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Human capital and labour market resilience over time: a regional perspective of the Portuguese case

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Abstract

This study examines the link between human capital and labour market resilience in the seven Portuguese NUTS-2 regions over the period 1995-2018. We use the Local Projection methodology (LPM) to estimate a SVAR model with three variables (employment, human capital, output) conditioning the response of the labour market to two scenarios depending on whether a shock to GDP occurs during recessions or during expansions, with output gap as the switching variable for the identification of recession and expansion regimes. The comparison of the employment responses to GDP shocks between the two regimes is informative about the degree of resilience of the labour market. We find evidence of: (i) distinct effects in terms of the sign and amplitude of GDP shocks on regional employment according to the level of educational attainment of employees; (ii) labour market resilience but jobless recoveries in several regions; and (iii) different regional reactions of human capital to GDP shocks depending on the regime.

Keywords: employment resilience, GDP shocks, local projections, structural VARs, NUTS-2, Portugal

Introduction

This study investigates the linkages between human capital and labour market resilience over the business cycle in the seven Portuguese NUTS-2 regions considering the period 1995-2018. To identify resilience, we use the Local Projection

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Methodology (LPM) applied to a SVAR model with three variables (employment, human capital output) and the output gap as the switching variable for the identification of recessionary and expansionary regimes. The LPM is quite flexible in dealing with state/regime dependency when estimating the effects of shocks. We explore SVAR specifications that condition the response of the labour market to two scenarios depending on whether the shock to output occurs during recessions or during expansions. The comparison of the employment responses to shocks between the two regimes is informative about the degree of resilience of the regional labour markets.

Portugal was one of the European Union (EU) member states most severely hit by the 2007-08 financial crisis. In 2009, Portuguese real GDP recorded a negative growth rate of -3.12% and, in 2012, of -4.06% and the unemployment rate reached 16.2% in 2013, a historic high (source: PORDATA). Additionally, Portugal still compares poorly with the average EU member state in terms of educational attainment, a fundamental driver of growth (Benos and Zotou, 2014; Ramos *et al.*, 2012). Employment is concentrated in three of the seven NUTS-2 regions, *Norte* (35.2%), *Lisboa* (27.4%) and *Centro* (21.6%) (Eurostat, year 2019). Correia and Alves (2017) provide a descriptive analysis of the dynamics of employment in Portugal at the NUTS-2 level over the period 2000-14. *Centro* and *Madeira* recorded the highest decreases in employment (17%), followed by *Alentejo* and *Norte* (12%), above the drop at the national level (11%), while *Lisboa*, *Algarve* and *Açores* recorded the lowest decreases (lower than 5%). The Global Labour Resilience Index (GLRI, 2020; Whiteshield_Partners, 2020) highlights education and skills as a priority for Portugal to increase labour market resilience.

This study is organised in five sections. After the introduction we review the literature on the determinants of (labour market) resilience; section 3 contains the description of the data used and the empirical methodology applied; section 4 presents and discusses the results and section 5 comprises the main conclusions.

1. Literature overview

The often cited works of Martin (2012) and Martin and Sunley (2015) provide the fundamental definitions of resilience that have been used in the analysis of this phenomenon at the regional level. Table 1 in both studies identifies three main types of resilience, associated with different scientific fields of study. Engineering resilience refers to the ability of a system to withstand and recover from shocks or disturbances. Ecological resilience is related to the capacity of a region to keep functioning within the same state or equilibrium in the presence of a shock before changing to a new equilibrium. Adaptative resilience is concerned with the ability of a region to adapt and renew itself in response to a shock. Martin (2012) also identifies four interrelated dimensions of resilience: resistance - the sensitivity to disturbances; recovery - the speed and extent of regional recovery after a perturbation; reorientation - the extent of structural changes in the regional economy following a shock; and renewal - the degree of renewal or resumption of the growth trajectory that characterised the regional economy before the disturbance.

Following the Great Recession initiated in 2007-08, there has been a renewed interest in measuring and describing regional resilience. According to Martin and Gardiner (2019), in 2007, a search in the Web of Science in the scientific fields of environmental studies, business and management studies, planning, urban studies, economics and economic geography identifies around 230 published works that contain the word "resilience" in their title while, in 2017, the number increased to more than 1,200. More recent studies investigate the determinants of regional resilience in the labour market. By using quarterly regional employment data over the period 1992–2012 for the 20 Italian NUTS-2 regions, Di Caro (2017) concludes that industrial diversification, high export ability, low financial constraints and rich endowments of human (average years of schooling) and social capital enhance regional resilience. Giannakis and Bruggeman (2017) investigate employment resilience to economic crisis across 268 EU-28 NUTS-2 regions. The share of workforce aged 25–64 years with upper secondary, post-secondary and tertiary education is found to be the most important determinant of regional employment resilience. The authors highlight that "All 7 Portuguese regions were among the 10 regions with the lowest shares of workforce with higher education across EU-28, ranging from 42% (PT17 – *ÁreaMetropolitana de Lisboa*) to 21% (PT20 –Açores)" (p. 1405). Another country specific study is that by Kitsos and Bishop (2018) who study the impact of several factors on local employment resilience in Great Britain following the 2007-08 shock.

Three variables are used to represent human capital: the shares of skilled and unskilled workers and employee training rates. Cross-section OLS findings confirm a positive role for the share of skilled workers and a younger population. Cappelli *et al.* (2020) provide a more encompassing analysis, again for the EU NUTS-2 regions, but by looking at the resistance of unemployment following the 2008 crisis and the role played by technological and human capital. The authors regress their measure of unemployment resistance over the period 2008-16 on a set of explanatory variables that include human capital (the percentage of the population aged 25–64 with tertiary education) using OLS. The results indicate that human capital alone is not enough to enhance unemployment resistance although a positive effect appears when human capital is interacted with an indicator of technological resistance. Hennebry (2020) is, to the best of our knowledge, the only study that examines the determinants of economic resilience at the regional level for Portugal by focusing on 16 NUTS-3 rural regions after the 2008-09 crisis. From the bivariate analysis carried out with the application of the Pearson correlation coefficient, the author concludes that employment resilience is highly negatively associated with the number of patents, reliance on tourism, employment in manufacturing, crime and higher voter turnout, while the median age of the population and employment in agriculture presented a positive association. The correlation coefficient with the share of labour force with tertiary education was positive but not statistically significant.

Since employment resilience in the Portuguese NUTS-2 regions may be linked to employment hysteresis, in what follows, we review the latter concept and previous literature focusing on Portugal to better clarify the differences between the two concepts. In the past, the steady increase of the unemployment rate explained why the concept of hysteresis started to be applied to the study of this variable. Hysteresis has its origins in physics and the majority of models that deal with permanent increases were inspired by this concept. In physics, hysteresis refers to the failure of an object to return to its original value after being submitted to an external force/shock and which remains after the force is removed, Ball and Mankiw (2002, p. 119). The use of this concept in economics gave rise to an extensive literature on its possible different meanings (e.g. weak vs. strong) and to a variety of models and methodologies for its study. Blanchard and Summers (1987) were the first to put forward the modern idea of sustained increases in the rate of unemployment. However, as O'Shaughnessy (2011, p. 334) explains, hysteresis is essentially a non-linear phenomenon, and the decrease of the long-term unemployment rate cannot be discarded. To the best of our knowledge, the first study on the presence of hysteresis in the Portuguese labour market is Modesto and Neves (1993), followed by e.g. Duarte and Andrade (2000), using macro data. Mota *et al.* (2012) and Mota and Vasconcelos (2012) study hysteresis by using industry data at the micro and macro levels. The former studies conclude for the non-rejection of the hysteresis hypothesis in the Portuguese labour market. More recently, using industry level monthly data for the period from January 2000 to December 2018, Mota and Vasconcelos (2021) do not find evidence of hysteresis after 2010 although some caution applies to the interpretation of this result. From the previous studies, it is possible to conclude that hysteresis was a characteristic of the Portuguese labour market until recently, especially just until before the labour market reforms in the wake of the 2007-08 financial crisis.

2. Empirical analysis

We apply a "complete information" methodology to study resilience in the labour market since we use all the information available on the business cycle. More specifically, we apply a SVAR - Local Projections Method (LPM), Ò. Jordà (2005). The LPM can be used to estimate economic resilience either in terms of GDP or labour market outcomes, see e.g. OECD (2017) that relates economic resilience to fiscal policy based on the literature on discretionary fiscal policy that flourished in the aftermath of the 2007-2008 crisis, (Auerbach and Gorodnichenko, 2012; Banerjee and Zampolli, 2019; Jordà and Taylor, 2015; Gechert and Rannenberg, 2018). To examine labour market resilience in the seven Portuguese NUTS2 regions, we consider that, in a recession, employment may react more to positive shocks than in the expansionary phase because a recession is characterized by excess production capacity and higher levels of unemployment. Therefore, after a positive shock in a recession, there is excess labour supply combined with lower fixed unit costs associated with the increase in hours worked (see Sorensen and Whitta-Jacobsen, 2010, chapter 13). The recent literature that flourished in the aftermath of the 2007-2008 crisis on discretionary fiscal policy and which mainly investigates fiscal multipliers also supports this contention (see Auerbach and Gorodnichenko, 2012). We then compare the effects of shocks on employment under each regime to determine the existence of resilience. We also study the effects of education/human capital shocks on employment.

We contribute to the literature by applying this new methodology to the study of resilience in the labour market. We define regional VAR models with three variables (employment, human capital and output) and estimate the response of regional employment to an impulse/shock to output considering the two distinct phases of the business cycle, recessions vs. expansions, using the output gap as the switching variable. Through the impulse-response analysis, we identify how employment reacts to a shock to output. We are also able to identify jobless recoveries by comparing the employment multipliers in the recession phase with those in the expansionary phase for the whole period under analysis. The existence of jobless recoveries indicates that factors that operate in the medium to long-run factors are important drivers of employment at the regional level. Hysteresis applies to an equilibrium value and is measured as a long-term phenomenon in terms of long memory associated to the evolution of employment and unemployment. Our study analyses the responses of regional employment to shocks in recessions relative to expansions focusing on the differences in the responses to shocks according to the phase of the business cycle. We thus fill an important gap in the literature although we realize that the former differences can occur in the presence of hysteresis. In fact, since we repeatedly find evidence of jobless recovery, this may be an indication of the existence of employment hysteresis at the regional level.

2.1. Data description

We build a regional database for Portugal covering the seven NUTS-2 regions (*Açores*, *Alentejo*, *Algarve*, *Centro*, *Lisboa e Vale do Tejo*, *Madeira* and *Norte*) with annual data from 1995 to 2018 including information on real GDP, *GDP*; the (real GDP) output gap, *GAP*; total hours worked, *HT*; the number of employees by levels of educational attainment, respectively, with less than 9 years of schooling, *G1*; at least 9 but less than 12 years of schooling *G2*, and with more than 12 years of schooling, *G3*; and average years of schooling of employees, *HC*. The variables were computed using primary data from three statistical sources: *Quadros de Pessoal*

(Personnel Records)[1], the National Statistics Office, INE, and Eurostat (Regional Economic Accounts (reg_eco10)).

Table 1 contains data on key indicators that provide a synthetic picture of the relative economic importance and dynamics of the seven Portuguese NUTS-2 regions.

Table 1. Human capital, employment and GDP in Portugal, NUTS-1 and NUT2, 1995-1998 (average) and 2015-2018 (average)

	HC		NFT		GDP	
Regions	**1995-1998**	**2015-2018**	**1995-1998**	**2015-2018**	**1995-1998**	**2015-2018**
Alentejo	6	10.69	4.62	4.98	7.27	6.42
Algarve	6.42	10.71	2.71	3.88	4.16	4.57
Açores	6.1	10.51	1.41	1.53	1.88	2.12
Centro	6.07	10.78	17.65	17.67	19.38	19.00
Lisboa	7.51	11.59	36.27	36.57	35.68	35.83
Madeira	6.22	10.76	1.87	1.81	2.08	2.37
Norte	5.98	10.78	35.47	33.56	29.38	29.58
Portugal	**6.56**	**11.06**	**100**	**100**	**100**	**100**

Notes: HC - average years of schooling of employees computed as a weighted average of the duration of the highest schooling level attained with the associated number of employees as weights; NFT – number of full-time equivalent employees as a % of the total for the national economy; GDP – real GDP at 2005 prices as a percentage of GDP for the national economy. *Source*: Authors' calculations based on data from *Quadros de Pessoal*

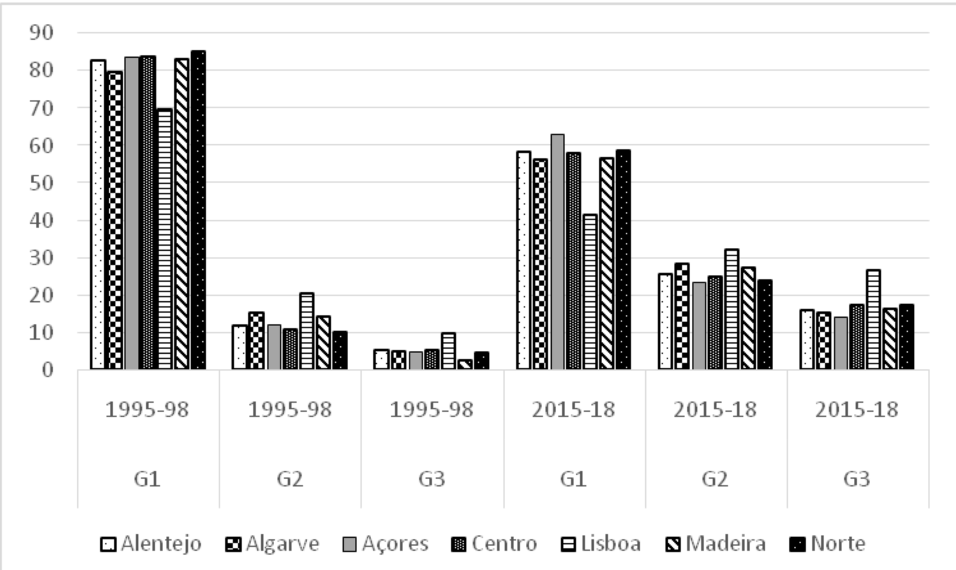
We present average values for 1995-1998, the initial four years of the period under analysis, and for 2015-2018, the last four years. *Lisboa*, *Norte* and *Centro* are the most important regions from an economic point of view: 89.4% (87.8%) of the Portuguese employees are located in one of these regions; at the beginning (end) of the period, 84.4% (84.42%) of the Portuguese GDP is created here. For the other regions, *Algarve* recorded the highest average annual growth rate of employment but *Açores* and *Madeira* experienced the highest average annual GDP growth rate. No re-ranking occurred among the seven regions, either in terms of employment or GDP. Human capital recorded a substantial increase in all regions, a result that is mostly explained by the implementation of educational policies aimed at reducing the Portuguese educational gap relative to the average EU and Economic and Monetary Union (EMU) member state. *Lisboa* is always the first region in the HC

[1]"*Quadros de Pessoal* (Personnel Records) is a compulsory survey of all firms, conducted in Portugal annually, in October, for purposes of monitoring compliance with labour law provisions. The dataset contains information on every wage earner in the Portuguese economy, with the exception of civil servants and independent workers, and respective employers." Taken from http://datalab.novasbe.pt/index.php/datalab-resources/27-databases-list/66-quadros-de-pessoal.

ranking; an upward re-ranking occurred in *Centro* and *Norte* from the 5th to the 2nd position and from the 7th position to the 3rd, respectively, whereas *Açores* experienced a downward re-ranking from the 4th to the 7th position.

Figure 1 contains the dynamics of employment composition by levels of schooling at the regional level. The relative importance of G3 and G2 has increased from 1995-98 to 2015-2018 and the opposite applies to G1. *Lisboa* is the best performing region. *Norte* follows this trend but, when compared to the remaining regions, it is the increase in the G3 share that stands out, leading this region to a re-ranking from the 6th to the 2nd position; however, the G1 share remains high, moving nevertheless from the first to the second position. *Centro* ends up with a situation comparable to that of *Norte* but it performs better in terms of G1. *Açores* is the region that shows the worst performance: at the end of the period, it records the highest G1 share and the smallest G2 and G3 shares. Educational policies implemented in Portugal during the period under analysis help explain the increase in the supply of more educated workers. Those policies focused mainly on secondary and tertiary education, extending compulsory schooling from 9 to 12 years in 2009 and increasing the number of individuals with Bachelor and PhD diplomas. These supply-side policies, together with an increase in the demand for more educated employees, help explain the dynamics of employment composition in terms of educational levels.

Figure 1. Share of employment by levels of schooling (%), 1995-2018



Source: Authors' representation based on data from *Quadros de Pessoal*

We use the (regional) GAP as the regime switching variable to compare the responses of employment to a GDP shock in recessions relative to expansions. The labour market is resilient if the employment effects in recessions are (in absolute value) at least equal to the employment effects (in absolute values) in expansions. To compute the regional GAP, the cyclical component of GDP (the difference between actual and trend GDP), we first computed regional real GDP (at 2015 prices). To apply the H-P filter (Hodrick and Prescott, 1997) with end-point bias correction (Mise *et al.,* 2003), we augmented the real GDP series by including three initial and three final observations that were estimated using ARIMA models with an optimal parameter search proposed by Hyndman and Khandakar (2008). Next, we applied the H-P filter to the augmented series to obtain the H-P cyclical component series, (Balcilar, 2019) and, finally, we applied the original range to the augmented H-P GAP series. We set the value of the parameter lambda at 6.25 as suggested by Ravn and Uhlig (2002).This value for lambda ensures our business cycle series for the national economy (Portugal) matches the business cycle turning points dates identified by the Portuguese Business Cycle Dating Committee *(Fundação Francisco Manuel dos Santos)*,CDCEFFMS (2020).

Table 2 contains information to characterise regional business cycles in Portugal from 1995 to 2018, measured from trough to trough. *Açores*, *Algarve*, *Centro*, *Lisboa* and *Norte* record an equal number of cycles, i.e. 3, the same as Portugal, although the dates do not coincide: *Açores* (1997-2000; 2000-2005; 2005-2014), *Algarve* (1996-2004; 2004-2009; 2009-2013), *Centro* (1995-2005; 2005-2009; 2009-2014), *Lisboa* (1996-2003; 2003-2009; 2009-2016), and *Norte* (1995-2003; 2003-2009 and 2009-2013). The exception is *Norte,* which presents the same turning points as Portugal. For this set of regions, the average duration of the business cycle varies between 5.7 (*Açores* and *Algarve*) and 6.7 years (*Lisboa*) and the average amplitude of the trough (in module) varies between 0.011 (*Lisboa*) and 0.052 (*Norte*), implying that, on average, current GDP is 1.13% and 5.2% below their H-P GDP trend, respectively. *Alentejo* and *Madeira* show different patterns in terms of the number of cycles and duration relative to the other five regions. The two regions record a higher number of cycles with a shorter duration. *Alentejo* records five cycles (1995-1999; 1999-2005; 2005-2009; 2009-2013; 2013-2016) with an average duration of 4.2 years; in *Madeira,* the number of cycles is four (1997-2001; 2001-2003; 2003-2009; 2009-2012); in both regions, the average amplitude of the business cycle is 1.91%. The main take away from Table 2 is that business cycles at the regional level should not be *proxied* by the business cycle identified based on the Portuguese (national) economy even though the regions share common institutions, rule of law and official language (Cooke *et al.*, 2015). If the length of regional business cycles differs from that of the business cycle for the national economy (Portugal), then, the same variable might record different dynamics because, in some regions, an expansion occurs while, at the national level, the economy still experiences a recession, or the other way around. Using the information on the national economy's business cycle and applying it to all the regions may weaken the results since our switching variable (the output gap) would not accurately describe the behaviour at the regional level and, consequently, the split of the series into the two regimes (recession vs. expansion) would be misleading. We, thus, work with the regional output gap series and not with the national series.

Table 2. Regional Business Cycles, 1995-2018

	Troughs		Cycles	
Regions	**Dates**	**Amplitude**	**Number (average)**	**Duration in years (average)**
Alentejo	1995; 1999; 2005; 2009; 2013; 2016	0.0191	5	4.2
Algarve	1996;2004;2009;2013	0.0197	3	5.7
Açores	1997;2000;2005;2014	0.0131	3	5.7
Centro	1995;2005;2009; 2014	0.0122	3	6.3
Lisboa	1996;2003;2009; 2016	0.0113	3	6.7
Madeira	1997-2001; 2001-2003; 2003-2009; 2009-2012	0.0191	4	4
Norte	1995;2003;2009;2013	0.0520	3	6

Source: Authors' calculations

2.2. Methodology

We apply the LPM proposed by Òscar Jordà (see Jordà, 2005), a new and simple way to estimate impulse responses based on local projections. For each region, we estimate four models, differing in the employment proxy used, and consider a forecast horizon of five years (h=1,2,3,4,5). VAR models (see equation 1) approximate the data globally and impulse-responses are functions of multi-step forecasts. The LPM suggests, instead, the use of local approximations for each forecast horizon. One advantage of LPs is that they are robust to misspecification. Contrary to VAR's impulse-responses, they are not asymmetric, not shape invariant and not history independent. By comparing finite-sample performance of impulse response confidence intervals based on local projections, Kilian and Kim (2011) conclude that they can be less accurate than for VAR models. This is part of the bias-variance trade-off between least squares LP, which tends to have lower bias, and least-squares VAR estimators, which tend to have lower variance. In Li *et al.* (2021), p. 4, this problem of an appropriate choice is summarised as follows: "VAR methods, indeed, invariably suffer from larger bias (...). Reducing that bias via direct projection, however, incurs a steep cost in terms of increased sampling variance at intermediate and long horizons. Researchers who employ LP estimators should be prepared to pay that price." However, this price should be low if we concentrate on impulses for a short time period. Olea and Plagborg-Møller (2021) show that local projections inference is robust to the estimation of impulse responses at long horizons if it uses lags of the variables as control variables. Either through the comparison of results from different models, as in Kilian and Kim (2011), or based on the results from inference analysis, as in Olea and Plagborg-Møller (2021), we can be confident in the results obtained with the LPM and that, moreover, this is an appropriate method to accommodate non-linearities in the computation of impulse responses.

A SVAR model can be represented by equation (1):

$$\boldsymbol{A}.\boldsymbol{Y}_t = \boldsymbol{\alpha}_t + \boldsymbol{B}(L).\boldsymbol{Y}_t + \boldsymbol{\varepsilon}_t \quad (1)$$

where the square matrix $\boldsymbol{A}$ includes the contemporaneous effects between a set of endogenous variables represented by $\boldsymbol{Y}$, $\boldsymbol{B(L)}$ is a polynomial of lag order $\boldsymbol{p}$, and $\boldsymbol{\alpha}$ and $\boldsymbol{\varepsilon}$ are vectors of constant values and unobservable error terms, respectively.

The reduced form of the previous SVAR model is given by equation (2):

$$\boldsymbol{Y}_t = \widetilde{\boldsymbol{\alpha}} + \widetilde{\boldsymbol{B}}(L).\boldsymbol{Y}_t + \boldsymbol{\mu}_t \quad (2)$$

where the variables with the tildes and $\boldsymbol{\mu}$, the structural shocks, are obtained by pre-multiplication by $\boldsymbol{A}^{-1}$.

Jordà (2005) suggests estimating impulse-responses (IR) using OLS for each forecast horizon, h=1,…,H (Adämmer (2019)) as in equation (3):

$$\boldsymbol{y}_t = \boldsymbol{\alpha}^h + \boldsymbol{B}_1^h.\boldsymbol{y}_{t-1} + \cdots + \boldsymbol{B}_p^h.\boldsymbol{y}_{t-p} + \boldsymbol{\mu}_{t+h}^h, \quad (3)$$

where $\boldsymbol{\alpha}^h$ and $\boldsymbol{B}_i^h$ are vectors of constant terms and matrices of parameters, respectively, for lag i and forecast horizon h. The vector of residuals is assumed to present the usual white noise characteristics. Jordà (2005) named the collection of all regressions in (3) as local projections (LP).

The structural IR are estimated as:

$$\widehat{IR}(t, h, \boldsymbol{d}_i) = \widehat{\boldsymbol{B}}_1^h.\boldsymbol{d}_i \quad (4)$$

with shock matrix $\boldsymbol{d}_i = \boldsymbol{A}^{-1}$ that must be identified from a linear VAR. Considering the probable autocorrelation of the $\boldsymbol{\mu}_{t+h}^h$, Jordà (2005) suggests estimating robust standard errors.

One of the advantages of LP is its use in nonlinear models. Instead of using dummy variables to identify different regimes, Auerbach and Gorodnichenko (2012) propose computing state probabilities with a logistic function which allows using all observations. $F(Z_{i,t})$ is the probability of an economy being in a recession, with *i* the economy and *t* the time period:

$$F(Z_{i,t}) = \frac{\exp(-\gamma Z_{i,t})}{1+\exp(-\gamma Z_{i,t})} \quad (5)$$

normalizing $Z_{i,t}$ to have mean zero and unit variance. The authors propose to set γ=1.5 implying that 20% of the time, the economy is in a recession. The values for $Z_{i,t}$ are derived from the output gap described before. The values of *F* close to zero correspond to a period of expansion. The values of the logistic function depend on the choice of parameter γ which defines how different two regimes are. A low value of γ contributes to the smoothness of regime-switching while a higher value causes a sharp change. Using values of 1. 5 and 10, Adämmer (2019) concludes that it is almost irrelevant which value to consider. On the contrary, Adämmer (2019) advises a careful choice of the parameter λ in the H-P filter taking into account the history of business cycles.

For the two regimes (R.1 and R.2), the observations are the product of the transition function by the endogenous variable, for *l*=1,..,p,

$$\begin{array}{ll} \text{R.1:} & \boldsymbol{y}_{t-l}.(1-F(z_{t-1})) \\ \text{R.2:} & \boldsymbol{y}_{t-l}.F(z_{t-1}) \end{array} \quad (6)$$

The IR of equation (4) takes the form:

$$\widehat{IR^{R_j}}(t,h,\boldsymbol{d}_i) = \widehat{\boldsymbol{B}}^h_{1,R_j}.\boldsymbol{d}_i \quad (7)$$

with *h*=1,…,H and *j*=1 or 2, the two regimes

The coefficients of the matrices $\widehat{\boldsymbol{B}}^h_{1,R_j}$ are computed applying LP according to equation (8):

$$\begin{array}{l} \boldsymbol{y}_{t+h} = \boldsymbol{\alpha}^h + \sum_{l=1}^{p} \boldsymbol{B}^h_{l,R_1}\cdot\boldsymbol{y}_{t-l}.(1-F(z_{t-1})) + \\ \sum_{l=1}^{p} \boldsymbol{B}^h_{l,R_2}\cdot\boldsymbol{y}_{t-l}.F(z_{t-1}) + \boldsymbol{\mu}^h_{t+h} \end{array} \quad (8)$$

This extension to nonlinear representations can also be applied to the calculation of the IR after an exogenous shock. In this case we need to add to equation (8) the new variable and its coefficient, β_h, is the response of $\boldsymbol{y}_{t+h}$ to this variable. The IR corresponds to the sequence of all estimated β_h.

We estimate the coefficients of the matrices $\widehat{\boldsymbol{B}}^h_{1,R_j}$ for each region for the period 1996-2018 using equation (8) according to the LP methodology. The vector of endogenous variables, $\boldsymbol{y}$, includes employment measured using different proxies, G,1 G2, G3 and HT; real GDP; and HC. The switching variable, *z*, is (normalized) GAP; $F(z_t)$ measures the probability for a region of being in a recession and its complement, (1- $F(z_t)$), measures the probability for a region of being in an expansion; and $\boldsymbol{\mu}_{t+h}^{h}$ denotes the error term for the forecast horizon *h*=1,2,3,4,5. We thus estimate for each region a SVAR model with three variables and two regimes. We assume that: shocks to GDP have an immediate impact on employment (total hours worked); shocks to HC have a contemporaneous impact on employment and GDP and that HC is determined by the past values of GDP.

3. Results

Table 3 presents the results of the selection of the optimal number of lags according to the Schwarz information criterion (SC). For most models, the optimal lag order is 1 although some qualifications apply. Model 1 is a first order VAR for all regions except *Lisboa*, where a third order VAR applies. Model 4 is a first order VAR for all regions. For models 2 and 3, the exceptions to a first order VAR are *Açores* and *Madeira*, both with second order VAR models. We decided to estimate first order VAR models for all the regions because we work with annual data and for the sake of regional comparability.

Table 3. Optimal number of lags in the different VAR models

Regions	Model 1 (HT)	Model 2 (G1)	Model 3 (G2)	Model 4 (G3)
Alentejo	1	1	1	1
Algarve	1	1	1	1
Açores	1	2	1	1
Centro	1	1	1	1
Lisbon	3	1	1	1
Madeira	1	1	2	1
Norte	1	1	1	1

Notes: the optimal number of lags included in each VAR model was determined according to the Schwarz information criterion (SC).
Source: Authors' representation

One of the problems with IRFs, especially when it comes to variables in levels, is to define the forecast horizon used for comparisons. In Table 4 we display the results concerning the maximum number of consecutive years of recession or expansion obtained by ordering the negative and positive output gaps in time. Based on these figures, since the maximum number of consecutive years of recessions and expansions in *Lisboa* and *Porto* (and also in Portugal), the two regions where Portuguese economic activities are concentrated is five, we chose IR values originating in the 5th year after the initial shock to compare both regimes. Since, however, this duration is uncertain, we also include current information on the sum of the first to fifth impulses and the maximum and minimum values of the 5th-year impulses and respective confidence intervals.

Table 4. Maximum number of consecutive years of recession or expansion

Output gap<0		Output gap>0	
Regions	**No. Years**	**Regions**	**No. Years**
Alentejo	3	*Alentejo*	2
Açores	4	*Algarve, Açores, Centro and Madeira*	3
Algarve, Centro, Lisboa, Madeira and Norte	5	*Lisboa and Norte*	5
Portugal	**5**	**Portugal**	**5**

Source: Authors' calculations

Table 5 contains the R-squared obtained by applying OLS estimators separately to each equation of the LP system (equation 8) considering that the time horizon for the impulses is one. For instance, in the HC equation of SVAR model 1, column 1, in all regions, the R-squared are higher than 90%, thus indicating the goodness of fit of the HC equation to estimate the value of the first impulse of HC from the identified shocks. Similar interpretations apply to the remaining equations concerning goodness of fit.

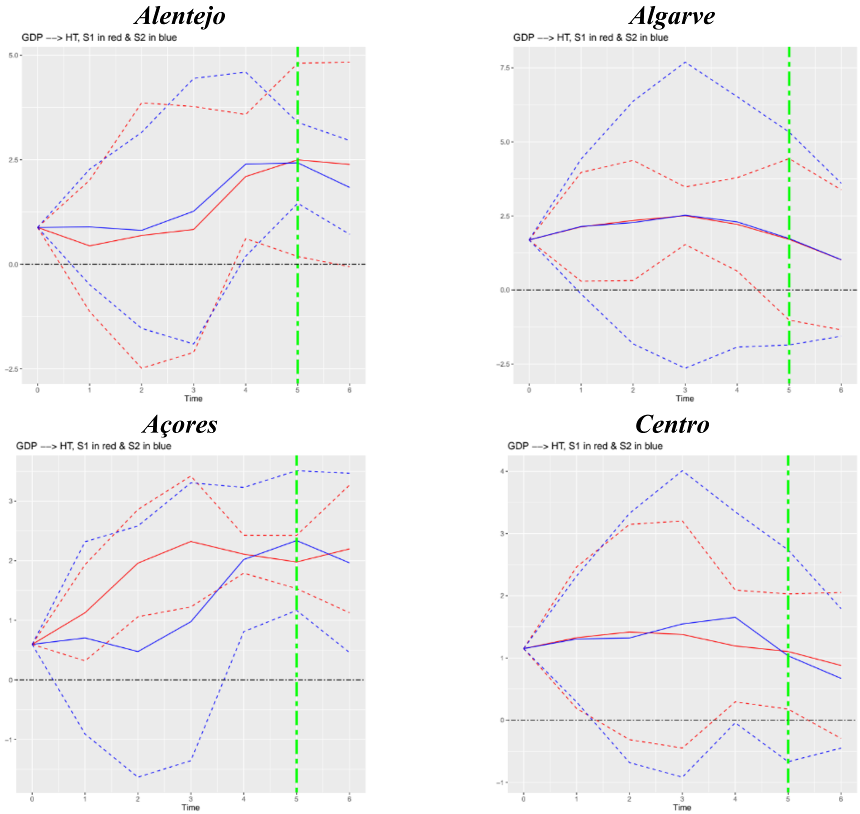
Table 5. OLS Diagnostic - R-squared (HC, GDP, EMP=HT; G1; G2; G3)

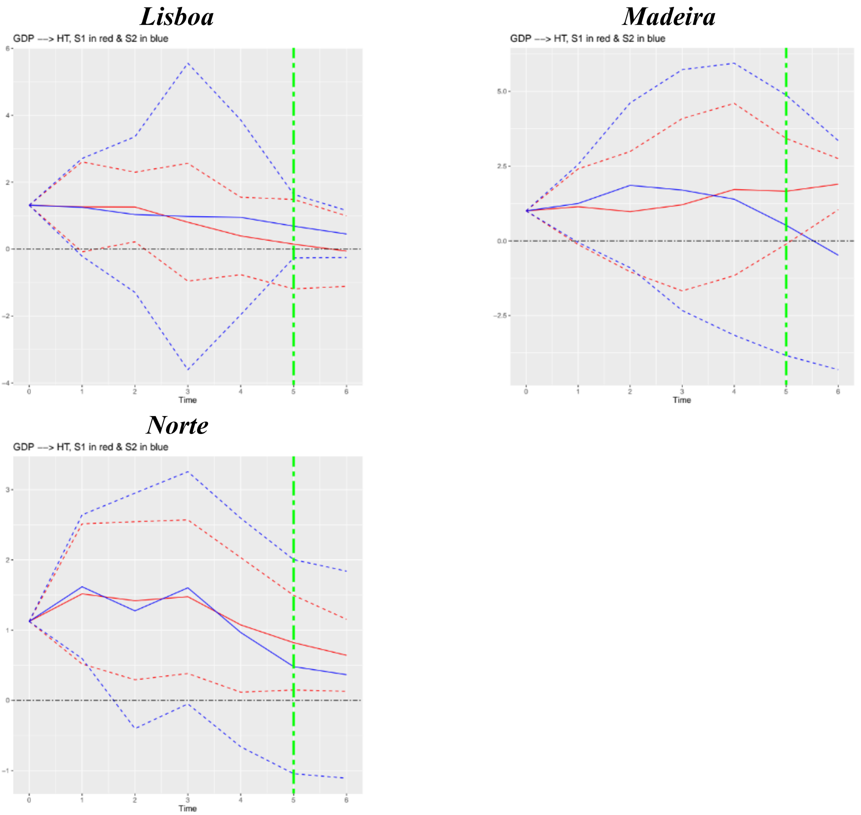
	Model 1			**Model 2**			**Model 3**			**Model 4**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Regions	**HC**	**GDP**	**HT**	**HC**	**GDP**	**G1**	**HC**	**GDP**	**G2**	**HC**	**GDP**	**G3**
Alentejo	0.950	0.869	0.922	0.935	0.863	0.955	0.968	0.870	0.990	0.937	0.862	0.955
Algarve	0.955	0.944	0.944	0.956	0.954	0.932	0.956	0.957	0.976	0.952	0.943	0.970
Açores	0.938	0.979	0.929	0.940	0.980	0.926	0.943	0.984	0.988	0.940	0.980	0.959
Center	0.925	0.949	0.935	0.927	0.953	0.954	0.957	0.949	0.989	0.932	0.942	0.967
Lisbon	0.962	0.970	0.899	0.976	0.963	0.940	0.966	0.976	0.983	0.969	0.964	0.926
Madeira	0.967	0.968	0.900	0.964	0.969	0.930	0.956	0.974	0.970	0.951	0.972	0.959
Norte	0.936	0.938	0.838	0.935	0.944	0.940	0.957	0.961	0.988	0.945	0.940	0.967
Portugal	**0.960**	**0.956**	**0.903**	**0.963**	**0.957**	**0.949**	**0.961**	**0.969**	**0.988**	**0.960**	**0.955**	**0.958**

Source: Authors' calculations

We should remember that labour market resilience means that the employment responses (sum of employment IRF over a five-year-time horizon) to a GDP shock in recessions (S1) is not smaller than the employment effects in expansions (S2). Since employment effects during recessions might be smaller but very close to the effects during expansions, we assume that they are equal if the absolute gap between the employment effects during recessions relative to expansions is less than 5% of their average. Additionally, a jobless recovery is defined as a labour market situation when the additional employment created in expansions due to a GDP shock is lower than the one created during recessions. In what follows, we describe the main results for the impact of a GDP shock on employment, see Figures 2 to 5 and Tables 6 and 7.

Figure 2. HT responses to a GDP shock in the 7 NUTS-2 regions



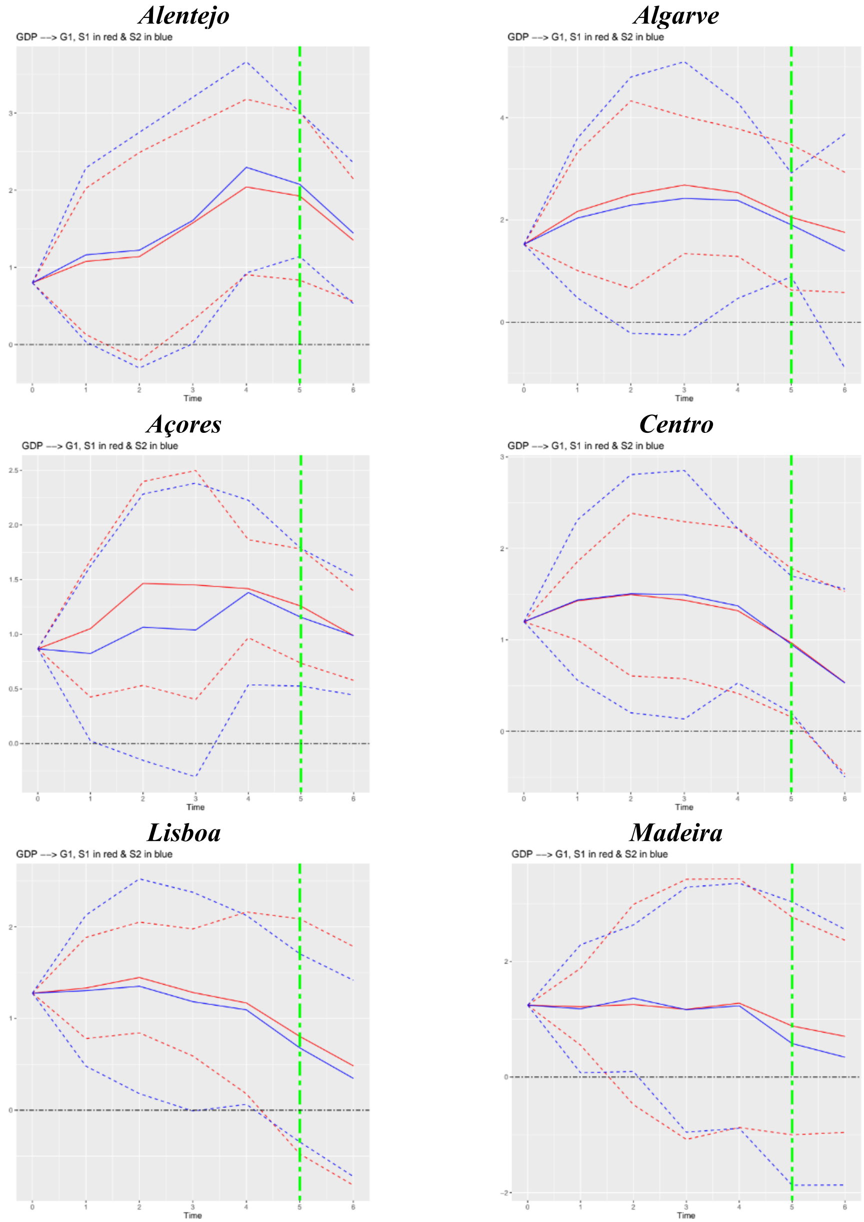


Notes: S1 - recessionary regime; S2 - expansionary regime.
Source: Authors' representation

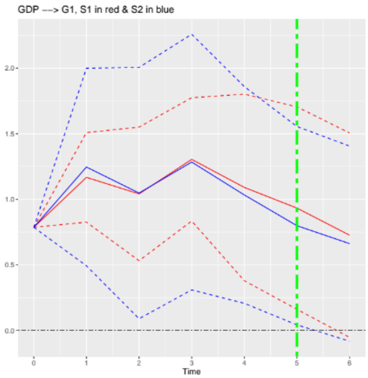
When employment is measured in terms of hours worked (HT), see Figure 2 and Tables 6 and 7, we find evidence of labour market resilience in *Açores*, *Norte*, *Algarve* and *Madeira*. For the remaining regions, *Alentejo*, *Centro* and *Lisboa*, labour market resilience is not confirmed. Additionally, jobless recoveries apply to *Açores* and *Norte*. Three out of the seven regions, including *Lisboa*, seem not to be flexible enough in terms of hours worked. This might explain why in some regions we do not find evidence of labour market resilience.

According to the results presented in Figure 3 and Tables 6 and 7, we confirm the existence of labour market resilience for employment of less educated workers (G1) in six out of the seven regions, the exception is *Alentejo*. Additionally, there is evidence of jobless recovery in *Algarve*, *Açores*, *Lisboa*, *Madeira* and *Norte*, suggesting that factors like innovation, structural change, supply of more educated workers associated with education policies, among others, might be in motion leading private sector firms to decrease their demand for less educated workers.

Figure 3. G1 responses to a GDP shock in the 7 NUTS-2 regions



Norte

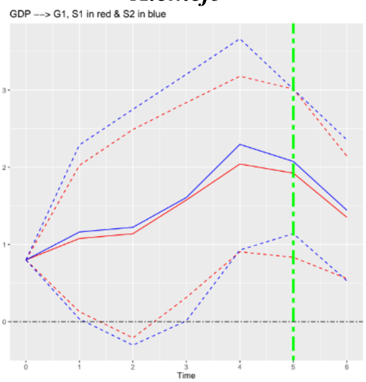


Notes: S1 -recessionary regime; S2 - expansionary regime.
Source: Authors' representation

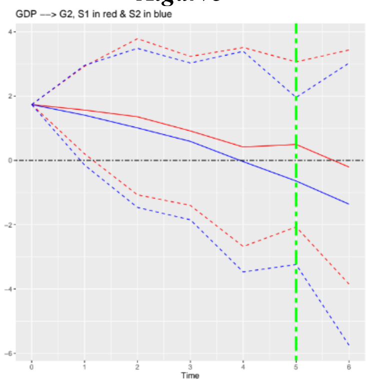
In what concerns labour market resilience in terms of G2 (see Figure 4 and Tables 6 and 7), *Alentejo*, *Açores* and *Norte* experience negative employment effects due to the GDP shock both in recessions and in expansions, so resilience is not confirmed for these regions. As for *Algarve*, *Lisboa* and *Madeira*, the signs of the two effects are both positive and higher in recessions than in expansions, thus confirming labour market resilience in these Portuguese regions. In the case of *Centro*, labour market resilience is also confirmed but the employment effect is positive in recessions and negative in expansions, consequently all the regions where the labour market is resilient are also the regions where jobless recoveries occur.

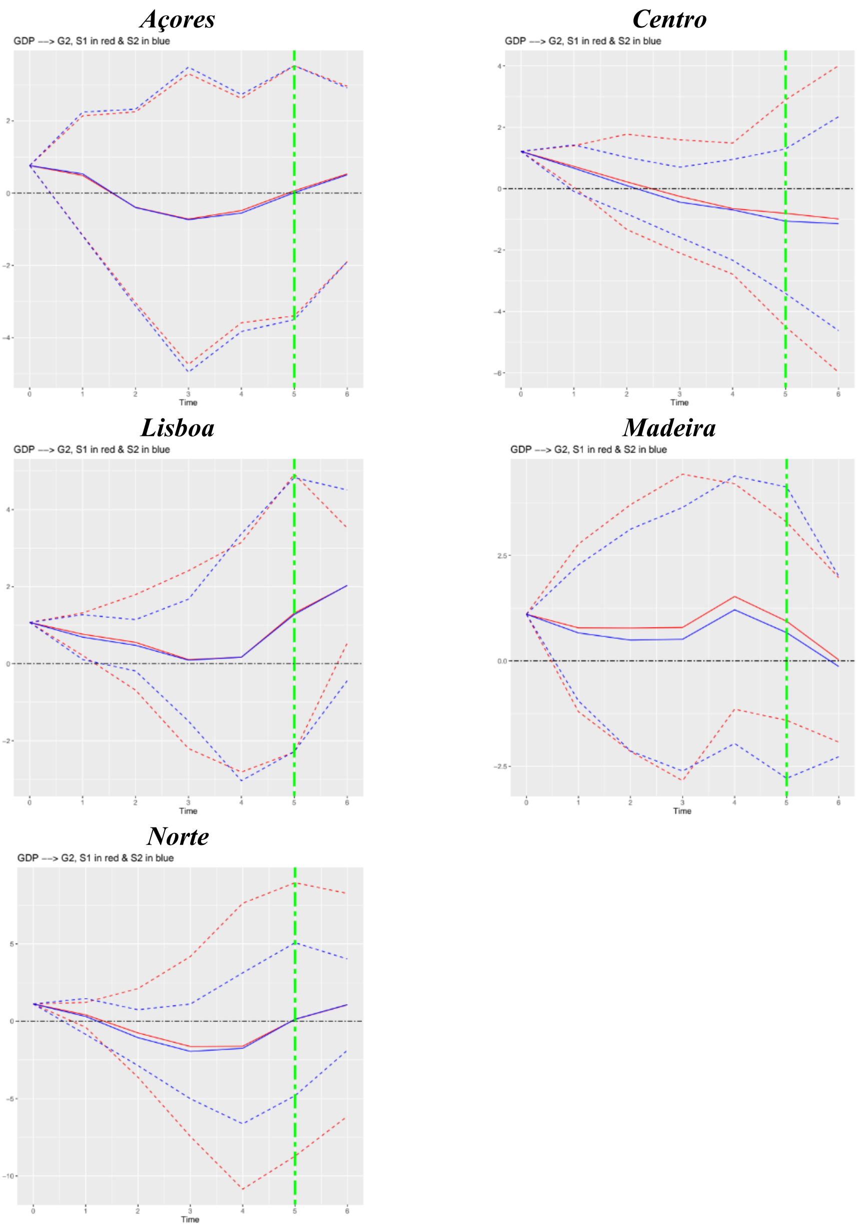
Figure 4. G2 responses to a GDP shock in the 7 NUTS-2 regions

Alentejo



Algarve

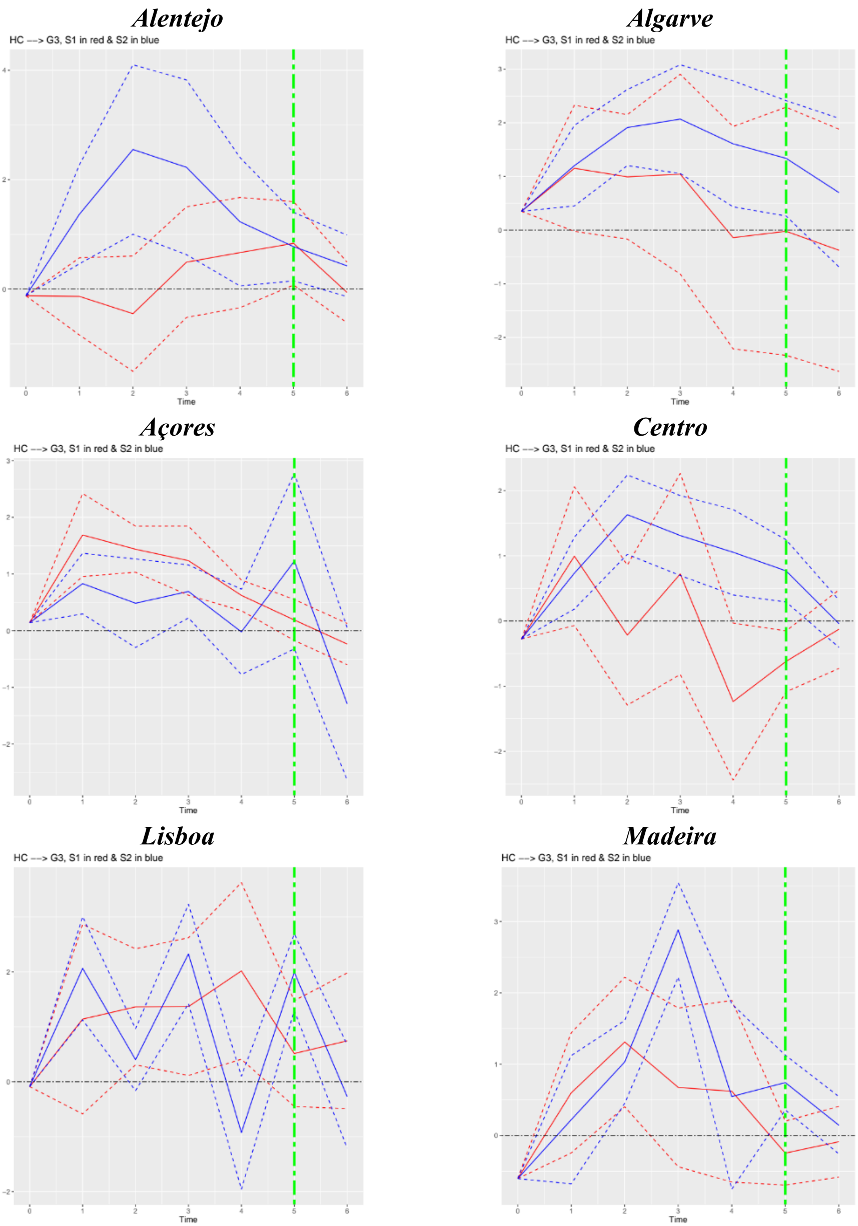




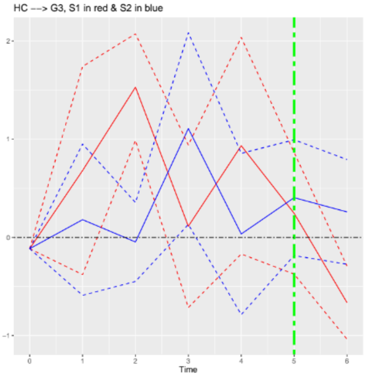
Notes: S1 -recessionary regime; S2 - expansionary regime.
Source: Authors' representation

We find evidence (see Figure 5 and Tables 6 and 7) of labour market resilience for employment of the most educated workers (G3) in all regions. Also, *Lisboa* and *Norte* are the only regions where the employment effects of a GDP shock are equal in recessions and expansions; in the remaining regions, there is evidence of jobless recoveries.

Figure 5. G3 responses to a GDP shock in the 7 NUTS-2 regions



Norte



Notes: S1 -recessionary regime; S2 - expansionary regime.
Source: Authors' representation

Table 6. Regional employment IR 5 years after the initial GDP shock with 90% CI

Regions	S	GDP→HT	l	U	GDP→G1	l	U	GDP→G2	l	U	GDP→G3	l	U
Alentejo	S1	2.5	0.187	4.81	1.92	0.834	3.01	-4.21	-5.88	-2.54	0.579	-1.81	2.96
	S2	2.43	1.46	3.39	2.08	1.14	3.01	-3.35	-4.75	-1.96	0.968	-1.06	2.99
Algarve	S1	1.71	-1.02	4.44	2.05	0.63	3.47	0.497	-2.07	3.06	2.59	0.169	5
	S2	1.74	-1.86	5.33	1.9	0.889	2.92	-0.641	-3.24	1.96	2.15	0.225	4.08
Açores	S1	1.98	1.53	2.42	1.26	0.735	1.78	0.0652	-3.4	3.53	2.28	1.37	3.2
	S2	2.34	1.17	3.51	1.16	0.526	1.78	0.014	-3.5	3.53	2.49	1.55	3.42
Centro	S1	1.1	0.178	2.03	0.968	0.157	1.78	-0.803	-4.5	2.89	1.6	0.097	3.09
	S2	1.03	-0.667	2.74	0.951	0.203	1.7	-1.06	-3.41	1.3	0.946	-0.334	2.23
Lisboa	S1	0.148	-1.19	1.49	0.804	-0.477	2.09	1.31	-2.3	4.92	1.29	0.421	2.15
	S2	0.686	-0.264	1.64	0.679	-0.347	1.71	1.28	-2.28	4.83	0.995	0.020	1.97
Madeira	S1	1.66	-0.107	3.43	0.884	-1.0	2.77	0.939	-1.41	3.29	2.52	1.33	3.72
	S2	0.519	-3.84	4.88	0.579	-1.87	3.03	0.669	-2.78	4.12	2.2	1.07	3.34
Norte	S1	0.822	0.148	1.5	0.933	0.161	1.7	0.121	-8.72	8.96	2.32	0.507	4.12
	S2	0.48	-1.04	2	0.799	0.043	1.56	0.134	-4.81	5.08	2.26	0.722	3.79
Portugal	**S1**	**0.658**	**-0.389**	**1.71**	**0.927**	**0.298**	**1.56**	**-0.040**	**-5.63**	**5.55**	**1.5**	**0.002**	**2.99**
	S2	**0.644**	**-1.22**	**2.51**	**0.816**	**-0.067**	**1.7**	**-0.207**	**-4.94**	**4.53**	**1.55**	**-0.041**	**3.15**

Notes: CI – confidence interval; l – lower bound; U – upper bound.
Source: Authors' calculations

Table 7 Regional employment IR accumulated over the 5 years after the initial GDP shock

Regions	S	GDP→HT			GDP→G1			GDP→G2			GDP→G3		
		Sum	**Min**	**Max**	**Sum**	**Min**	**Max**	**Sum**	**Min**	**Max**	**Sum**	**Min**	**Max**
Alentejo	S1	7.44	0.441	2.497	8.56	0.80	2.04	-12.2	-4.208	0.216	14.8	0.579	3.945
	S2	8.68	0.812	2.425	9.16	0.8	2.3	-10.1	-3.351	0.216	10.9	0.968	2.168

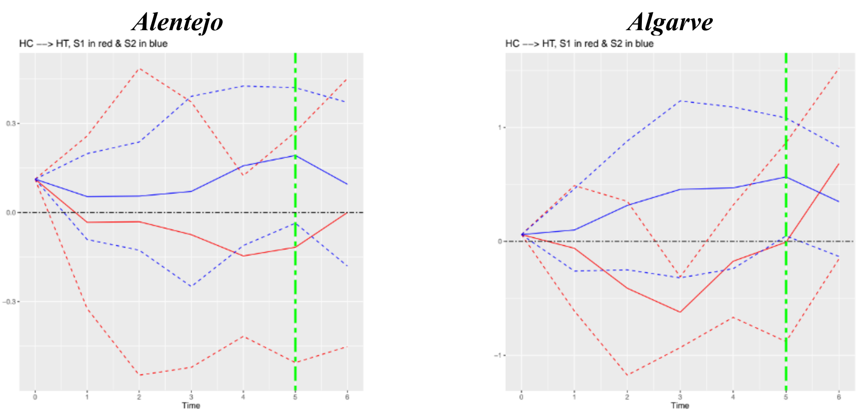
Algarve	S1	12.6	1.69	2.51	13.5	1.52	2.68	6.49	0.417	1.737	22.1	1.84	4.89
	S2	12.7	1.69	2.52	12.6	1.52	2.42	4.07	-0.641	1.737	20.3	1.84	4.6
Açores	S1	10.1	0.595	2.323	7.51	0.867	1.465	-0.272	-0.717	0.764	13.2	0.203	3.339
	S2	7.11	0.475	2.338	6.33	0.824	1.382	-0.372	-0.734	0.764	13.1	0.203	3.04
Centro	S1	7.57	1.10	1.42	7.84	0.968	1.495	0.458	-0.803	1.214	15.7	1.6	4.1
	S2	8.01	1.03	1.65	7.95	0.951	1.505	-0.205	-1.06	1.21	13.2	0.946	3.326
Lisboa	S1	5.18	0.148	1.312	7.31	0.804	1.447	3.97	0.105	1.311	13.5	1.11	3.51
	S2	6.2	0.686	1.312	6.89	0.679	1.352	3.77	0.092	1.276	13.6	0.995	3.699
Madeira	S1	7.71	0.977	1.719	7.05	0.884	1.278	5.93	0.779	1.528	21.5	1.8	5.31
	S2	7.72	0.519	1.857	6.77	0.579	1.364	4.65	0.493	1.212	21.2	1.8	5.26
Norte	S1	7.43	0.822	1.516	6.32	0.786	1.304	-2.34	-1.63	1.12	25.7	1.73	6.66
	S2	7.07	0.48	1.62	6.2	0.786	1.284	-3.19	-1.95	1.12	26.4	1.73	7.12
Portugal	**S1**	**7.23**	**0.658**	**1.504**	**7.68**	**0.927**	**1.455**	**0.325**	**-0.761**	**1.093**	**17**	**1.5**	**3.83**
	S2	**7.63**	**0.644**	**1.542**	**7.4**	**0.816**	**1.453**	**-0.113**	**-0.799**	**1.093**	**19.9**	**1.55**	**5.52**

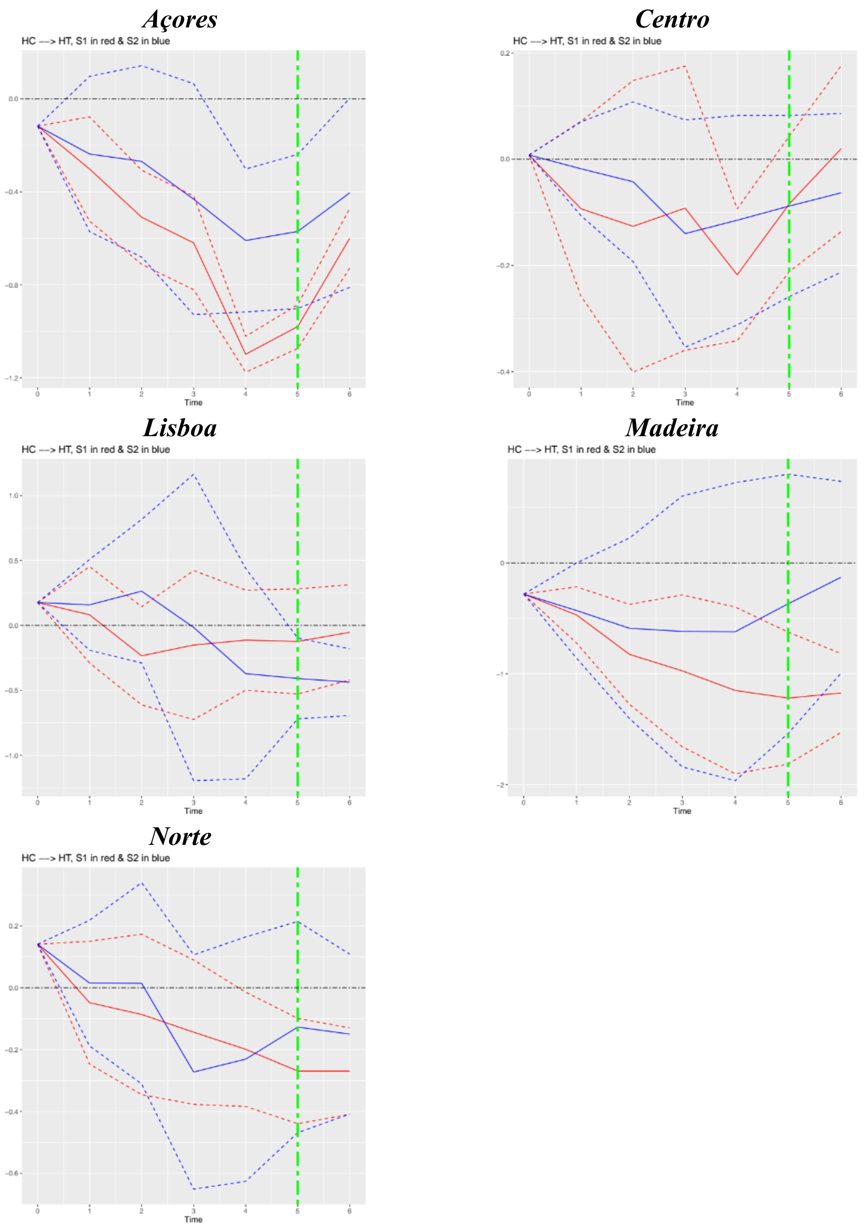
Source: Authors' calculations

In what follows we describe the main results associated with the impact of a shock to human capital on employment based on the information presented in Figures 6 to 9 and Tables 8 and 9.

Concerning the impact of a shock to HC on HT (see Figure 6 and Tables 8 and 9), no matter the phase of the business cycle, the employment effect is negative except in the cases of *Alentejo* and *Algarve*, where the effect is positive during expansions and overcomes the absolute value of the employment effect in recessions. For the remaining regions, the absolute value of the employment effect in recessions is higher than the absolute value of the employment effect in expansions. We conclude that the higher availability of more educated workers results in fewer hours worked.

Figure 6. HT responses to a HC shock in the 7 NUTS-2 regions

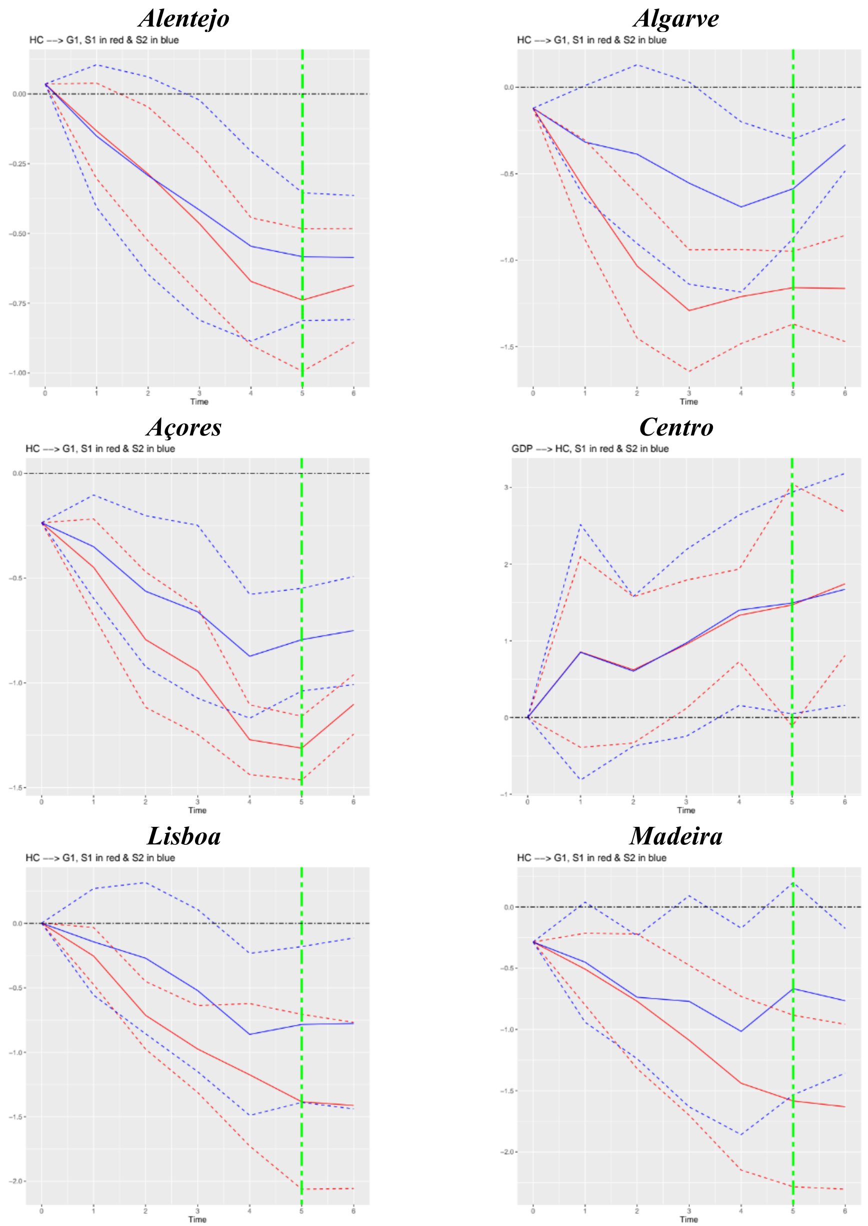




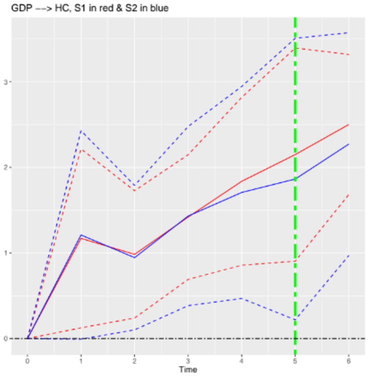
Notes: S1 -recessionary regime; S2 - expansionary regime.
Source: Authors' representation

According to the results presented in Figure 7 and Tables 8 and 9, a shock to HC leads to a decrease in G1. This effect is more important in absolute terms in recessions than in expansions in all regions, except for *Centro*, where the employment effect in expansions is slightly more important.

Figure 7. G1 responses to a HC shock in the 7 NUTS-2 regions



Norte

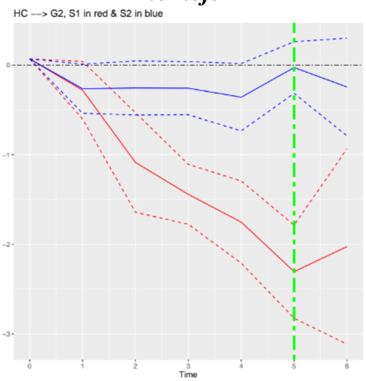


Notes: S1 -recessionary regime; S2 - expansionary regime.
Source: Authors' representation

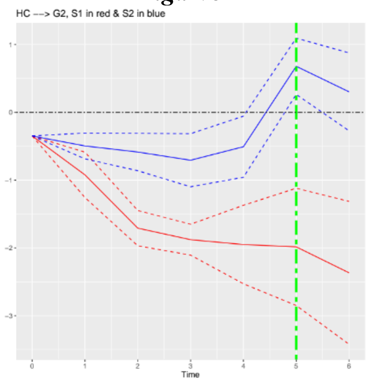
A shock to HC lowers G2 in recessions and, also, in expansions – during these periods *Madeira*, *Lisboa* and *Norte* are exceptions with positive employment effects during expansions, but the negative effects in absolute value are higher in recessions in all the regions, except in *Lisboa*. See Figure 8 and Tables 8 and 9.

Figure 8. G2 responses to a HC shock in the 7 NUTS-2 regions

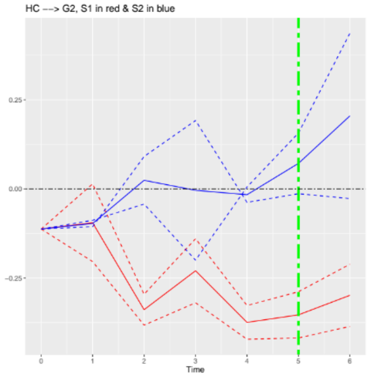
Alentejo



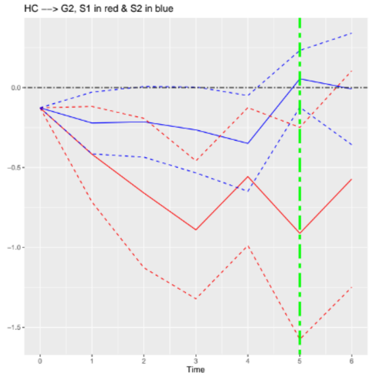
Algarve



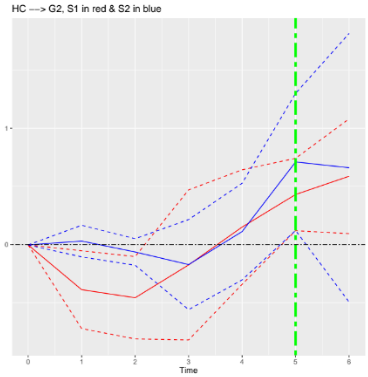
Açores



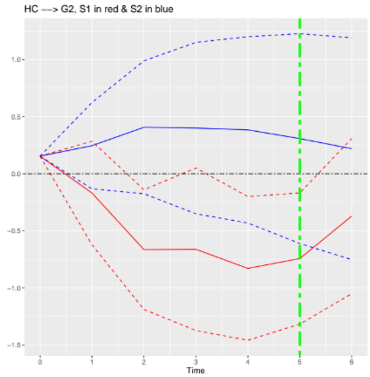
Centro



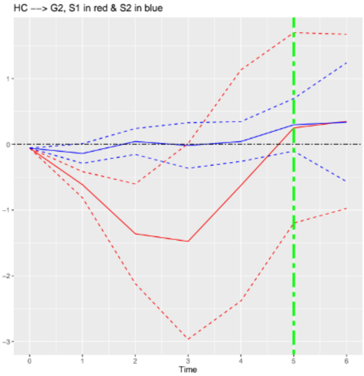
Lisboa



Madeira



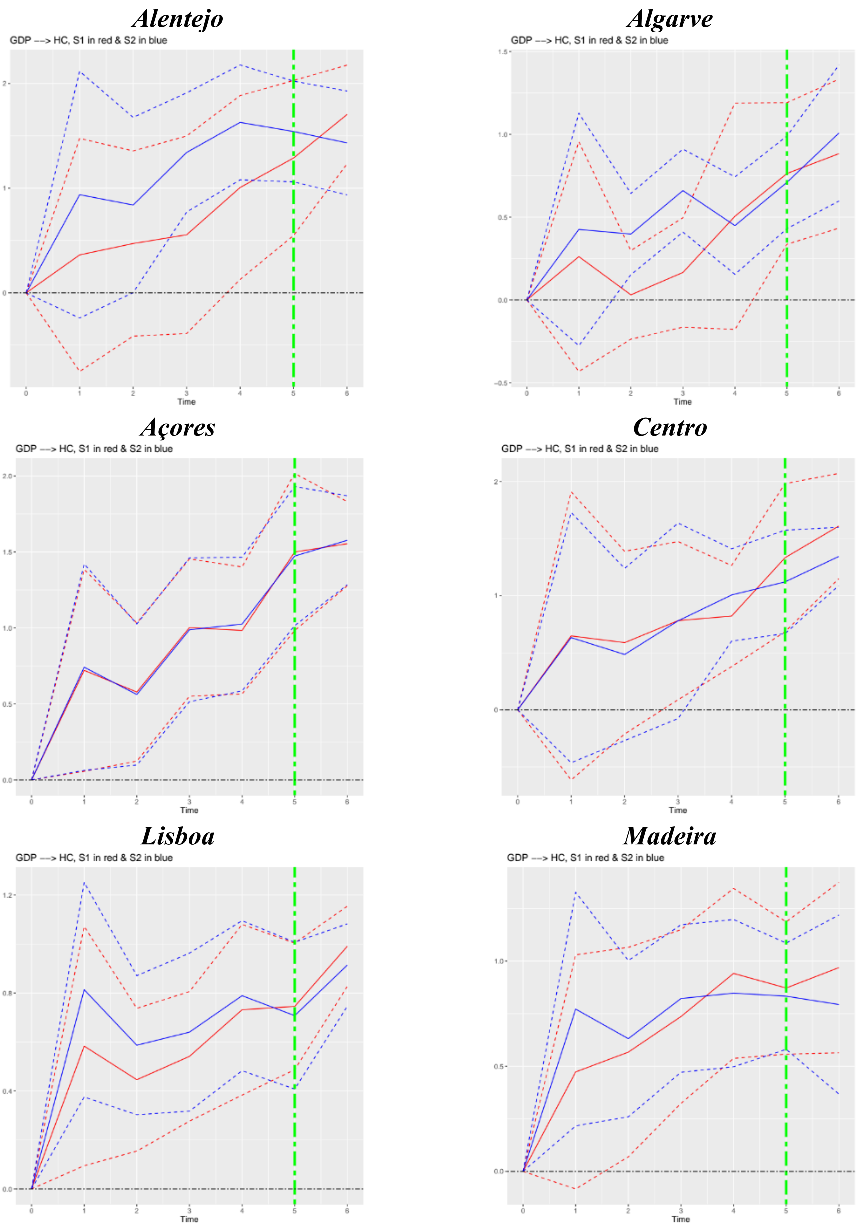
Norte



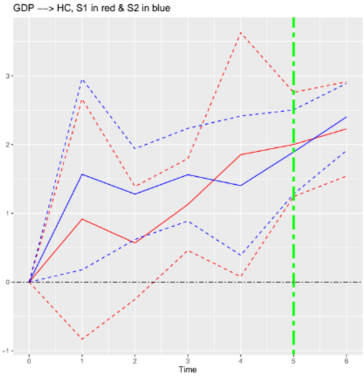
Notes: S1 - recessionary regime; S2 - expansionary regime.
Source: Authors' representation

A shock to HC has positive effects on G3 during recessions and expansions, with the exception of *Centro* during recessions. The positive effect is more important in recessions in *Açores*, *Lisboa*, and *Norte*; the opposite occurs in *Alentejo*, *Algarve*, *Centro* and *Madeira*. See Figure 9 and Tables 8 and 9.

Figure 9. G3 responses to a HC shock in the 7 NUTS-2 regions



Norte



Source: Authors' representation

Table 8. Regional employment IR 5 years after the initial HC shock with 90% CI

Regions	S	HC→HT	l	U	HC→G1	l	U	GDP→G2	l	U	GDP→G3	l	U
Alentejo	S1	-0.117	-0.506	0.272	-0.739	-0.994	-0.483	-2.3	-2.82	-1.79	0.836	0.073	1.6
	S2	0.192	-0.036	0.42	-0.583	-0.812	-0.354	-0.028	-0.316	0.26	0.776	0.15	1.4
Algarve	S1	-0.006	-0.879	0.867	-1.16	-1.37	-0.948	-1.98	-2.85	-1.12	-0.021	-2.33	2.29
	S2	0.566	0.048	1.08	-0.586	-0.873	-0.299	0.68	0.265	1.09	1.34	0.263	2.41
Açores	S1	-0.979	-1.07	-0.885	-1.31	-1.46	-1.16	-0.353	-0.418	-0.288	0.189	-0.173	0.551
	S2	-0.57	-0.902	-0.239	-0.794	-1.04	-0.549	0.072	-0.013	0.157	1.23	-0.322	2.77
Centro	S1	-0.084	-0.212	0.043	-0.886	-1.05	-0.722	-0.911	-1.57	-0.249	-0.619	-1.09	-0.152
	S2	-0.088	-0.259	0.082	-0.766	-0.925	-0.608	0.055	-0.123	0.233	0.768	0.291	1.25
Lisboa	S1	-0.124	-0.528	0.281	-1.38	-2.06	-0.706	0.43	0.119	0.741	0.513	-0.45	1.48
	S2	-0.408	-0.719	-0.097	-0.784	-1.39	-0.18	0.71	0.121	1.3	1.99	1.29	2.69
Madeira	S1	-1.22	-1.81	-0.624	-1.58	-2.28	-0.884	-0.743	-1.32	-0.168	-0.246	-0.694	0.203
	S2	-0.369	-1.54	0.8	-0.667	-1.53	0.199	0.308	-0.611	1.23	0.743	0.359	1.13
Norte	S1	-0.269	-0.439	-0.099	-0.824	-1.07	-0.576	0.249	-1.2	1.7	0.245	-0.374	0.864
	S2	-0.127	-0.468	0.214	-0.535	-0.789	-0.281	0.296	-0.103	0.695	0.404	-0.185	0.994
Portugal	**S1**	**-0.297**	**-0.513**	**-0.081**	**-1.22**	**-1.38**	**-1.06**	**-0.57**	**-1.35**	**0.213**	**0.582**	**0.0778**	**1.09**
	S2	**-0.125**	**-0.501**	**0.252**	**-0.601**	**-0.95**	**-0.253**	**0.402**	**0.022**	**0.782**	**0.58**	**0.042**	**1.12**

Notes: CI – confidence interval; l – lower bound; U – upper bound.
Source: Authors' calculations

Table 9. Regional employment IR accumulated over the 5 years after the initial HC shock

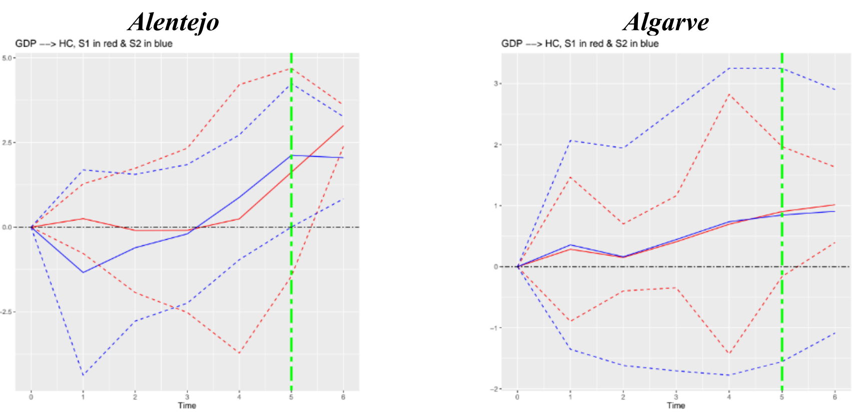
Regions	S	HC→HT			HC→G1			HC→G2			HC→G3		
		Sum	Min	Max	Sum	Min	Max	Sum	Min	Max	Sum	Min	Max
Alentejo	S1	-0.29	-0.146	0.112	-2.26	-0.739	0.036	-6.8	-2.305	0.069	1.29	-0.450	0.836
	S2	0.641	0.054	0.192	-1.95	-0.583	0.036	-1.1	-0.359	0.069	8.03	-0.123	2.552
Algarve	S1	-1.21	-0.622	0.060	-5.41	-1.291	-0.121	-8.79	-1.984	-0.348	3.37	-0.141	1.152
	S2	1.97	0.060	0.566	-2.66	-0.692	-0.121	-1.96	-0.706	0.680	8.48	0.35	2.07

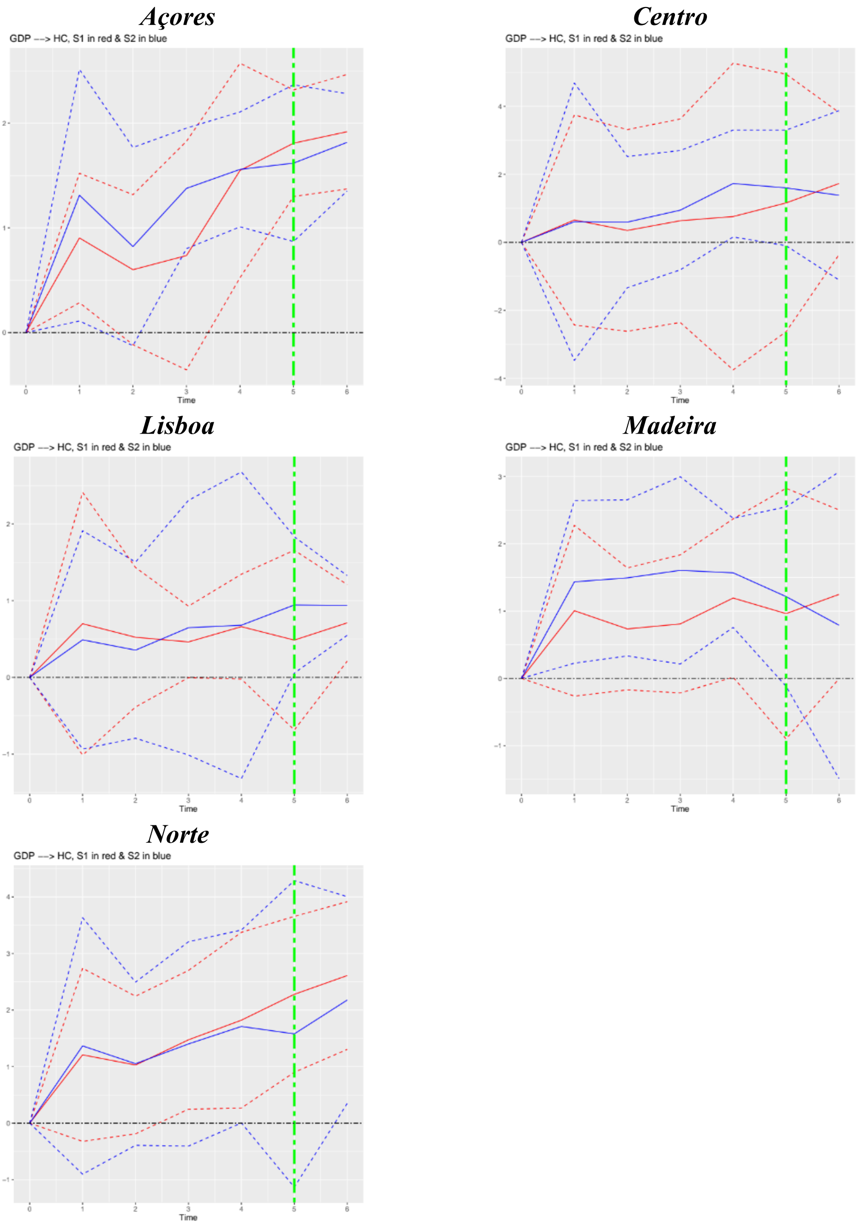
Açores	S1	-3.63	-1.098	-0.117	-5.0	-1.312	-0.236	-1.5	-0.374	-0.095	5.31	0.141	1.688
	S2	-2.23	-0.609	-0.117	-3.48	-0.873	-0.236	-0.133	-0.113	0.072	3.35	-0.021	1.226
Centro	S1	-0.606	-0.218	0.008	-3.26	-0.886	-0.128	-3.56	-0.911	-0.126	-0.633	-1.236	0.995
	S2	-0.396	-0.140	0.008	-3.38	-0.856	-0.128	-1.12	-0.349	0.055	5.22	-0.277	1.631
Lisboa	S1	-0.363	-0.234	0.176	-4.5	-1.384	0.001	-0.444	-0.458	0.430	6.31	-0.089	2.018
	S2	-0.196	-0.408	0.264	-2.58	-0.861	0.001	0.612	-0.172	0.710	5.77	-0.926	2.328
Madeira	S1	-4.92	-1.219	-0.281	-5.68	-1.584	-2.286	-2.91	-0.830	0.154	2.36	-0.603	1.311
	S2	-2.91	-0.620	-0.281	-3.93	-1.016	-0.286	1.9	0.154	0.407	4.83	-0.603	2.885
Norte	S1	-0.605	-0.269	0.141	-2.35	-0.824	0.093	-3.89	-1.477	0.249	3.39	-0.115	1.530
	S2	-0.459	-0.272	0.141	-1.88	-0.561	0.093	0.166	-0.140	0.296	1.57	-0.115	1.108
Portugal	**S1**	**-0.943**	**-0.297**	**0.100**	**-3.91**	**1.220**	**-0.011**	**-3.44**	**-0.993**	**-0.080**	**5.9**	**-0.591**	**2.395**
	S2	**-0.366**	**-0.235**	**0.100**	**-2.33**	**-0.672**	**-0.010**	**-0.932**	**-0.415**	**0.402**	**3.12**	**-0.716**	**1.894**

Source: Authors' calculations

Finally, we focus on the model that uses an aggregate measure of employment, HT, and to highlight the main results associated with a shock to GDP on human capital, see Figure 10 and Tables 10 and 11. The figures with similar results associated with the other proxies of employment, G1, G2 and G3 are available from the authors. The effects of the shock to GDP on HC are always positive, as expected. For some regions, like *Alentejo* and *Norte*, the positive effects are higher during recessions than during expansions, most likely because, during recessions, lower educated individuals have lower chances to find a job and decide to continue their studies to increase the respective returns to education. This is particularly relevant for *Norte*, on the second position after *Lisboa* in terms of employment and GDP but on the last position in terms of the initial human capital availability.

Figure 10. HC responses to a GDP shock in the 7 NUTS-2 regions (SVAR model with HT)





Source: Authors' calculations

Table 10. Regional human capital IR 5 years after the initial GDP shock with 90% CI

Regions	S	GDP->HC (Model HT)			GDP->HC (Model G1)			GDP->HC (Model G2)			GDP->HC (Model G3)		
		HC resp.	l	U	HC resp.	l	U	HC resp.	l	U	HC resp.	l	U
Alentejo	S1	1.62	-1.45	4.69	3.03	2.29	3.77	-0.31	-0.73	0.11	1.29	0.55	2.03
	S2	2.12	0.00	4.24	3.18	2.32	4.05	0.19	-0.27	0.65	1.54	1.06	2.02
Algarve	S1	0.90	-0.16	1.97	1.16	0.21	2.11	0.62	-0.05	1.28	0.76	0.34	1.19
	S2	0.85	-1.55	3.25	1.20	0.05	2.35	0.79	0.05	1.54	0.71	0.43	0.99
Açores	S1	1.81	1.30	2.32	1.60	0.24	2.95	2.43	0.48	4.38	1.50	0.98	2.02
	S2	1.62	0.87	2.37	1.66	1.06	2.27	2.38	0.28	4.48	1.47	1.02	1.93
Centro	S1	1.16	-2.63	4.95	1.47	-0.1	3.05	0.85	-1.39	3.08	1.33	0.68	1.98
	S2	1.60	-0.10	3.30	1.49	0.05	2.94	0.77	-0.36	1.90	1.12	0.67	1.57
Lisboa	S1	0.49	-0.69	1.66	0.71	0.18	1.24	0.92	-0.38	2.21	0.75	0.49	1.00
	S2	0.94	0.06	1.83	0.75	0.13	1.37	0.96	-0.53	2.44	0.71	0.41	1.01
Madeira	S1	0.96	-0.90	2.82	1.09	0.64	1.54	0.92	-0.34	2.18	0.87	0.56	1.19
	S2	1.22	-0.12	2.55	1.11	0.35	1.87	0.97	-0.12	2.05	0.83	0.58	1.09
Norte	S1	2.28	0.90	3.66	2.15	0.90	3.39	1.42	-2.31	5.14	2.00	1.24	2.76
	S2	1.58	-1.13	4.29	1.86	0.22	3.51	1.87	-1.68	5.43	1.89	1.28	2.50

Notes: CI – confidence interval; l – lower bound; U – upper bound.
Source: Authors' calculations

Table 11. Regional human capital IR accumulated over the 5 years after the initial GDP shock

Regions	S	GDP→HC (Model with HT)		
		Sum	**Min**	**Max**
Alentejo	S1	1.93	-0.10	1.62
	S2	0.86	-1.34	2.12
Algarve	S1	2.45	0.00	0.90
	S2	2.55	0.00	0.85
Açores	S1	5.59	0.00	1.81
	S2	6.68	0.00	1.62
Centro	S1	3.57	0.00	1.16
	S2	5.49	0.00	1.73
Lisboa	S1	2.83	0.00	0.70
	S2	3.11	0.00	0.94
Madeira	S1	4.71	0.00	1.19
	S2	7.32	0.00	1.61
Norte	S1	7.81	0.00	2.28
	S2	7.11	0.00	1.71

Source: Author's calculations

Conclusion

We used the Local Projections method to find evidence of labour market resilience in the seven Portuguese NUTS-2 regions over the period 1995-2018 by considering regional SVAR models with three variables: employment, human capital and output. We estimated the responses of regional employment to output shocks for the two phases of the business cycle, using the output gap as a switching variable and taking into account that, in a recession, the economy might react more to positive shocks than in expansions. We assessed labour market resilience by comparing the effects of GDP shocks on employment under each regime. We also tested for the presence of jobless recoveries.

Overall, our findings suggest that regional labour markets are resilient both in terms of total hours worked and in terms of employment by level of education. The absence of jobless recoveries in terms of total hours worked prevails. However, it applies to an important region, *Norte*. Jobless recoveries also apply to most regions in terms of employees with low levels of education, including the largest two, *Lisboa* and *Norte*. The same applies to employees with medium levels of education, but *Norte* is now replaced by *Centro*. The situation of jobless recovery in terms of employees with high levels of education is more region-specific: it applies to most regions but not to the largest two. In any case, the evidence found indicates that regional employment is resilient, whether measured as total hours worked or as employees with different levels of education.

Additionally, we found that output growth leads to an increase in the level of human capital that will result in fewer total hours worked. Since the labour market is always resilient as far as employees with the highest levels of education are concerned, implementing education policies that raise the level of education of the median employee are in order. Finally, the effects of a shock to human capital on total hours worked are negative, except for *Alentejo* and *Algarve* in the expansionary phase, which could be due to the seasonal nature of tourism in these regions. The effects of a shock to GDP on human capital are always positive, as expected. For some regions, like *Alentejo* and *Norte,* the positive effects are higher during recessions than during expansions, most likely because, during recessions, lower educated individuals have fewer chances to find a job. This is particularly relevant for the region *Norte*, the second most important in terms of employment and GDP but on the last position in terms of initial human capital availability.

Our findings suggest that discretionary fiscal policy may prove effective at the regional level if designed considering the regional business cycle as there is no full synchronization with the business cycle for the national economy. Additionally, the results highlight the disadvantageous situation of workers with low levels of education, pointing to the importance of training policies implementation. In any case, since the data used has a short time coverage, which may hinder the robustness of the results obtained with the LP method, our findings should be considered as tentative and further justify future research as more data becomes available.

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