a standardized questionnaire that is mandatory for all private establishments with wage earners.

The main contributions of this study to the existing literature are two-fold. First, I extend the time window of the data analysed in Carneiro et al. (2012) to the 2008-2021 period, which includes the years of the financial crisis that, in Portugal, was followed by a sovereign debt crisis, and the years of the COVID-19 pandemic. This enables me to show that the sensitivity of real hourly earnings to the unemployment rate has been decreasing in Portugal since 1992, confirming the results of Martins (2021) and that, as previous literature has shown, shocks of different natures can lead to different patterns and magnitudes of wage cyclicality over the cycle that they start. I also confirm the finding of previous literature that there is an asymmetry between the different phases of the business cycle in terms of wage cyclicality, and show that the most extreme phases are the ones that lead to the highest cyclicality.

Second, this study disentangles the global cyclicality into that registered by specific sociodemographic groups (e.g., gender, education, age). This disentanglement enables me to confirm the results of previous studies that concluded that there seems not to exist any evidence of gender differences in terms of wage cyclicality in the Portuguese labour market. I also show that more education tends to lead to lower wage cyclicality and less cyclical job upgrading/downgrading. Additionally, I demonstrate that wage cyclicality tends to increase with age.

Furthermore, I also assess the impact of firm characteristics (size and location) on wage cyclicality and conclude that larger firms adjust more their hiring wages than the wages of more-tenured workers. I also demonstrate that workers in the two autonomous regions of "Açores" and "Madeira" experience significantly lower real wage cyclicality than workers in Mainland Portugal.

As a robustness check on these results, I decided to test the sensitivity of real hourly earnings to the real Gross Domestic Product (GDP) growth rate, and show that no statistically significant effect can be estimated, which leads me to conclude that real wage cyclicality is much more correlated with labour market conditions, especially the evolution of the unemployment rate, than other aggregate macroeconomic indicators.

The remainder of this work is organized as follows. Section 2 reviews previous literature. Section 3 presents the methodology and data used. In section 4, the empirical results are presented and discussed. And, finally, in section 5, the concluding remarks are presented.

2. Literature Review

2.1 Macro Data Studies

The cyclicality of real wages has been the object of study of economists ever since Keynes proposed that there should be a negative correlation between nominal and real wages which, as noted by Bils (1985), implies that real wages should be countercyclical since nominal wages tend to be strongly procyclical. This prediction was based on the assumption that nominal wages are stickier than prices due to the fact that during recessions workers tend to resist wage cuts and during expansions, as firms move up their output supply curve, they will have a tendency to rise wages more sluggishly than prices. Therefore, because nominal wages adjust slower than prices, during expansions real wages should decline despite nominal wages increasing and during recessions real wages should increase due to prices falling (Pencavel et al., 2015).

The first branch of research on real wage cyclicality focused on aggregate data. Very shortly after Keynes published the General Theory in 1936, Dunlop (1938) found evidence that, in England, during the 1860-1937 period, increases in nominal wages tended to be associated with increases in real wages while decreases tended to be equally often associated with rises or falls in real wages. Similarly, Tarshis (1939) concluded that nominal wages and real wages in the United States (US) between January 1932 and March 1938 were strongly positively correlated, contradicting Keynes's prediction.

However, Ruggles (1940) put Dunlop's conclusion into question by showing that the empirical deviation of real wages from theoretical frequencies was smaller than Dunlop's results would suggest and argued that even if nominal wages and real wages tended to rise together that would not necessarily mean that the increase in nominal wages was the driver of the rise in real wages. The author also questioned the validity of Tarshis's (1939) conclusion, arguing that the period under analysis in that study was too short, not even including one complete economic cycle, and that the validity of the coefficient of association determined was doubtful due to the data selection process. This present work avoids this type of problem since the period being analysed includes various complete economic cycles.

Later on, Kuh (1966) found that in the US, between 1913 and 1957, real wages tended to be less procyclical than nominal wages, and Bodkin (1969) found a positive but not statistically significant correlation between detrended real wages and unemployment for Canada for the

1921-1965 period, as well as a negative but not significant correlation between unemployment and real trend-adjusted wages when taking into account seasonal effects in the United States (US) for 1900-1965.

Robert Lucas summarized the implications of such contradictions in evidence about the cyclicality of real wages for economic theory as: "Observed real wages are not constant over the cycle, but neither do they exhibit consistent pro- or countercyclical tendencies. This suggests that any attempt to assign systematic real wage movements a central role in an explanation of business cycles is doomed to failure." (Lucas, 1977, p.17).

A second approach based on dynamic models rose with Neftçi's (1978) argument that the relationship between real wages and employment was more complicated than previously considered and the conclusion that a statistically significant negative correlation between real wages and employment in the US in the post-II World War period would appear when distributed lags are taken into consideration. Similarly, Sargent (1978) argued that simple contemporaneous correlation analysis are not sufficient to examine the dynamic relationship between real wages and employment and, through the estimation of a dynamic linear demand schedule for labour, found evidence of an inverse relationship between real wages and employment in the US for the 1947-1972 period.

However, later on, Geary and Kennan (1982) concluded that using the Wholesale Price Index (WPI) as a deflator instead of the Consumer Price Index (CPI) used by Neftçi (1978) made it difficult to reject the null hypothesis that real wages and employment were statistically independent in 12 OECD countries during the 1947-1977 period.

In a review of the existing literature, Abraham and Haltiwanger (1995) pointed out that these contradictions in evidence seemed to stem from the fact that important specification choices like the type of deflator, the time period of the data, the data detrending method, and the cyclical stance indicator can seriously impact the measurement of the cyclicality of wages. This motivated me to test the GDP growth rate as the cyclical stance indicator and five alternative deflators in the robustness checks section of this study.

2.2 Micro Data Studies

Another branch of more recent studies has turned to micro panel data in an attempt to avoid composition bias. This issue consists of the fact that the failure to control for the possibility that less skilled and experienced workers (who are more likely to have lower wages) might

be more vulnerable to becoming unemployed during the low phase of the business cycle will introduce a counter-cyclical bias in the estimates of the cyclicality of wages. One additional problem with aggregate data that micro panel data studies can avoid is specification bias: because macroeconomic data studies measure the relationship between the average wage in the economy and a cyclical stance indicator, they assume that this relationship is the same for all individuals, an assumption that, if violated, will bias the results. Solon et al. (1994) demonstrated that longitudinal data showed a very procyclical behaviour of real wages in the US for the 1967-1987 period, while studies for the same period based on aggregate data could not pick nearly as much procyclicality, thus, proving that composition bias can have a decisive impact. Furthermore, Beaudry and DiNardo (1991) showed that labour market conditions were very procyclical in the US for the 1976-1984 period, and Vroman and Wachter (1977) demonstrated that in the US between 1964 and 1971 the workers with more experience and seniority tended to increase their proportion among stayers during the low phase of the business cycle which emphasizes the importance of controlling for job quality heterogeneity. Similarly, Schaefer and Singleton (2019) concluded that during the Great Recession in the United Kingdom (UK), the hours worked by new hires significantly declined mainly due to firms switching from hiring full-time employees to preferring part-time workers. Moreover, Verdugo (2016) showed that estimates of wage cyclicality for 6 major Eurozone countries [1] derived from macro data depict wages as being almost totally unresponsive to variations of the unemployment rate during the Great Recession, while estimates obtained from micro data (which account for compositional bias) detect a significant level of procyclicality, emphasizing the definite impact that compositional changes of the labour force throughout the business cycle can have on estimates of wage cyclicality if not accounted for. Stüber (2016) reached similar conclusions for Germany for the period 1975-2009. Additionally, more recently, Dapi (2020) showed that even in countries with strong labour market regulations and high unionization rates, like Norway, where collective agreements and centralized wage bargaining are common, the composition of the employed population can exhibit a very cyclical pattern, thus biasing any estimates of wage cyclicality that do not control for that reality. That study also revealed that while both individual and firm fixed heterogeneity give rise to a countercyclical bias, the impact of including individual fixed effects in the estimates is larger (about two-thirds of the total) than that of including

[1] Austria, Belgium, Spain, Finland, France, the Netherlands, and Portugal.

firm fixed effects, suggesting that the cyclical pattern exhibited by the composition of the employed population is the main source of the bias in previous research. Additionally, the author compared the fifth and ninety-fifth percentiles of the distribution of estimated fixed effects coefficients to show that the fifth percentile varies more around its trend in a synchronized way with the unemployment rate which suggests that the cyclical variation in the composition of the employed population is mainly "driven by low-wage workers who are more likely to be full-time employed when unemployment is low than when unemployment is high." (Dapi, 2020, p. 1417). The author also divided new hires into two subgroups, those coming out of unemployment and those coming from another job, and found out that individual fixed effects remove a much higher counter-cyclical bias in the estimates of wages of new hires coming from unemployment than for new hires coming from another job.

Motivated by the lack of research on wage cyclicality for developing economies, Gambetti and Messina (2018) studied how wage cyclicality evolved in four Latin American countries (Brazil, Chile, Colombia and Mexico) during the 1980-2010 period. This study yielded evidence that in all four countries, the procyclicality of real wages declined as inflation volatility was reduced through macroeconomic stabilization plans. This reduction in wage volatility was accompanied by an increase in unemployment volatility in Colombia. However, the same did not happen in Brazil, where the adjustment was conducted mainly through the intensive margin: as the procyclicality of real wages declined, the volatility of hours worked registered a moderated increase. Similarly to the results of previous research, this study also found an asymmetry in wage cyclicality between the different phases of the business cycle. However, for these four economies, wages appear to be more volatile during expansions than in recessions. The authors confronted these results obtained with macro data with evidence derived from microdata from Brazil and concluded that, remarkably, controlling for changes in the observable characteristics of the employed population over the business cycle had very little impact on the estimates of wage cyclicality, a result that contradicts almost all previous research made for developed economies. In order to assess how compositional bias can affect estimates of wage cyclicality for the Portuguese labour market, I compare estimates obtained through a simple OLS regression with estimates derived from a model with worker, firm and job-title fixed effects.

Using panel data, Bils (1985) found evidence of strong real wage procyclicality and showed that the real wages of job changers were much more procyclical than those of workers who stayed with the same employer in the US between 1966 and 1980 and, similarly, that the wages of people moving in and out of the workforce tend to also be more procyclical. The explanation given by the author for the discrepancy between his results and those of previous research was that earlier studies failed to include overtime hours in the earnings and, given that these tend to be strongly procyclical, that failure introduced a countercyclical bias in the results. Kydland and Prescott (1993) provided further support to Bils's (1985) conclusions by showing that in the US, between 1969 and 1982, hours worked were strongly procyclical. Based on this evidence, the authors argued that measuring the cyclicality of average hourly earnings was a biased proxy of the behaviour of real wages and proved that controlling for this countercyclical bias through a different measure of labour input yielded a much higher procyclicality of labour input compensation. Devereux (2001) provided even more support to this view by reporting that average hourly earnings (which include income from extra jobs as well as bonuses) of hourly workers were much more procyclical than reported hourly wages in the US from 1970 to 1992 and that the wages of salaried workers were much less procyclical than average earnings which proves that non-salary elements of earnings like bonuses, tips, commissions and overtime payments tend to be much more procyclical and, thus, a failure to control for this reality will bias estimates of wage cyclicality. To determine wether this evidence also applies to the Portuguese case, I also estimate wage cyclicality using various measures of wages.

On top of that, Bils (1985) pointed towards the possibility that different periods could be associated with different patterns of wage cyclicality. Sumner and Silver (1989) backed this hypothesis with evidence that in the US, during periods where cyclical changes were caused by aggregate demand shocks, real wages tended to be countercyclical, while aggregate supply shocks tended to be associated with procyclical real wages. Similarly, Elsby et al. (2016) concluded that the degree of real wage cyclicality changed across time both in the US and the UK, which emphasizes the importance of my intention of extending the initial sample used by Carneiro et al. (2012). Furthermore, Elsby et al. (2016) also demonstrated that the pattern of wage cyclicality evolved in a remarkably different way in the two countries between 1980 and 2012: while in the US real wages reacted quite significantly to the recessions of the early 1980s and 1990s but only moderately to the Great Recession, in the UK real wage procyclicality increased over time culminating in a much greater response of wages to the

Great Recession than had been registered during the previous crisis. This discrepancy in the evolution of real wage cyclicality between the two countries is even more striking when we consider that, as noted by the authors, they both registered a similar decrease in inflation and unionization rates during this period.

In contrast with the findings of Bils (1985), Gertler and Trigari (2009) showed that the wages of newly hired workers in the US in the 1990-1996 period looked much more procyclical than the wages of stayers only when firm heterogeneity was not controlled for, but once firm-specific fixed effects were included that difference turned statistically insignificant. The results of this study emphasize the importance of the control for firm permanent heterogeneity that I include in my analysis. Later on, however, Haefke et al. (2013) provided further evidence that the wages of newly hired workers out of non-employment tended to be strongly positively correlated with labour productivity and much more procyclical than the wages of stayers in the US between 1979 and 2006. The authors point out that this disentanglement is important because it contradicts the reliance of macroeconomic models on wage rigidity to explain unemployment fluctuations: there are many more job stayers than new hires in an economy and so aggregate data will tend to point to wage rigidity, but the wages of 'marginal' newly hired workers are what affects firms decisions to create jobs and, thus, the fact that the wages of newly hired workers are much more procyclical than those of job stayers means that the apparent wage rigidity of aggregate data simply does not explain the unemployment volatility puzzle. This study also revealed that splitting the sample into two different periods, 1979-2006 and 1984-2006, had a quite significant impact on the magnitude of the results, further supporting Bils's (1985) intuition that differences in the period of analysis could be responsible for some of the discrepancies in the results of previous research. Moreover, De la Roca (2014) showed that in a country with a rigid labour market like Spain, the difference between the wage cyclicality faced by newly hired workers and that experienced by job stayers can assume even greater importance and that workers under temporary contracts experience a wage cyclicality up to as twice as large as that experienced by workers under permanent contracts. As summarized by the author, this evidence of wage cyclicality declining more with tenure in Spain than in other European countries with less rigid labour markets suggests that stricter labour market regulations deter firms from adjusting wages along the business cycle. Similarly, Martins et al. (2012) tracked the real hiring wages of more than one thousand job categories in Portugal between 1982

and 2009 and concluded that real entry wages were significantly procyclical (although, less volatile than the wages of workers who changed firm).

However, authors like Reynolds (1951), Reder (1955) and Hall (1974), as cited in Solon et al. (1997), had already, many years before, raised a debate about the importance of job-title changes over the cycle for wage cyclicality, but due to unavailability of within-firm wage data, their hypothesis could not be tested. That is until Solon et al. (1997), using 1920s to 1930s data from Ford Motor Company and A. M. Byers Company, showed that, indeed, most of the wage cyclicality within those firms was driven by changes in job titles rather than wage changes within the same job title. However, being based on two case studies, this work lacked the external validity of research based on large and representative samples of workers. Later on, Devereux and Hart (2006), using survey data from the UK for the 1975-2001 period, offered further support to the so-called Reynolds-Reder-Hall hypothesis by showing that the wages of within-firm movers were significantly more procyclical than those of job stayers and slightly more procyclical than those of between-firm movers. More recently, Gertler et al. (2020) have shown that in the US, between 1990 and 2012, the wages of new hires from unemployment were no more flexible than those of job stayers, while the wages of workers making job-to-job transitions appeared more cyclical. Based on this evidence, the authors argue that the excess wage cyclicality revealed by previous research for new hires is mainly driven by procyclical upgrading of job match quality achieved by new hires from employment during the high phase of the business cycle. Similarly, Dapi (2020) has shown that in Norway, while the wages of new hires seem to be more cyclical than those of job stayers, that difference is not statistically significant for new hires coming out of unemployment. Furthermore, Figueiredo (2022) has also concluded that the excess wage cyclicality registered for new hires in the US is driven by that of job changers. By using a skill mismatch index to separate wage cyclicality from compositional effects, the author has also shown that, for job stayers and new hires from unemployment, wage flexibility over the cycle is proportional to the worker's position in the skill mismatch distribution: for workers at the bottom of the distribution (well-matched workers), wage semielasticity with respect to the unemployment rate is not statistically significantly different from zero, while for workers at the top of the skill mismatch distribution (the worst-matched workers), wages are significantly procyclical. In order to test if the reliance of macroeconomic models on wage rigidity to explain unemployment fluctuations is disconnected from reality, I estimate the difference in terms of wage cyclicality experienced between workers with more than 12 months of tenure

(stayers) and workers with less than a year of tenure (new hires), while including a job title fixed effect to control for the impact of cyclical job upgrading/downgrading.

Remaining on the topic of heterogeneity between workers, but now turning the attention to differences between genders, Tremblay (1990) showed that in the US, during the 1968-1978 period, the real wages of white men were significantly more procyclical than those of white women. The author suggests that several reasons could explain this result: first, in the sample used, white men have significantly more occupational training than white women which could yield a lower cyclicality in employment, thus affecting the cyclicality of wages; and second, there is an asymmetry in the composition of the workforce of the more cyclically volatile industries like manufacturing, construction and mining, with white men constituting a disproportionate amount of the labour force in these industries when compared to white women. Likewise, Dapi (2020) concluded that in the Norwegian private sector, between 1997 and 2014, men's wages were significantly more procyclical than women's wages and that men were more likely to change to a better-paying firm during economic expansions while there is no such evidence for women. These studies motivated the test for the existence of differences between genders in terms of wage cyclicality in Portugal that this work presents further ahead.

2.3 Studies for Portugal

Martins (2007) was one of the first studies to measure wage cyclicality for the Portuguese labour market. In an attempt to comprehend how representative of the entire labour market, average estimates of wage cyclicality can be, the author split his sample of workers into three different groups: those who stay in the same job, those who moved across job categories within the same firm, and those who changed firm. He also divided it by gender and age. When considering only base wages, movers across firms register significantly greater wage cyclicality than the other two groups of workers. However, when total wages (which include bonuses, overtime pay and performance-based pay) are taken into account, these differences turn statistically insignificant, suggesting that non-base components of wages are less sensitive to the business cycle, which contradicts the results of most of the previous research, with the exception of Grigsby et al. (2021) which looked into payroll data from one of the US largest payroll processing companies and found that base wages were much more procyclical than non-base components like bonuses and overtime pay. The explanation proposed by Martins (2007) for this striking evidence was that in Portugal firms might prefer

to cut base wages during recessions while only partially compensating workers with more generous performance-dependent components of wages. The author also showed that there is an asymmetry in wage cyclicality between the different phases of the business cycle in Portugal: during downturns, wages tend to decline substantially, while, during expansions, wages react only moderately, which yields an overall modest procyclicality. This asymmetry is stronger for workers who move across firms and is valid for all age groups tested, except for senior employees (55-64 years old) who appear to be insulated from wage decreases during recessions. The author argues that this might be a result of the role played by tenure and/or age in the Portuguese employment protection legislation which ends up segmenting the labour market and making younger workers bear most of the burden of adjustments during the low phase of the business cycle. Similarly, Clark and Summers (1981) had already demonstrated that in the US young workers bear a disproportionate share of cyclical employment fluctuations and Haefke et al. (2013) showed that controlling for a worker's schooling level is an important control for composition bias in wage cyclicality which motivated me to disentangle overall cyclicality into that of different sociodemographic groups, namely education levels and age.

Later on, Carneiro et al. (2012), the study that inspired this present work, using a different methodology confirmed some of the results found by Martins (2007) for Portugal and contradicted others. The authors found an overall pattern of procyclicality and showed that, as reported by Dapi (2020), the inclusion of worker fixed effects absorbed the most significant countercyclical bias. The authors also showed that the inclusion of a job-title fixed effect increased the incremental effect estimated for workers with less than 12 months of tenure, which contradicts the hypothesis that a significant portion of the wage cyclicality experienced by newly hired workers is attributable to cyclical job upgrading/downgrading.

More recently, Martins (2021) showed that the reduction in wage cyclicality associated with the reduction in the volatility of inflation detected by Gambetti and Messina (2018) also applied to Portugal, by showing that the change that occurred in Portugal, from a macroeconomic regime of high inflation and interest rates to its opposite, during the preparation for entry into the Eurozone, led to a significant decline in the degree of procyclicality of collective bargaining wages (from a semi-elasticity of -5.17 with respect to the unemployment rate during the 1982-1992 period to a coefficient of only -0.23 for the 1993-2017 period), which the author considers might be, at least in part, responsible for the

higher responsiveness observed by the unemployment rate during the financial crisis when compared to the adjustments registered in previous crisis.

All of these studies show that, as pointed out by Hagedorn and Manovskii (2013), "understanding the behaviour of real wages over the business cycle is a classic yet still open question in economics" (Hagedorn & Manovskii, 2013, p.771) since patterns of cyclicality seem to change across time and between countries, workers and even firms.

3. Methodology and Data Description

3.1 Data

The data used in this study come from 'Quadros de Pessoal', which are administrative linked employer-employee data collected annually by the Ministry of Labour, Solidarity and Social Security for legal compliance monitoring reasons. The fact that the data serve this purpose and are collected through a standardized mandatory questionnaire ensures a high degree of reliability. This annual census covers all establishments with wage earners with the exceptions of the public administration, nonmarket services and self-employed workers. This very high degree of coverage makes the dataset a very good representation of the whole Portuguese labour market and avoids sample selection bias problems. The dataset is comprised of information on establishments (e.g., location, number of workers), workers (e.g., age, gender, earnings, hours worked, education, type of contract), and firms (e.g., industry, sales, capital), and has a longitudinal nature since each firm and worker have a unique identifying number which allows us to track them and their matches throughout time, allowing us to classify each worker as either a stayer (more than 12 months of tenure) or as a new hire (less than 12 months). The information about workers' salaries is very complete and enables us to decompose total earnings into different components like base wages, regular benefits and irregular benefits.

For this study, 34 spells of 'Quadros de Pessoal', between 1986 and 2021, were used[2]. Between 1986 and 1993 the census collected data referring to the month of March, while in 1994 and onwards the information refers to the month of October of each year. Therefore, to deflate wages, a monthly CPI[3] with March as the base was used from 1986 to 1993, and the same CPI with October as the base was used from 1994 on. This means that the adjustment between the CPI of 1993 and that of 1994 corresponds to the inflation rate registered between March 1993 and October 1994.

In order to replicate the study conducted by Carneiro et al. (2012), some of the data treatment [4] adopted in that study needed to be recreated in this work. Thus, only observations referring to full-time workers that worked at least 120 hours in the reference month and that earned

[2] The dataset does not contain information on workers for the years 1990 and 2001.

[3] The series for the unemployment rate, deflators, and GDP growth rate used are reported in Tables A1 and A2 of the Annex.

[4] Only the largest connected set of observations was used.

at least 80% of the minimum wage[5] were kept. Multiple spells (workers that appear in more than one job in the same year) were also treated according to Carneiro et al. (2012) and so we kept only the entry referring to the job in which the worker had the highest number of hours worked. After these data treatment, we ended up with a dataset that contains 62,127,466 observations, which corresponds to 8,119,124 unique workers, 758,703 unique firms, and 175,528 distinct job categories. As mentioned before, the full sample of workers was split into two main groups- stayers and entrants. The average proportion of entrants is 17.09% with an average real monthly wage of 709.01 euros. The average real monthly wage of stayers is 890.84 euros. Entrants have an average age of only 33 years, while stayers have an average age of 39 years and an average tenure of approximately 10 years.

Table 1 Means of some variables, Portugal, 1986-2021

	Stayers (more than 12 months of tenure)	New Hires (less than 12 months of tenure)
Age (in years)	39.44	33.31
Tenure (in years)	9.94	0
Proportion of Females	42.36	42.14
Proportion of workers in each education category		
9 years or less	66.99	62.84
High School complete	20.14	23.60
Polytechnic Degree	1.90	1.50
College Degree	10.97	12.06
Log real base hourly wage (euros)	1.48	1.29
Log real regular hourly wage (euros)	1.62	1.41
Log real total hourly wage (euros)	1.64	1.43
Number of observations	51,893,748	10,935,450

[5] Legally, only apprentices and trainees can earn less than the minimum wage, down to a minimum of 80%. Another exception are workers with disabilities, but we did not take these cases into consideration.

3.2 Methodology

To measure the cyclicality of real wages, the baseline model will be the following level wage equation, proposed by Carneiro et al. (2012):

$$\textbf{(3.1)}\ \ln(W_{ijft}) = \lambda_I + \theta_j + \gamma_f + \delta x_{it} + \alpha_0 t + \alpha_1 t^2 + \phi hire_{ijft} + \beta_1 cycle_t + \beta_2 cycle_t * hire_{ijft} + u_{ijft},$$

where W_{ijft} are the real average hourly earnings of worker i, in job category j, in firm f, in period t; λ_i is a worker fixed effect; θ_j is a job category fixed effect; γ_f is a firm fixed effect; u_{ijft} is a random term assumed to follow the Gauss-Markov assumptions; x_{it} is a vector of time-varying individual characteristics (like age and education); t and t^2 are a linear and a quadratic time trends, respectively; $cycle_t$ is the cyclical stance indicator[6]; $hire_{ijft}$ consists of a dummy variable that assumes the value of 1 if the worker has a tenure of less than 12 months.

Therefore, β_1 measures the semi-elasticity of real average hourly earnings with respect to the unemployment rate for workers with more than 12 months of tenure, and β_2 measures the difference in the semi-elasticity of earnings between workers with 12 or more months of tenure (stayers) and workers with less (new-hires).

The average hourly earnings will be obtained by dividing different measures of labour compensation received by the workers by the total number of hours worked. This enables the control for the cyclicality of hours worked and accounts for the cyclicality of non-salary components of labour compensation. Three measures of wages will be used: base wages, which include only the base salary of workers; regular wages, which include regular benefits; and total wages, which include both regular and irregular benefits.

In order to test the sensitivity of the results to the choice of cyclical stance indicator, the sensitivity of real wages to the real GDP growth rate will also be tested.

This equation will be estimated through an iterative process that alternates between the estimation of each of the multiple parameters until convergence is achieved and the estimates for the parameters of interest- β_1 and β_2- are obtained.

[6] Since wages are usually set for the future while taking into account present economic conditions, the cyclical stance indicator is lagged by 1 period (1 year, in this case).

4. Empirical Results

4.1 Base Model for the 1986-2021 Period

As a starting point, I decided to replicate some of the key results presented in Carneiro et al. (2012) for the 1986-2007 period. For this purpose, I estimated 4 different models and 3 measures of wages. The results are presented in Table 2. The first 4 rows refer to base wages; rows 5-8 to regular wages (base wages + regular benefits); and the last 4 rows to total wages (base wages + regular benefits + irregular benefits). For each measure of wages, the first model is a simple OLS regression; the second model consists of a specification with a worker fixed effect; the third model includes worker and firm fixed effects; and the fourth model is the complete base model with the worker, firm and job title fixed effects, presented in equation 3.1.

There are three important notes to take from this attempt to replicate the results of the original paper. First, I was able to find a similar overall pattern of procyclicality, with new hires experiencing higher wage cyclicality than stayers. Secondly, I also found that, as in the original paper, both the worker fixed effects and the job title fixed effects seem to absorb some countercyclical bias for stayers, while the inclusion of a firm fixed effect seems to leave the estimates unchanged or even reduce their magnitude by a very small amount. For new hires, however, the inclusion of each fixed effect reduces the estimated incremental effect, which contradicts the evidence reported in the original paper. And, in third place, I have to note that the magnitude of the estimates that I was able to come up with is significantly lower than that of the estimates of the original paper and, thus, even though qualitatively these estimates are a good replication of the results reported in the original paper, quantitatively they are rather different. I have no definite explanation for these differences, but they might result, at least in part, from some differences between this present work and the original paper, like the computing process used to obtain the estimates and the choice of deflator.

These results lead me to conclude that the estimates that I present in the next sections of this work should be viewed as lower bounds for real wage cyclicality in the Portuguese labour market.

Table 2 Real Wage Sensitivity to the Unemployment Rate, 1986-2007

	Stayers (more than 12 months of tenure)	Additional Effect for New Hires (less than 12 months of tenure)
1. OLS (Base Wages) N = 31,964,278	-0.57*** (0.17)	-0.94*** (0.00)
2. Worker Fixed Effects (Base Wages) N = 29,685,343	-0.77*** (0.07)	-0.88*** (0.00)
3. Worker and Firm Fixed Effects (Base Wages) N = 29,593,842	-0.75*** (0.07)	-0.80*** (0.00)
4. Worker, Firm and Job Title Fixed Effects (Base Wages) N = 29,581,797	-0.88*** (0.05)	-0.46*** (0.00)
5. OLS (Regular Wages) N = 31,964,278	-0.79*** (0.04)	-0.94*** (0.01)
6. Worker Fixed Effects (Regular Wages) N = 29,685,343	-0.97*** (0.02)	-0.91*** (0.00)
7. Worker and Firm Fixed Effects (Regular Wages) N = 29,593,842	-0.95*** (0.02)	-0.78*** (0.00)
8. Worker, Firm and Job Title Fixed Effects (Regular Wages) N = 29,581,797	-0.98*** (0.02)	-0.45*** (0.00)
9. OLS (Total Wages) N = 31,964,278	-0.51** (0.21)	-0.80*** (0.00)
10. Worker Fixed Effects (Total Wages) N = 29,685,343	-0.68*** (0.11)	-0.86*** (0.00)
11. Worker and Firm Fixed Effects (Total Wages) N = 29,593,842	-0.68*** (0.10)	-0.76*** (0.00)
12. Worker, Firm and Job Title Fixed Effects (Total Wages) N = 29,581,797	-0.80*** (0.07)	-0.45*** (0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regressions include a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The analysis for the 1986-2021 period starts with the estimation of the same 4 different models for the 3 different measures of wages described before. The results are presented in Table 3.

The first important takeaway from these results is that a pattern of procyclicality similar to the one found for the previous period for both stayers and new hires seems to persist.

Secondly, as before, including a worker fixed effect absorbs some countercyclical bias and increases the estimates of wage procyclicality for stayers, even though by a small amount. However, the same is not true for the job title fixed effect which now, when included, seems to slightly reduce the magnitude of the wage procyclicality estimated. For new hires, the inclusion of each fixed effect continues to reduce the estimated procyclicality of real hourly earnings. As before, the inclusion of a firm fixed effect also leads to a reduction of the estimated wage procyclicality both for stayers and new hires.

In third place, I have to highlight a change in the pattern of cyclicality regarding the different measures of wages. While for the 1986-2007 period, the results show base wages to exhibit the highest cyclicality and total wages to exhibit the lowest cyclicality, for the 1986-2021 period, total wages look to be the more procyclical ones with base wages coming second and regular wages in last place. The evidence that total wages are the more cyclical measure is very in line with what is reported in most previous research about how different measures of wages evolve over the business cycle and can be explained by the fact that total wages include some components like bonuses and performance fees which are more performance-dependent and, thus, will tend to vary more throughout the business cycle. Now turning to the evidence that base wages look more procyclical than regular wages, this might be attributable to the fast increases registered by the national minimum wage after 2015, which, if not accompanied by increases of the same magnitude by the remaining components of regular wages, will make base wages look more cyclical than regular wages.

Table 3 Real Wage Sensitivity to the Unemployment Rate, Portugal, 1986–2021

	Stayers (more than 12 months of tenure)	Additional Effect for New Hires (less than 12 months of tenure)
1. OLS (Base Wages)	-1.00***	-0.41***
N = 62,127,466	(0.00)	(0.00)
2. Worker Fixed Effects (Base Wages)	-1.03***	-0.36***
N = 59,995,098	(0.00)	(0.00)
3. Worker and Firm Fixed Effects (Base Wages)	-0.98***	-0.24***
N = 59,911,192	(0.00)	(0.00)
4. Worker, Firm and Job Title Fixed Effects (Base Wages)	-0.96***	-0.21***
N = 59,908,933	(0.00)	(0.00)
5. OLS (Regular Wages)	-0.97***	-0.50***
N = 62,127,466	(0.00)	(0.00)
6. Worker Fixed Effects (Regular Wages)	-1.01***	-0.43***
N = 59,995,098	(0.00)	(0.00)
7. Worker and Firm Fixed Effects (Regular Wages)	-0.98***	-0.27***
N = 59,911,192	(0.00)	(0.00)
8. Worker, Firm and Job Title Fixed Effects (Regular Wages)	-0.94***	-0.22***
N = 59,908,933	(0.00)	(0.00)
9. OLS (Total Wages)	-1.04***	-0.37***
N = 62,127,466	(0.00)	(0.00)
10. Worker Fixed Effects (Total Wages)	-1.08***	-0.38***
N = 59,995,098	(0.00)	(0.00)
11. Worker and Firm Fixed Effects (Total Wages)	-1.06***	-0.23***
N = 59,911,192	(0.00)	(0.00)
12. Worker, Firm and Job Title Fixed Effects (Total Wages)	-1.02***	-0.20***
N = 59,908,933	(0.00)	(0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regressions include a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Extensions of the Model

Since regular wages are what workers expect to be paid every month, while base wages are incomplete and total wages are not homogeneous throughout every month of the year, for the following extensions to the base model, only the semi-elasticity of regular wages will be analysed.

4.2.1 Asymmetries between Business Cycle Phases

The first extension of the baseline model aims to identify asymmetries between the different phases of the business cycle in terms of wage cyclicality. For that purpose, the sample was split into 4 sub-periods[7]: (i) years when the unemployment rate increased from the previous period but remained below the sample average (7.88%), called recession periods; (ii) years in which the unemployment rate increased and surpassed the sample average, called depression periods; (iii) years when the unemployment rate decreased but remained above the sample average, called recovery periods; and (iv) years when the unemployment rate decreased to values below the sample average, called expansion periods.

This extension will be implemented through the following equation:

$$\textbf{(4.1)}\ \ln(W_{ijft}) = \lambda_i + \theta_j + \gamma_f + x_{it}\delta + \alpha_0 t + \alpha_1 t^2 + \phi hire_{ijft} + \mu recession_t + \nu depression_t + \varepsilon recovery_t + \beta_1 cycle_t + \beta_2 cycle_t * recession_t + \beta_3 cycle_t * depression_t + \beta_4 cycle_t * recovery_t + \beta_5 cycle_t * hire_{ijft} + \beta_6 cycle_t * hire_{ijft} * recession_t + \beta_7 cycle_t * hire_{ijft} * depression_t + \beta_8 cycle_t * hire_{ijft} * recovery_t + \tau hire_{ijft} * recession_t + \pi hire_{ijft} * depression_t + \sigma hire_{ijft} * recovery_t + u_{ijft},$$

where *recession*$_t$ is a dummy variable that takes value 1 if year t is classified as a recession period, and 0 otherwise; *depression*$_t$ is a dummy variable that takes value 1 if year t is classified as a depression period, and 0 otherwise; and *recovery*$_t$ is a dummy variable that takes value 1 if year t is classified as a period of recovery, and 0 otherwise. Therefore, β_1 now measures the semi-elasticity of real average hourly earnings with respect to the unemployment rate for stayers during periods of expansion, ($\beta_1 + \beta_2$) measures the semi-elasticity for stayers during recessions; ($\beta_1 + \beta_3$) measures the semi-elasticity for stayers during depressions; ($\beta_1 + \beta_4$) measures the semi-elasticity for stayers during recoveries; ($\beta_1 + \beta_5$) measures the semi-

[7] Table A2 shows to which sub-period each year of the sample belongs.

elasticity for new hires during expansions; ($\beta_1 + \beta_2 + \beta_5 + \beta_6$) measures the semi-elasticity for new hires during recessions; ($\beta_1 + \beta_3 + \beta_5 + \beta_7$) measures the semi-elasticity for new hires during depressions; and ($\beta_1 + \beta_4 + \beta_5 + \beta_8$) measures the semi-elasticity for new hires during recoveries.

The results for stayers are presented in Table 4, and the incremental effects for new hires are presented in Table 5.

Table 4 Real Wage Sensitivity to the Unemployment Rate for Stayers– Asymmetries between Business Cycle Phases, Portugal, 1986–2021

	Expansions (β_1)	Additional effect for recessions (β_2)	Additional effect for depressions (β_3)	Additional effect for recoveries (β_4)
1. OLS	-1.92***	0.76***	-0.89***	1.42***
N = 62,127,459	(0.00)	(0.24)	(0.19)	(0.00)
2. Worker Fixed Effects	-1.46***	0.95***	-1.06***	0.79***
N = 59,995,009	(0.00)	(0.08)	(0.08)	(0.09)
3. Worker and Firm Fixed Effects	-1.33***	0.90***	-0.96***	0.64***
N = 59,911,104	(0.00)	(0.09)	(0.09)	(0.14)
4. Worker, Firm and Job Title Fixed Effects	-1.20***	0.93*	-0.99*	0.51
N = 59,908,933	(0.00)	(0.00)	(0.00)	(0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

For stayers, the periods of highest real wage cyclicality are depressions and expansions, respectively- when the unemployment rate is above the sample average and increasing (depressions), a 1 percentage point rise in the unemployment rate is estimated to decrease real regular hourly earnings by 2.19 per cent. And, when the unemployment rate is below the sample average and decreasing (expansions), a 1 percentage point drop in the unemployment rate is estimated to increase real wages by 1.20 per cent. During recessions, stayers experience

a much lower real wage procyclicality- when the unemployment rate increases but remains below the sample average, the semi-elasticity of real hourly earnings is estimated to be -0.27 per cent. This shows that the most extreme phases of the business cycle are the ones that result in the greatest real wage cyclicality.

For recovery periods no statistically significant incremental effect can be estimated when using the model with job title fixed effects, but when including only worker and firm fixed effects, a very statistically significant effect of 0.64 can be estimated, even though the sample only includes 4 years classified as recovery periods. This contradicts the hypothesis that, during recoveries, an important portion of the real wage cyclicality experienced by stayers is driven by cyclical job upgrading.

Regarding the incremental effect for new hires, no statistically significant asymmetry between the different phases of the business cycle could be observed.

Table 5 Real Wage Sensitivity to the Unemployment Rate– Asymmetries between Business Cycle Phases (Incremental Effect for New Hires), Portugal, 1986–2021

	Expansions (β_5)	Additional effect for recessions (β_6)	Additional effect for depressions (β_7)	Additional effect for recoveries (β_8)
1. OLS	-0.46	0.64	0.01	-0.65***
N = 62,127,459	(0.38)	(0.54)	(0.99)	(0.23)
2. Worker Fixed Effects	-0.67***	0.22	0.08	-0.05
N = 59,995,009	(0.00)	(0.66)	(0.88)	(0.84)
3. Worker and Firm Fixed Effects	-0.62***	0.16	-0.00	0.16
N = 59,911,104	(0.00)	(0.48)	(0.99)	(0.33)
4. Worker, Firm and Job Title Fixed Effects	-0.45***	0.16	-0.00	0.02
N = 59,908,933	(0.00)	(0.00)	(0.00)	(0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2.2 Intertemporal Asymmetries

As many studies have shown, economic shocks of different natures can lead to distinct patterns of wage cyclicality. Therefore, as a second extension of the base model, I decided to divide the sample into three different complete business cycles according to the pioneering work of business cycle dating conducted by Fundação Francisco Manuel dos Santos for Portugal, and test for the existence of differences between these cycles. The first complete cycle goes from 1992 to 2001 and it was started by an international recession kicked off by the Gulf War that led to a climb in oil prices. The second complete cycle goes from 2002 to 2007 and was marked by two first years of recession that essentially resulted from internal macroeconomic imbalances. The third complete cycle lasted between 2008 and 2019 and was started by the international financial crisis and later worsened by a sovereign debt crisis. Another cycle began in 2020 with the COVID-19 pandemic and, even though data is only available for the two first years of this cycle, I decided to keep these two years as a separate cycle, given the very distinct nature of this crisis.

For this extension, the following equation will be estimated:

$$\textbf{(4.2)}\ \ln(W_{ijft}) = \lambda_i + \theta_j + \gamma_f + x_{it}\mu + \alpha_0 t + \alpha_1 t^2 + \phi hire_{ijft} + \delta pre\_cycle1_t + \sigma cycle2_t + \tau cycle3_t + \mu cycle4_t + \beta_1 stance_t + \beta_2 stance_t * pre\_cycle1_t + \beta_3 stance_t * cycle2_t + \beta_4 stance_t * cycle3_t + \beta_5 stance_t * cycle4_t + \beta_6 stance_t * hire_{ijft} + \beta_7 stance_t * hire_{ijft} * pre\_cycle1_t + \beta_8 stance_t * hire_{ijft} * cycle2_t + \beta_9 stance_t * hire_{ijft} * cycle3_t + \beta_{10} stance_t * hire_{ijft} * cycle4_t + \varkappa hire_{ijft} * pre\_cycle1_t + \varepsilon hire_{ijft} * cycle2_t + \omega hire_{ijft} * cycle3_t + \eta hire_{ijft} * cycle4_t + u_{ijft},$$

where $stance_t$ is now the cyclical stance indicator; pre_cycle1_t is a dummy variable that takes value 1 for the 1986-1991 period, and 0 otherwise; $cycle2_t$ is a dummy variable that takes value 1 for the 2002-2007 period, and 0 otherwise; $cycle3_t$ is a dummy variable that takes value 1 for the 2008-2019 period, and 0 otherwise; $cycle4_t$ is a dummy variable that takes value 1 for the 2020-2021 period, and 0 otherwise. Therefore, β_1 measures the semi-elasticity of real average hourly earnings with respect to the unemployment rate for stayers for the 1992-2001 period; $(\beta_1 + \beta_2)$ measures the semi-elasticity for stayers for the 1986-1991 period; $(\beta_1 + \beta_3)$ measures the semi-elasticity for stayers for the 2002-2007 period; $(\beta_1 + \beta_4)$ measures the semi-elasticity for stayers for the 2008-2019 period; $(\beta_1 + \beta_5)$ measures the semi-elasticity for stayers for the 2020-2021 period; $(\beta_1 + \beta_6)$ measures the semi-elasticity for new hires for the 1992-2001

period; ($\beta_1 + \beta_2 + \beta_6 + \beta_7$) measures the semi-elasticity for new hires for the 1986-1991 period; ($\beta_1 + \beta_3 + \beta_6 + \beta_8$) measures the semi-elasticity for new hires for the 2002-2007 period; ($\beta_1 + \beta_4 + \beta_6 + \beta_9$) measures the semi-elasticity for new hires for the 2008-2019 period; and ($\beta_1 + \beta_5 + \beta_6 + \beta_{10}$) measures the semi-elasticity for new hires for the 2020-2021 period.

The results for stayers are presented in Table 6, and the incremental effects for new hires are reported in Table 7.

Table 6 Real Wage Sensitivity to the Unemployment Rate– Intertemporal Asymmetries, Portugal, 1986–2021

	Additional effect for the 1986-1991 period	cycle 1 (1992-2001)	Additional effect for cycle 2 (2002-2007)	Additional effect for cycle 3 (2008-2019)	Additional effect for cycle 4 (2020-2021)
1. OLS N = 62,127,419	1.33 (0.01)	-1.38*** (0.00)	0.01 (0.00)	0.68 (0.00)	6.74*** (0.00)
2. Worker Fixed Effects N = 59,995,092	3.01*** (0.00)	-1.79*** (0.00)	0.50 (0.00)	0.92* (0.00)	6.86*** (0.00)
3. Worker and Firm Fixed Effects N = 59,911,144	3.22*** (0.01)	-1.78*** (0.00)	0.54 (0.01)	0.92* (0.01)	6.25*** (0.01)
4. Worker, Firm and Job Title Fixed Effects N = 59,894,300	2.77*** (0.01)	-1.78*** (0.00)	0.41* (0.01)	0.91* (0.01)	6.12*** (0.01)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

First taking a look into the wage cyclicality of job stayers, two main conclusions can be drawn from these results. First, while during the three complete business cycles, real wages appear to have been procyclical, for the two subperiods of incomplete cycles, wages appear to be strongly countercyclical. For the two last years of the sample– 2020 and 2021– which are the two first years of a new business cycle started by the COVID-19 pandemic, this should be explained by the very atypical nature of this crisis and the measures taken to combat it,

like layoffs, that resulted in significant changes in workers' earnings but enabled the unemployment rate to remain low. Second, wage procyclicality appears to decline throughout the three complete cycles. While for the 1992-2001 period, a one percentage point increase in the unemployment rate is estimated to decrease real wages by 1.78 per cent, for the 2002-2007 period, it is estimated to decrease real wages by 1.37 per cent, and for the 2008-2019 period, it is estimated to decrease real wages by only 0.87 per cent.

Table 7 Real Wage Sensitivity to the Unemployment Rate– Intertemporal Asymmetries (Incremental Effect for New Hires), Portugal, 1986–2021

	Additional effect for Pre-cycle 1 (1986-1991)	cycle 1 (1992-2001)	Additional effect for cycle 2 (2002-2007)	Additional effect for cycle 3 (2008-2019)	Additional effect for cycle 4 (2020-2021)
1. OLS	-0.33	-1.24***	0.94***	0.62**	3.18***
N = 62,127,459	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2. Worker Fixed Effects	-0.96***	-0.66**	0.16	0.19	3.46**
N = 59,995,092	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)
3. Worker and Firm Fixed Effects	-0.84***	-0.54***	0.03	0.25	1.58
N = 59,911,144	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)
4. Worker, Firm and Job Title Fixed Effects	-0.58**	-0.41*	0.07	0.15	1.64
N = 59,894,300	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Now turning our attention to new hires, in all five subperiods, these less tenured workers seem to have experienced incremental wage cyclicality. However, that incremental effect appears to have declined over time. While for the 1986-1991 period, the effect is estimated at -0.99, for the 1992-2001 period, it is estimated at -0.41. For the following subperiods, no statistically significant differences were observed when accounting for worker, firm and job-title heterogeneity.

4.2.3 Heterogeneity between Education Levels

The third extension to the base model aims at measuring differences in terms of real wage cyclicality between workers with different education levels. For this purpose, the sample was split into 4 different groups: workers with 9 or fewer years of complete schooling; workers with a complete high school education; workers with a complete polytechnic degree; and workers with a complete college degree. For this extension, the following equation will be employed:

$$\textbf{(4.3)}\ \ln(W_{ijft}) = \lambda_i + \theta_j + \gamma_f + x_{it}\mu + \alpha_0 t + \alpha_1 t^2 + \phi hire_{ijft} + \tau h\_school_i + \eta p\_degree_i + \delta c\_degreel_i + \beta_1 cycle_t + \beta_2 cycle_t * h\_school_i + \beta_3 cycle_t * p\_degree_i + \beta_4 cycle_t * c\_degree_i + \beta_5 cycle_t * hire_{ijft} + \beta_6 cycle_t * hire_{ijft} * h\_school_i + \beta_7 cycle_t * hire_{ijft} * p\_degree_i + \beta_8 cycle_t * hire_{ijft} * c\_degree_i + \pi h\_school_i * hire_{ijft} + \tau p\_degree_i * hire_{ijft} + \omega c\_degree_i * hire_{ijft} + u_{ijft},$$

Where *h_school*$_i$ is a dummy variable that takes the value 1 if worker i has completed high school education, and 0 otherwise; *p_degree*$_i$ is a dummy variable that takes the value 1 if worker i has a polytechnic degree, and 0 otherwise; and *c_degree*$_i$ is a dummy variable that takes the value 1 if worker i has a college degree, and 0 otherwise. Thus, now, β_1 measures the semi-elasticity of real average hourly earnings with respect to the unemployment rate for stayers with 9 or fewer years of education; $(\beta_1 + \beta_2)$ measures the semi-elasticity for stayers with complete high school education; $(\beta_1 + \beta_3)$ measures the semi-elasticity for stayers with a polytechnic degree; $(\beta_1 + \beta_4)$ measures semi-elasticity for stayers with a college degree; $(\beta_1 + \beta_5)$ measures the semi-elasticity for new hires with 9 or fewer years of education; $(\beta_1 + \beta_2 + \beta_5 + \beta_6)$ measures the semi-elasticity for new hires with complete high school education; $(\beta_1 + \beta_3 + \beta_5 + \beta_7)$ measures the semi-elasticity for new hires with a polytechnic degree; and $(\beta_1 + \beta_4 + \beta_5 + \beta_8)$ measures semi-elasticity for new hires with a college degree;

The results for stayers are presented in Table 8 and the incremental effects for new hires are displayed in Table 9.

The model with worker and firm fixed effects indicates that for stayers more education means less wage cyclicality. While a one percentage point increase in the unemployment rate is estimated to reduce the wages of workers with 9 or fewer years of education by 1.1 per cent, for workers with complete high school education that reduction is estimated to be only

0.86 per cent; for workers with a polytechnic degree to be 0.56 per cent; and for workers with a college degree to be 0.83 per cent. However, that pattern does not hold for the estimates obtained with the model with job title fixed effects. This seems to hint at the possibility that more education leads to less cyclical job upgrading/downgrading.

Even though there does not seem to exist much heterogeneity between the various education groups for stayers, it is worth noting that the model with the three fixed effects detected a statistically significant incremental effect of 0.16 for polytechnic degrees, which indicates that this type of education tends to lead to around 16% less real wage cyclicality.

Table 8 Real Wage Sensitivity to the Unemployment Rate for Stayers– Heterogeneity between Education Levels, Portugal, 1986–2021

	9 years of education or less (β_1)	Additional effect for high school (β_2)	Additional effect for polytechnic degree (β_3)	Additional effect for college degree (β_4)
1. OLS	-0.46***	-1.11***	-1.19***	-1.69***
N = 62,127,459	(0.01)	(0.00)	(0.00)	(0.00)
2. Worker Fixed Effects	-1.12***	0.25***	0.56***	0.21***
N = 59,995,009	(0.00)	(0.00)	(0.00)	(0.05)
3. Worker and Firm Fixed Effects	-1.10***	0.24***	0.54***	0.27***
N = 59,911,104	(0.00)	(0.00)	(0.00)	(0.01)
4. Worker, Firm and Job Title Fixed Effects	-0.97***	0.04	0.16***	0.03
	(0.00)	(0.00)	(0.00)	(0.00)
N = 59,908,933				

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As for new hires, only high school education seems to reduce wage procyclicality. While the incremental real wage cyclicality for workers with only 9 or fewer years of education is estimated to be -0.18 per cent when the unemployment rate increases by one percentage

point, for workers with complete high school education it is estimated to be only -0.07 per cent. This means a reduction of around 61 per cent of the incremental effect.

Table 9 Real Wage Sensitivity to the Unemployment Rate– Heterogeneity between Education Levels (Incremental Effect for New Hires), Portugal, 1986–2021

	9 years of education or less (β_5)	Additional effect for high school (β_6)	Additional effect for polytechnic degree (β_7)	Additional effect for college degree (β_8)
1. OLS	0.19***	-0.34***	-1.69***	-1.22***
N = 62,127,459	(0.02)	(0.05)	(0.00)	(0.00)
2. Worker Fixed Effects	-0.32***	0.04	-0.23***	-0.27*
N = 59,995,009	(0.00)	(0.60)	(0.05)	(0.15)
3. Worker and Firm Fixed Effects	-0.23***	0.14***	-0.03	-0.05
N = 59,911,104	(0.00)	(0.01)	(0.77)	(0.66)
4. Worker, Firm and Job Title Fixed Effects	-0.18***	0.11***	-0.06	-0.08
	(0.00)	(0.00)	(0.00)	(0.00)
N = 59,908,933				

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2.4 Heterogeneity between Age Groups

The fourth extension to the base model tested here aims to identify differences in the wage cyclicality experienced by workers of different age groups. For this purpose, the sample was divided into 4 age categories: workers under 26 years of age, workers between 26 and 35 years of age, workers between 36 and 50 years of age, and workers older than 50. For this extension, the following equation will be used:

$$\textbf{(4.4)}\ \ln(W_{ijft}) = \lambda_i + \theta_j + \gamma_f + x_{it}\sigma + \alpha_0 t + \alpha_1 t^2 + \phi hire_{ijft} + \omega cat\_2_{it} + \pi cat\_3_{it} +$$
$$\delta cat\_4_{it} + \beta_1 cycle_t + \beta_2 cycle_t * cat\_2_{it} + \beta_3 cycle_t * cat\_3_{it} + \beta_4 cycle_t * cat\_4_{it} + \beta_5 cycle_t *$$
$$hire_{ijft} + \beta_6 cycle_t * hire_{ijft} * cat\_2_{it} + \beta_7 cycle_t * hire_{ijft} * cat\_3_{it} + \beta_8 cycle_t *$$
$$hire_{ijft} * cat\_4_{it} + \nu hire_{ijft} * cat\_2_{it} + \mu hire_{ijft} * cat\_3_{it} + \varepsilon hire_{ijft} * cat\_4_{it} + u_{ijft},$$

where cat_2_i is a dummy variable that takes the value 1 if worker i is aged between 26 and 35 in period t, and 0 otherwise; cat_2_i is a dummy variable that takes the value 1 if worker i is aged between 36 and 50 in period t, and 0 otherwise; and cat_3_i is a dummy variable that takes the value 1 if worker i is older than 50 in period t, and 0 otherwise. Thus, now, β_1 measures the semi-elasticity of real average hourly earnings with respect to the unemployment rate for stayers younger than 26 years of age; $(\beta_1 + \beta_2)$ measures the semi-elasticity for stayers older than 25 and younger than 36; $(\beta_1 + \beta_3)$ measures the semi-elasticity for stayers aged between 36 and 50; $(\beta_1 + \beta_4)$ measures the semi-elasticity for stayers older than 50; $(\beta_1 + \beta_5)$ measures the semi-elasticity for new hires younger than 26 years of age; $(\beta_1 + \beta_2 + \beta_5 + \beta_6)$ measures the semi-elasticity for new hires aged between 26 and 35; $(\beta_1 + \beta_3 + \beta_5 + \beta_7)$ measures the semi-elasticity for new hires aged between 36 and 50; and $(\beta_1 + \beta_4 + \beta_5 + \beta_8)$ measures the semi-elasticity for new hires older than 50.

The results for stayers are presented in Table 10 and the incremental effects for new hires are exhibited in Table 11.

Table 10 Real Wage Sensitivity to the Unemployment Rate– Heterogeneity between Age Groups, Portugal, 1986–2021

	Under 26 years of age (β_1)	Additional Effect for Workers between 26 and 35 years of Age (β_2)	Additional Effect for Workers between 36 and 50 years of Age (β_3)	Additional Effect for Workers Older than 50 (β_4)
1. OLS	-0.77***	-0.80***	-0.27***	0.64***
N = 62,127,459	(0.00)	(0.00)	(0.03)	(0.00)
2. Worker Fixed Effects	-0.43***	-0.37***	-0.52***	-0.63***
N = 59,995,009	(0.08)	(0.01)	(0.05)	(0.10)
3. Worker and Firm Fixed Effects	-0.32**	-0.41***	-0.59***	-0.74***
	(0.15)	(0.00)	(0.02)	(0.04)
N = 59,911,104				
4. Worker, Firm and Job Title Fixed Effects	-0.54***	-0.19**	-0.32*	-0.41
	(0.00)	(0.00)	(0.00)	(0.00)
N = 59,908,933				

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

When looking at these results, one clear pattern seems to stand out–older workers experience higher real wage cyclicality.

In regards to stayers, a one percentage point increase in the unemployment rate is estimated to decrease the wages of workers under 26 years of age by 0.54 per cent; the wages of workers aged between 26 and 35 by 0.73 per cent; and the wages of workers aged between 36 and 50 by 0.86 per cent. For workers older than 50, no statistically significant incremental effect can be found when using the model with job title fixed effects, but an effect of -0.74 with high statistical significance can be estimated when using the model with only worker and firm fixed effects. Additionally, the coefficients for the other age groups, with the exception of workers under 26, also decrease and lose statistical significance when the job title fixed effects are added to the model. This seems to indicate that cyclical job upgrading/downgrading also tends to increase with age.

Table 11 Real Wage Sensitivity to the Unemployment Rate– Heterogeneity between Age Groups (Incremental Effect for New Hires), Portugal, 1986–2021

	Under 26 years of age (β_5)	Additional Effect for Workers between 26 and 35 years of Age (β_6)	Additional Effect for Workers between 36 and 50 years of Age (β_7)	Additional Effect for Workers Older than 50 (β_8)
1. OLS	-0.43***	0.20***	0.57***	0.21
N = 62,127,459	(0.00)	(0.00)	(0.00)	(0.14)
2. Worker Fixed Effects	-0.07	-0.20***	-0.45***	-0.36***
N = 59,995,009	(0.08)	(0.00)	(0.00)	(0.01)
3. Worker and Firm Fixed Effects	0.03	-0.16***	-0.37***	-0.30***
N = 59,911,104	(0.52)	(0.01)	(0.00)	(0.01)
4. Worker, Firm and Job Title Fixed Effects	-0.02	-0.11**	-0.24***	-0.22***
	(0.00)	(0.00)	(0.00)	(0.00)
N = 59,908,933				

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As for new hires, the conclusions are similar. While no statistically significant incremental effect can be estimated for workers under 26, for workers aged between 26 and 35 an additional effect of -0.11 is estimated; for workers aged between 36 and 50 the incremental effect is estimated to be -0.24; and for workers older than 50, the incremental effect is estimated at -0.22. The coefficients also reduce in magnitude and lose statistical significance with the inclusion of job title fixed effects.

4.2.5 Heterogeneity between Genders

The fifth extension to the base model is designed to test for the existence of differences between genders in terms of real wage cyclicality. For that purpose, the following equation will be used:

$$\textbf{(4.5)}\ \ln(W_{ijft}) = \lambda_i + \theta_j + \gamma_f + x_{it}\mu + \alpha_0 t + \alpha_1 t^2 + \phi hire_{ijft} + \pi female_i + \beta_1 cycle_t + \beta_2 cycle_t * female_i + \beta_3 cycle_t * hire_{ijft} + \beta_4 cycle_t * female_i * hire_{ijft} + \delta hire_{ijft} * female_i + u_{ijft},$$

where $female_i$ is a dummy variable that takes the value 1 if worker i is a female and 0, otherwise. Therefore, β_1 now measures the semi-elasticity of real average hourly earnings with respect to the unemployment rate for male stayers; $(\beta_1 + \beta_2)$ measures the semi-elasticity for male new hires; $(\beta_1 + \beta_3)$ measures the semi-elasticity for female stayers; and $(\beta_1 + \beta_2 + \beta_3 + \beta_4)$ measures the semi-elasticity for female new hires.

The results of this extension are presented in Table 12.

For male stayers, the semi-elasticity of real regular hourly earnings is estimated to be -0.94 per cent, and no statistically significant incremental effect could be estimated for female stayers. Male new hires are estimated to experience an additional cyclicality of -0.22 per cent when compared with male stayers, and for female new hires, no statistically significant incremental effect was detected.

These results confirm the conclusion presented by Martins (2007) that there seems not to exist evidence of gender differences in terms of wage cyclicality for the Portuguese labour market.

Table 12 Real Wage Sensitivity to the Unemployment Rate– Gender Differences, Portugal, 1986–2007

	Male Stayers (β_1)	Additional effect for female stayers (β_2)	Additional effect for male new hires (β_3)	Additional effect for female new hires (β_4)
1. OLS	-0.95***	-0.02	-0.53***	0.02
N = 62,127,459	(0.00)	(0.72)	(0.00)	(0.43)
2. Worker Fixed Effects	-0.97***	-0.09	-0.47***	0.09***
N = 59,995,009	(0.00)	(0.07)	(0.00)	(0.00)
3. Worker and Firm Fixed Effects	-0.97***	-0.02	-0.29***	0.06***
N = 59,911,104	(0.00)	(0.54)	(0.00)	(0.02)
4. Worker, Firm and Job Title Fixed Effects	-0.94***	-0.00	-0.22***	0.01
N = 59,908,933	(0.00)	(0.00)	(0.00)	(0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2.6 Heterogeneity across Firms

The sixth extension to the base model tests whether being employed by firms of different sizes can impact wage cyclicality. For this purpose, the sample of firms was divided into four groups- micro firms, small firms, medium firms and large firms- according to the criteria adopted by Statistics Portugal for statistical purposes. According to these criteria, a firm is classified as a micro firm if it has less than 10 workers and annual sales of less than 2 million euros; a firm is classified as a small firm if it has less than 50 workers and annual sales of less than 10 million euros, and is not classified as a micro firm; a firm is considered a medium firm if it has less than 250 workers and annual sales of less than 50 million euros, and is not classified as a small firm; and in all remaining cases, the firm is classified as a large firm. The sample is composed of around 85.87% micro firms, 11.83% small firms, 1.91% medium firms and 0.39% large firms. The following equation will be used for this extension:

$$\textbf{(4.6)}\ \ln(W_{ijft}) = \lambda_i + \theta_j + \gamma_f + x_{it}\delta + \alpha_0 t + \alpha_1 t^2 + \phi hire_{ijft} + \sigma s\_firm_{ft} + \tau m\_firm_{ft} + \pi l\_firm_{ft} + \beta_1 cycle_t + \beta_2 cycle_t * s\_firm_{ft} + \beta_3 cycle_t * m\_firm_{ft} + \beta_4 cycle_t * l\_firm_{ft} + \beta_5 cycle_t * hire_{ijft} + \beta_6 cycle_t * hire_{ijft} * s\_firm_{ft} + \beta_7 cycle_t * hire_{ijft} * m\_firm_{ft} + \beta_8 cycle_t * hire_{ijft} * l\_firm_{ft} + \varepsilon hire_{ijft} * s\_firm_{ft} + \mu hire_{ijft} * m\_firm_{ft} + \nu hire_{ijft} * l\_firm_{ft} + u_{ijft},$$

Where *s_firm$_f$* is a dummy variable that takes value 1 if firm f is classified as a small firm in period t, and value 0 otherwise; *m_firm$_f$* is a dummy variable that takes value 1 if firm f is classified as a medium firm in period t, and 0 otherwise; and *l_firm$_f$* is a dummy variable that takes value 1 if firm f is classified as a large firm in period t, and 0 otherwise. Therefore, now, β_1 measures the semi-elasticity of real average hourly earnings with respect to the unemployment rate for stayers employed in micro firms; ($\beta_1 + \beta_2$) measures the semi-elasticity for stayers employed in small firms; ($\beta_1 + \beta_3$) measures the semi-elasticity for stayers employed in medium firms; ($\beta_1 + \beta_4$) measures the semi-elasticity for stayers employed in large firms; ($\beta_1 + \beta_5$) measures the semi-elasticity for new hires employed in micro firms; ($\beta_1 + \beta_2 + \beta_5 + \beta_6$) measures the semi-elasticity for new hires employed in small firms; ($\beta_1 + \beta_3 + \beta_5 + \beta_7$) measures the semi-elasticity for new hires employed in medium firms; and ($\beta_1 + \beta_4 + \beta_5 + \beta_8$) measures the semi-elasticity for new hires employed in large firms.

The results of the regressions for stayers are presented in Table 13 and the incremental effects for new hires are displayed in Table 14.

A very clear pattern stands out from these estimates. For stayers, the larger the firm, the lower the real wage cyclicality a worker tends to experience. As for the incremental effect for new hires, the exact opposite is true- the larger the firm, the higher the additional cyclicality experienced by the worker. This indicates that, in large firms, incumbent workers are more insulated from the business cycle than newly hired workers. One possible explanation for this could be that, in large firms, there is a larger margin for differentiation between workers than in small firms. On top of that, larger firms have a lower proportion of new hires[8] and higher average worker tenure[9]. Thus, since workers with more tenure are better represented in larger firms, they might be able to negotiate wage stability based on tenure.

Table 13 Real Wage Sensitivity to the Unemployment Rate– Impact of Firm Size, Portugal, 1986–2021

	Micro Firms	Additional Effect for Small Firms	Additional Effect for Medium Firms	Additional Effect for Large Firms
1. OLS	-1.22***	0.55***	0.45***	-0.23
N = 62,127,459	(0.00)	(0.00)	(0.00)	(0.17)
2. Worker Fixed Effects	-1.28***	0.23***	0.21***	0.49***
N = 59,995,009	(0.00)	(0.00)	(0.00)	(0.00)
3. Worker and Firm Fixed Effects	-1.14***	0.11***	0.09***	0.36***
N = 59,911,104	(0.00)	(0.00)	(0.01)	(0.00)
4. Worker, Firm and Job Title Fixed Effects	-1.09***	0.13***	0.14***	0.28***
	(0.00)	(0.00)	(0.00)	(0.00)
N = 59,139,613				

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[8] In micro firms, new hires represent about 22% of the workforce, while in small firms the proportion reduces to about 19%, in medium firms to around 16%, and in large firms to no more than 14%.
[9] For micro firms the mean tenure is 6.26 years; for small firms, it is 6.92 years; for medium firms 8.60 years; and 10.56 years for large firms.

Table 14 Real Wage Sensitivity to the Unemployment Rate– Impact of Firm Size (Incremental Effect for New Hires), Portugal, 1986–2021

	Micro Firms	Additional Effect for Small Firms	Additional Effect for Medium Firms	Additional Effect for Large Firms
1. OLS	-0.02	-0.57***	-0.77***	-0.90***
N = 62,127,459	(0.75)	(0.00)	(0.00)	(0.00)
2. Worker Fixed Effects	-0.13***	-0.21***	-0.25***	-0.74***
N = 59,995,009	(0.02)	(0.00)	(0.00)	(0.00)
3. Worker and Firm Fixed Effects	-0.09	-0.14***	-0.15***	-0.34***
N = 59,911,104	(0.09)	(0.00)	(0.00)	(0.00)
4. Worker, Firm and Job Title Fixed Effects	-0.08**	-0.12***	-0.13***	-0.27***
	(0.00)	(0.00)	(0.00)	(0.00)
N = 59,139,613				

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2.7 Regional Asymmetries

The seventh and last extension will test for the existence of asymmetries in terms of real wage cyclicality between the seven NUTSII regions of Portugal- "Norte", "Algarve", "Centro", "Lisboa", "Alentejo", "Açores" and "Madeira". The following equation will be used for this extension:

$$\textbf{(4.7)}\ \ln(W_{ijft}) = \lambda_i + \theta_j + \gamma_f + x_{it}\varphi + \alpha_0 t + \alpha_1 t^2 + \phi hire_{ijft} + \nu algarve_f + \mu centro_f + \varepsilon lisboa_f + \pi alentejo_f + \sigma açores_f + \delta madeira_f + \beta_1 cycle_t + \beta_2 cycle_t * algarve_f + \beta_3 cycle_t * centro_f + \beta_4 cycle_t * lisboa_f + \beta_5 cycle_t * alentejo_f + \beta_6 cycle_t * açores_f + \beta_7 cycle_t * madeira_f + \beta_8 cycle_t * hire_{ijft} + \beta_9 cycle_t * algarve_f * hire_{ijft} + \beta_{10} cycle_t * centro_f * hire_{ijft} + \beta_{11} cycle_t * lisboa_f * hire_{ijft} + \beta_{12} cycle_t * alentejo_f * hire_{ijft} + \beta_{13} cycle_t * açores_f * hire_{ijft} + \beta_{14} cycle_t * madeira_f * hire_{ijft} + \omega algarve_f * hire_{ijft} + \varsigma centro_f * hire_{ijft} + \chi lisboa_f * hire_{ijft} + \eta alentejo_f * hire_{ijft} + \kappa açores_f * hire_{ijft} + \rho madeira_f * hire_{ijft} + u_{ijft},$$

where $algarve_f$ is a dummy variable that takes the value 1 if firm f is located in the region of "Algarve", and 0 otherwise; $centro_f$ is a dummy variable that takes the value 1 if firm f is located in the region of "Centro", and 0 otherwise; $lisboa_f$ is a dummy variable that takes the value 1 if firm f is located in the region of "Lisboa", and 0 otherwise; $alentejo_f$ is a dummy variable that takes the value 1 if firm f is located in the region of "Alentejo", and 0 otherwise; $açores_f$ is a dummy variable that takes the value 1 if firm f is located in the region of "Açores", and 0 otherwise; and $madeira_f$ is a dummy variable that takes the value 1 if firm f is located in the region of "Madeira", and 0 otherwise. Thus, β_1 now measures the semi-elasticity of real average hourly earnings with respect to the unemployment rate for stayers employed in firms of the "Norte" region; $(\beta_1 + \beta_2)$ measures the semi-elasticity for stayers employed in firms of the "Algarve" region; $(\beta_1 + \beta_3)$ measures the semi-elasticity for stayers employed in firms of the "Centro" region; $(\beta_1 + \beta_4)$ measures the semi-elasticity for stayers employed in firms of the "Lisboa" region; $(\beta_1 + \beta_5)$ measures the semi-elasticity for stayers employed in firms of the "Alentejo" region; $(\beta_1 + \beta_6)$ measures the semi-elasticity for stayers employed in firms of the "Açores" region; $(\beta_1 + \beta_7)$ measures the semi-elasticity for stayers employed in firms of the "Madeira" region; $(\beta_1 + \beta_8)$ measures the semi-elasticity for new hires employed in firms of the "Norte" region; $(\beta_1 + \beta_2 + \beta_8 + \beta_9)$ measures the semi-elasticity for new hires employed in firms of the "Algarve" region; $(\beta_1 + \beta_3 + \beta_8 + \beta_{10})$ measures the semi-elasticity for new hires employed in firms of the "Centro" region; $(\beta_1 + \beta_4 + \beta_8 + \beta_{11})$ measures the semi-elasticity for new hires employed in firms of the "Lisboa" region; $(\beta_1 + \beta_5 + \beta_8 + \beta_{12})$ measures the semi-elasticity for new hires employed in firms of the "Alentejo" region; $(\beta_1 + \beta_6 + \beta_8 + \beta_{13})$ measures the semi-elasticity for new hires employed in firms of the "Açores" region; and $(\beta_1 + \beta_7 + \beta_8 + \beta_{14})$ measures the semi-elasticity for new hires employed in firms of the "Madeira" region.

The results for stayers are presented in Table 15 and the incremental effects for new hires are reported in Table 16.

For stayers, the two autonomous regions of "Açores" and "Madeira" seem to observe lower real wage cyclicality than the remaining five NUTS II regions of Mainland Portugal. While a one percentage point increase in the unemployment rate is estimated to reduce the wages of workers employed in firms of the "Norte" region by 0.98 per cent, that reduction is estimated to be of only 0.62 per cent for workers of the region of "Açores", and 0.79 per cent, for

workers in the region of "Madeira".This effect might be due to a more homogeneous labour force in the islands.

In Mainland Portugal, the region of "Lisboa" seems to be the only one to observe a slightly lower cyclicality, but the effect is very small, at 0.09 percentage points.

Table 15 Real Wage Sensitivity to the Unemployment Rate– Regional Asymmetries, Portugal, 1986–2021

	OLS	Worker Fixed Effects	Worker and Firm Fixed Effects	Worker, Firm and Job Title Fixed Effects
"Norte"	-0.84***	-1.15***	-1.07***	-0.98***
	(0.00)	(0.00)	(0.00)	(0.00)
Additional Effect for "Algarve"	-0.37***	-0.09	-0.13**	-0.07
	(0.02)	(0.14)	(0.00)	(0.00)
Additional Effect for "Centro"	0.08**	0.04	-0.02	-0.03
	(0.10)	(0.33)	(0.27)	(0.00)
Additional Effect for "Lisboa"	-0.47***	0.29***	0.21***	0.09**
	(0.00)	(0.00)	(0.00)	(0.00)
Additional Effect for "Alentejo"	0.57***	0.25***	0.13***	0.02
	(0.00)	(0.00)	(0.02)	(0.00)
Additional Effect for "Açores"	0.64***	0.82***	0.65***	0.36***
	(0.00)	(0.00)	(0.00)	(0.00)
Additional Effect for "Madeira"	0.89***	0.61***	0.44***	0.19*
	(0.00)	(0.00)	(0.00)	(0.00)
N	61,338,525	59,240,300	59,156,642	59,139,825

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In regards to new hires, while it is possible to detect a pattern of incremental real wage cyclicality in all seven regions, this effect is not homogeneous across all regions. Newly-hired

workers employed in the regions of "Lisboa", "Açores" and "Alentejo" experience a significantly higher effect than newly-hired workers employed in the four remaining regions.

Table 16 Real Wage Sensitivity to the Unemployment Rate– Regional Asymmetries (Incremental Effect for New Hires), Portugal, 1986–2021

	OLS	Worker Fixed Effects	Worker and Firm Fixed Effects	Worker, Firm and Job Title Fixed Effects
"Norte"	-0.36***	-0.20***	-0.16***	-0.13***
	(0.00)	(0.00)	(0.00)	(0.00)
Additional Effect for "Algarve"	0.39**	-0.11***	-0.07**	-0.03
	(0.05)	(0.01)	(0.00)	(0.00)
Additional Effect for "Centro"	-0.11***	-0.06**	-0.03	0.04*
	(0.01)	(0.04)	(0.00)	(0.00)
Additional Effect for "Lisboa"	-0.43***	-0.55***	-0.23***	-0.19***
	(0.00)	(0.00)	(0.00)	(0.00)
Additional Effect for "Alentejo"	-0.30***	-0.22***	-0.14***	-0.10***
	(0.00)	(0.00)	(0.00)	(0.00)
Additional Effect for "Açores"	0.08	-0.25**	-0.16**	-0.15***
	(0.42)	(0.00)	(0.00)	(0.00)
Additional Effect for "Madeira"	-0.34***	-0.11	0.04	0.02
	(0.01)	(0.26)	(0.00)	(0.00)
N	61,338,525	59,240,300	59,156,642	59,139,825

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.3 Robustness Checks

4.3.1 Different Deflators

As the first robustness check, I decided to test five alternative deflators: the total CPI excluding housing; the total CPI excluding food and energy; the total CPI excluding energy; the total CPI excluding non-processed food; and the current prices GDP deflator.

The results obtained with the GDP deflator are displayed in Table 17 and the results for the four alternative CPI deflators are presented in Tables A3 to A6 of the Annex.

Even though the magnitude of the estimated cyclicality varies somewhat significantly between the five deflators used, the results are qualitatively similar.

This change in the magnitude of the estimates is especially evident for the Current Prices GDP Deflator, for which the semi-elasticity of real regular hourly earnings is estimated to be -0.41 per cent when using the complete model with three fixed effects (regression 8 of Table 17). When we compare this value with the -0.94 per cent from regression 8 of Table 3, where the Total CPI was used as the deflator, it becomes quite apparent that, from the perspective of firms, real wages look almost 50% less procyclical. This indicates that some of the wage cyclicality estimated using the Total CPI as a deflator is attributable to changes in prices.

As for the four alternative CPI deflators, the highest value estimated for the semi-elasticity of real regular hourly earnings was obtained using the Total CPI excluding Housing (-0.99 per cent) and the lowest value was obtained using the Total CPI excluding Food and Energy (-0.69 per cent) and, thus, the dispersion in the results is much lower.

Table 17 Real Wage Sensitivity to the Unemployment Rate– Current Prices GDP Deflator, Portugal, 1986–2021

	Stayers (more than 12 months of tenure)	Additional Effect for New Hires (less than 12 months of tenure)
1. OLS (Base Wages) N = 62,127,466	-0.50*** (0.00)	-0.42*** (0.00)
2. Worker Fixed Effects (Base Wages) N = 59,995,098	-0.51*** (0.00)	-0.38*** (0.00)
3. Worker and Firm Fixed Effects (Base Wages) N = 59,911,192	-0.46*** (0.00)	-0.27*** (0.00)
4. Worker, Firm and Job Title Fixed Effects (Base Wages) N = 59,908,907	-0.43*** (0.00)	-0.22*** (0.00)
5. OLS (Regular Wages) N = 62,127,466	-0.46*** (0.00)	-0.51*** (0.00)
6. Worker Fixed Effects (Regular Wages) N = 59,995,098	-0.49*** (0.00)	-0.45*** (0.00)
7. Worker and Firm Fixed Effects (Regular Wages) N = 59,911,192	-0.46*** (0.00)	-0.29*** (0.00)
8. Worker, Firm and Job Title Fixed Effects (Regular Wages) N = 59,908,907	-0.41*** (0.00)	-0.23*** (0.00)
9. OLS (Total Wages) N = 62,127,466	-0.54*** (0.00)	-0.38*** (0.00)
10. Worker Fixed Effects (Total Wages) N = 59,995,098	-0.57*** (0.00)	-0.39*** (0.00)
11. Worker and Firm Fixed Effects (Total Wages) N = 59,911,192	-0.54*** (0.00)	-0.26*** (0.00)
12. Worker, Firm and Job Title Fixed Effects (Total Wages) N = 59,908,907	-0.49*** (0.00)	-0.21*** (0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.3.2 Different Cyclical Stance Indicators

As a second check for the robustness of the previous results, I decided to swap the unemployment rate for the real GDP growth rate as the cyclical stance indicator. The results are presented in Table 18.

Table 18 Real Wage Sensitivity to the Real GDP Growth Rate, Portugal, 1986–2021

	Stayers (more than 12 months of tenure)	Additional Effect for New Hires (less than 12 months of tenure)
1. OLS (Regular Wages) N = 62,127,459	-0.16 (0.60)	0.06 (0.83)
2. Worker Fixed Effects (Regular Wages) N = 59,995,009	-0.10 (0.75)	0.12 (0.31)
3. Worker and Firm Fixed Effects (Regular Wages) N = 59,911,104	-0.08 (0.77)	0.07 (0.30)
4. Worker, Firm and Job Title Fixed Effects (Regular Wages) N = 59,908,933	-0.15 (0.00)	0.04 (0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regression includes a dummy for gender in the explanatory variables
Total CPI (Statistics Portugal)
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

These results show that no statistically significant change in real regular hourly wages in response to changes in the GDP growth rate could be estimated, which demonstrates that wage cyclicality tends to be much more influenced by labour market conditions and, in particular, by changes in the unemployment rate, than by changes in other aggregate economic indicators like the GDP. This was expected since, even though labour market conditions and output are obviously connected, the two do not react to shocks

simultaneously and in the same magnitude- it is a stylized fact that the unemployment rate is less volatile than GDP[10].

[10] See Ball et al. (2013) for a good empirical demonstration of Okun's Law.

5. Conclusion

By extending the time period of the sample used by Carneiro et al. (2012) to include the 2008-2021 period, I was able to construct a sample including three complete business cycles and the start of a fourth one and show that the sensitivity of real hourly wages to the unemployment rate has been decreasing since 1992 in Portugal., which confirms that, as reported by previous literature, shocks of different natures lead to different patterns and magnitudes of real wage cyclicality.

I also split the years in the sample into four business cycle phases- expansions, recessions, depressions and recoveries- and show that the most extreme phases- depressions and expansions- are the ones that lead to the highest cyclicality.

Additionally, I disentangle the global wage cyclicality into that experienced by different sociodemographic groups (gender, education, and age) and by firm characteristics (size and location). This disentanglement led to three key findings. First, I show that more education tends to lead to less real wage cyclicality and less job upgrading/downgrading and that polytechnic degrees are the type of education that most enhance this effect. Second, I show that wage cyclicality tends, in general, to increase with age. Third, I present evidence that in larger firms stayers experience lower wage cyclicality, while new hires observe a higher incremental wage cyclicality.

By also testing the sensitivity of real wages to the real GDP growth rate, I show that the evolution of wages over the business cycle is much more connected to labour market conditions and, in particular, to the unemployment rate than to other aggregate economic indicators.

All of these findings seem to prove right Robert Luca's prediction that trying to establish a systematic global pattern of how real wages evolve over the business cycle could only lead to failure. Thus, the solution for the development of macroeconomic models with adherence to reality seems to be to include heterogeneity in wage cyclicality into those models, by allowing workers with different characteristics to observe different magnitudes of wage cyclicality and different shocks to lead to different patterns of wage cyclicality.

Naturally, some of the analyses presented in this work have their limitations. For example, the test for regional asymmetries was conducted using the national unemployment rate as in all the other sections. However, there are high mobility costs and, thus, the wages of a worker

in a certain region of Portugal might not be so influenced by the national unemployment rate as by the unemployment rate registered in that region (this is especially true for the two autonomous regions of "Açores" and "Madeira"). But, regional unemployment rates are not available for Portugal for the whole sample period used in this study and, thus, I did not test whether using such a cyclical stance indicator would alter the results found. This would be an interesting test for future research focusing on a shorter period.

Another good topic for future studies on the heterogeneity of wage cyclicality would be to test whether different industries and economic sectors experience different magnitudes of wage cyclicality in an attempt to explain some of the findings presented in this study, like the fact that a Polytechnic degree seems to be the type of education that most reduce real wage procyclicality in Portugal.

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Annex

Table A1 Total CPI, Total CPI excluding Housing, Total CPI excluding Unprocessed Food and Energy and Total CPI excluding Energy, Total CPI excluding Unprocessed Food and Current Prices GDP Deflator, Portugal, 1986-2021

Year	Total CPI	Total CPI excluding Housing	Total CPI excluding Unprocessed Food and Energy	Total CPI excluding Energy	Total CPI excluding Unprocessed Food	Current Prices GDP Deflator
1985	-	-	-	-	-	-
1986	28.75	29.85	27.23	29.41	26.84	26.71
1987	31.71	32.83	30.28	32.79	29.42	29.57
1988	34.44	35.48	33.18	35.67	32.13	33.22
1989	38.65	39.77	37.94	40.17	36.53	37.05
1990	43.69	44.84	42.66	45.40	41.11	41.90
1991	49.36	50.21	48.60	51.18	46.92	46.69
1992	53.93	54.48	53.94	56.12	51.84	51.52
1993	58.01	58.45	59.46	60.57	56.78	54.62
1994	62.63	63.03	64.81	65.49	61.74	58.18
1995	65.20	65.55	67.93	68.29	64.56	61.35
1996	67.10	67.46	70.13	70.26	66.66	62.81
1997	68.48	68.70	71.47	71.64	68.01	65.25
1998	70.50	70.73	73.22	73.91	69.54	67.75
1999	71.89	72.09	75.12	75.64	71.04	70.03
2000	74.43	74.63	77.23	78.00	73.38	72.43
2001	77.47	77.68	80.10	81.26	76.06	75.12
2002	80.55	80.71	83.92	84.62	79.50	78.27
2003	82.90	83.07	86.22	87.02	81.76	80.95
2004	84.71	84.86	87.93	88.38	83.94	82.89
2005	86.99	87.11	89.70	89.84	86.58	85.65
2006	89.32	89.42	92.18	92.58	88.63	88.38
2007	91.62	91.70	94.30	94.61	91.04	91.00
2008	93.80	93.86	96.55	96.66	93.41	92.58
2009	92.43	92.34	96.10	95.53	92.57	93.60
2010	94.60	94.53	97.04	96.93	94.45	94.20
2011	98.57	98.59	99.37	99.24	98.62	93.95
2012	100.67	100.68	100.43	100.54	100.60	93.59
2013	100.43	100.41	100.62	100.73	100.30	95.69
2014	100.43	100.29	100.78	100.83	100.34	96.37
2015	101.07	100.91	101.72	101.94	100.76	98.31
2016	101.96	101.76	102.47	102.83	101.53	100.00
2017	103.38	103.20	103.84	104.13	103.03	101.51
2018	104.37	104.12	104.31	104.53	104.15	103.35
2019	104.39	103.99	104.63	105.00	103.99	105.16
2020	104.31	103.81	104.53	105.45	103.36	107.20
2021	106.22	105.71	105.65	106.34	105.59	108.70

Source: Statistics Portugal

Table A2 Unemployment Rate, Expansion Years, Recovery Years, Recession Years and Depression Years, Portugal, 1986-2021

Year	Unemployment rate (%)	Expansion Years	Recovery Years	Recession Years	Depression Years
1985	7.18	-	-	-	-
1986	7.42	Yes	No	No	No
1987	6.53	No	No	Yes	No
1988	5.72	Yes	No	No	No
1989	4.50	Yes	No	No	No
1990	5.10	-	-	-	-
1991	4.73	Yes	No	No	No
1992	3.89	Yes	No	No	No
1993	4.94	Yes	No	No	No
1994	5.96	No	No	Yes	No
1995	6.25	No	No	Yes	No
1996	6.35	No	No	Yes	No
1997	5.84	No	No	Yes	No
1998	4.95	Yes	No	No	No
1999	4.40	Yes	No	No	No
2000	3.90	Yes	No	No	No
2001	4.00	-	-	-	-
2002	5.00	Yes	No	No	No
2003	6.25	No	No	Yes	No
2004	6.65	No	No	Yes	No
2005	7.60	No	No	Yes	No
2006	7.60	No	No	Yes	No
2007	8.00	Yes	No	No	No
2008	7.60	No	No	No	Yes
2009	9.40	Yes	No	No	No
2010	10.80	No	No	No	Yes
2011	13.40	No	No	No	Yes
2012	16.50	No	No	No	Yes
2013	17.10	No	No	No	Yes
2014	14.50	No	No	No	Yes
2015	12.90	No	Yes	No	No
2016	11.50	No	Yes	No	No
2017	9.20	No	Yes	No	No
2018	7.20	No	Yes	No	No
2019	6.60	Yes	No	No	No
2020	7.00	Yes	No	No	No
2021	-	No	No	Yes	No

Source: The unemployment rate comes from Statistics Portugal

Table A3 Real Wage Sensitivity to the Unemployment Rate- Total CPI excluding Housing, Portugal, 1986-2021

	Stayers (more than 12 months of tenure)	Additional Effect for New Hires (less than 12 months of tenure)
1. OLS (Base Wages)	-1.06***	-0.40***
N = 62,127,466	(0.00)	(0.00)
2. Worker Fixed Effects (Base Wages)	-1.08***	-0.37***
N = 59,995,098	(0.00)	(0.00)
3. Worker and Firm Fixed Effects (Base Wages)	-1.03***	-0.25***
N = 59,911,192	(0.00)	(0.00)
4. Worker, Firm and Job Title Fixed Effects (Base Wages)	-1.01***	-0.21***
N = 59,909,071	(0.00)	(0.00)
5. OLS (Regular Wages)	-1.03***	-0.50***
N = 62,127,466	(0.00)	(0.00)
6. Worker Fixed Effects (Regular Wages)	-1.06***	-0.43***
N = 59,995,098	(0.00)	(0.00)
7. Worker and Firm Fixed Effects (Regular Wages)	-1.03***	-0.27***
N = 59,911,192	(0.00)	(0.00)
8. Worker, Firm and Job Title Fixed Effects (Regular Wages)	-0.99***	-0.22***
N = 59,909,071	(0.00)	(0.00)
9. OLS (Total Wages)	-1.11***	-0.37***
N = 62,127,466	(0.00)	(0.00)
10. Worker Fixed Effects (Total Wages)	-1.14***	-0.38***
N = 59,995,098	(0.00)	(0.00)
11. Worker and Firm Fixed Effects (Total Wages)	-1.11***	-0.24***
N = 59,911,192	(0.00)	(0.00)
12. Worker, Firm and Job Title Fixed Effects (Total Wages)	-1.07***	-0.20***
N = 59,909,071	(0.00)	(0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regressions include a dummy for gender in the explanatory variables
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4 Real Wage Sensitivity to the Unemployment Rate- Total CPI excluding Food and Energy, Portugal, 1986-2021

	Stayers (more than 12 months of tenure)	Additional Effect for New Hires (less than 12 months of tenure)
1. OLS (Base Wages) N = 62,127,466	-0.69*** (0.00)	-0.42*** (0.00)
2. Worker Fixed Effects (Base Wages) N = 59,995,098	-0.74*** (0.00)	-0.36*** (0.00)
3. Worker and Firm Fixed Effects (Base Wages) N = 59,911,192	-0.70*** (0.00)	-0.24*** (0.00)
4. Worker, Firm and Job Title Fixed Effects (Base Wages) N =	-0.71*** (0.00)	-0.21*** (0.00)
5. OLS (Regular Wages) N = 62,127,466	-0.66*** (0.00)	-0.51*** (0.00)
6. Worker Fixed Effects (Regular Wages) N = 59,995,098	-0.72*** (0.00)	-0.42*** (0.00)
7. Worker and Firm Fixed Effects (Regular Wages) N = 59,911,192	-0.70*** (0.00)	-0.26*** (0.00)
8. Worker, Firm and Job Title Fixed Effects (Regular Wages) N = 59,909,159	-0.69*** (0.00)	-0.22*** (0.00)
9. OLS (Total Wages) N = 62,127,466	-0.74*** (0.00)	-0.38*** (0.00)
10. Worker Fixed Effects (Total Wages) N = 59,995,098	-0.79*** (0.00)	-0.37*** (0.00)
11. Worker and Firm Fixed Effects (Total Wages) N = 59,911,192	-0.78*** (0.00)	-0.23*** (0.00)
12. Worker, Firm and Job Title Fixed Effects (Total Wages) N = 59,909,071	-0.76*** (0.00)	-0.20*** (0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regressions include a dummy for gender in the explanatory variables
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5 Real Wage Sensitivity to the Unemployment Rate- Total CPI excluding Energy, Portugal, 1986-2021

	Stayers (more than 12 months of tenure)	Additional Effect for New Hires (less than 12 months of tenure)
1. OLS (Base Wages)	-0.76***	-0.41***
N = 62,127,466	(0.00)	(0.00)
2. Worker Fixed Effects (Base Wages)	-0.79***	-0.37***
N = 59,995,098	(0.00)	(0.00)
3. Worker and Firm Fixed Effects (Base Wages)	-0.75***	-0.24***
N = 59,911,192	(0.00)	(0.00)
4. Worker, Firm and Job Title Fixed Effects (Base Wages)	-0.75***	-0.21***
N = 59,909,071	(0.00)	(0.00)
5. OLS (Regular Wages)	-0.73***	-0.51***
N = 62,127,466	(0.00)	(0.00)
6. Worker Fixed Effects (Regular Wages)	-0.78***	-0.43***
N = 59,995,098	(0.00)	(0.00)
7. Worker and Firm Fixed Effects (Regular Wages)	-0.75***	-0.27***
N = 59,911,192	(0.00)	(0.00)
8. Worker, Firm and Job Title Fixed Effects (Regular Wages)	-0.73***	-0.22***
N = 59,909,071	(0.00)	(0.00)
9. OLS (Total Wages)	-0.80***	-0.38***
N = 62,127,466	(0.00)	(0.00)
10. Worker Fixed Effects (Total Wages)	-0.85***	-0.38***
N = 59,995,098	(0.00)	(0.00)
11. Worker and Firm Fixed Effects (Total Wages)	-0.83***	-0.23***
N = 59,911,192	(0.00)	(0.00)
12. Worker, Firm and Job Title Fixed Effects (Total Wages)	-0.81***	-0.20***
N = 59,909,071	(0.00)	(0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regressions include a dummy for gender in the explanatory variables
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A6 Real Wage Sensitivity to the Unemployment Rate- Total CPI excluding Non-processed Food, Portugal, 1986-2021

	Stayers (more than 12 months of tenure)	Additional Effect for New Hires (less than 12 months of tenure)
1. OLS (Base Wages)	-0.90***	-0.42***
N = 62,127,466	(0.00)	(0.00)
2. Worker Fixed Effects (Base Wages)	-0.94***	-0.37***
N = 59,995,098	(0.00)	(0.00)
3. Worker and Firm Fixed Effects (Base Wages)	-0.90***	-0.25***
N = 59,911,192	(0.00)	(0.00)
4. Worker, Firm and Job Title Fixed Effects (Base Wages)	-0.82***	-0.21***
N = 59,909,071	(0.00)	(0.00)
5. OLS (Regular Wages)	-0.87***	-0.51***
N = 62,127,466	(0.00)	(0.00)
6. Worker Fixed Effects (Regular Wages)	-0.92***	-0.44***
N = 59,995,098	(0.00)	(0.00)
7. Worker and Firm Fixed Effects (Regular Wages)	-0.90***	-0.28***
N = 59,911,192	(0.00)	(0.00)
8. Worker, Firm and Job Title Fixed Effects (Regular Wages)	-0.80***	-0.22***
N = 59,909,071	(0.00)	(0.00)
9. OLS (Total Wages)	-0.94***	-0.39***
N = 62,127,466	(0.00)	(0.00)
10. Worker Fixed Effects (Total Wages)	-1.00***	-0.38***
N = 59,995,098	(0.00)	(0.00)
11. Worker and Firm Fixed Effects (Total Wages)	-0.98***	-0.24***
N = 59,911,192	(0.00)	(0.00)
12. Worker, Firm and Job Title Fixed Effects (Total Wages)	-0.88***	-0.20***
N = 59,909,071	(0.00)	(0.00)

Cluster-robust standard errors in parentheses (cluster by year)
The OLS regressions include a dummy for gender in the explanatory variables
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$