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

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Abstract

This paper examines the influence of human capital on labour market resilience in the seven Portuguese NUTS-2 over the period 1995-2018. We define resilience as the ability of regional employment to recover from a shock to output over the business cycle. We use the Local Projection (LP) methodology applied to a SVAR model with three variables - employment, human capital, real GDP - and the output gap as the switching variable for the identification of recession and expansion regimes. We explore SVAR specifications that condition the response of the labour market to two scenarios: (a) the shock to GDP occurs during recessions; and (b) the shock to GDP occurs during expansions. 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 the employees; (ii) labour market resilience and 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, NUTS2, Portugal

JEL Classification: I25; J21; J24; R10; R15

1. Introduction

This paper examines the influence of human capital on labour market resilience in the seven Portuguese NUTS-2 over the period 1995-2018. We define resilience as the ability of regional employment to recover from a shock to output over the business cycle. To identify resilience defined in this way we use the Local Projection (LP) methodology applied to a SVAR model with three variables - employment (alternatively, hours worked, employees with less than 9 years of schooling, with at least 9 and less than 12 years of schooling and with more than 12 years of schooling), human capital (average years of schooling), real GDP - and the output gap as the switching variable for the identification of recession and expansion regimes. An advantage of the LP method in estimating the effects of shocks to is its flexibility in dealing with state/regime dependency. We thus explore SVAR specifications that condition the response of the labour market to two scenarios: (a) the shock occurs during recessions; and (b) the shock occurs 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 is an interesting case study since it was one of the European Union (EU) member states most severely hit by the 2007-08 financial crisis that led to public finances sustainability problems. The latter resulted in a bailout from the IMF, the ECB and the EC that lasted from May 2011 to June 2104 and implied the introduction of strong fiscal consolidation (austerity) measures. In 2009, Portuguese real GDP recorded a negative growth rate of -3.12% and in 2012 -4.06% and the unemployment rate reached 16.2% in 2013, an historic high (source: PORDATA). Additionally, Portugal still compares poorly with the average EU member states in terms of educational attainment of the workforce (2019: 47.6% of 15-64 year olds with less than lower secondary education in Portugal; 24.9% EU-28 average, Eurostat data), regarded as an important determinant of economic resilience and long run growth (Mankiw et al. (1992); Romer (1990); Jones (2005); Benos and Zotou (2014)); Ramos et al. (2012)).

Portugal is also an unequal country at the regional level. The European Commission classifies four of the seven NUTS-2 Portuguese regions as less developed (*Norte, Centro, Alentejo* and *Açores*), the *Algarve* is considered a transition region and the only regions classified as more developed are *Lisboa* and *Madeira*. Employment is concentrated in three regions, *Norte* (35.2%), *Lisboa* (27.4%) and *Centro* (21.6%), corresponding to 84.2% of total employment (Eurostat data for the year 2019). Alexandre et al. (2020) focusing on the period 2008-2016 highlight, for both the recession and the recovery periods, the varied growth patterns of regional GDP per capita. Between 2008 and 2012, in the *Algarve* and *Lisboa* output decreased, respectively, -17% and -15%, while in other NUTS-3 regions the drop was between 2 and 4%. In the recovery period, 2012-16, some regions grew 29% (*Alentejo Litoral*), while others grew at only one-digit rates, e.g. 5% in *Lisboa*. 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%). They also conclude that the majority of the NUTS-2 regions (the exception is *Madeira*) shows a high correlation with the national employment cycle. As far as human capital is concerned, the Global Labour Resilience Index (GLRI) 2020 (Whiteshield_Partners (2020)), that puts Portugal in position number 33 in a total of 145 countries, highlights education and skills as a priority for Portugal to increase labour market resilience, together with decreasing inequality and promoting innovation (see figure 5, p. 21). The GLRI 2020 report also gives particular emphasis to analyses at the regional and city level since “One of the major challenges governments face is to address regional disparities, both urban and rural, at the heart of recent social unrest in many countries (…).” (p. 65)

The paper 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 contains the main conclusions.

2. An overview of the literature on the determinants of regional labour market resilience

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. This type of resilience has been associated with the plucking model of business fluctuations (Friedman (1993)), the neoclassical growth model according to which shocks have only transitory growth effects and more generally to real business cycle theory or endogenous growth models that emphasize the differences between short and long-run dynamics relative to the equilibrium situation (Fingleton et al. (2012)). 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. From an economic perspective, this might imply the existence of multiple equilibria or steady states so that the shock can move the region to a different steady state and the notion of hysteresis applies according to which the shock can have a permanent effect on the regional equilibrium level and/or growth path (Fingleton et al. (2012); Ringwood et al. (2019)). Finally, adaptative resilience is concerned with the ability of a region to adapt and renew itself in response to a shock. This understanding of resilience aligns well with the evolutionary economics perspective and the idea that regional economies are continually changing and adapting, rejecting the ‘equilibrist’ approach (Reggiani et al. (2002); Simmie and Martin (2010); Diodato and Weterings (2015)). From these main types of resilience, Martin (2012) identifies four interrelated dimensions of resilience: resistance - the sensitivity to disturbances; recovery - the speed and extent of regional recovery after a perturbation; re-orientation - 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.

Given the controversies on the definition of resilience and following the Great Recession initiated in 2007-08, there has been a renewed interest in measuring and describing regional resilience (see e.g. Simmie and Martin (2010); Fingleton et al. (2012); Martin (2012); Dubé and PolèSe (2016); Sensier and Artis (2016); Sensier et al. (2016); Angulo et al. (2018); Di Caro (2018); Faggian et al. (2018); Lapuh (2018); Ringwood et al. (2019)). For instance, according to Martin and Gardiner (2019), 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 in 2007 around 230 published works that contain the word “resilience” in the respective title, while in 2017 the number increased to more than 1,200 works. The most often proposed measures of resilience refer to the resistance and recoverability dimensions identified before.

More recent studies are also concerned with the identification of the determinants of regional resilience. Within the analysis of labour market resilience, Di Caro (2017) uses quarterly regional employment data over the period 1992–2012 for the 20 Italian NUTS-2 regions to distinguish between engineering and ecological resilience using a smooth-transition autoregressive (STAR) model. Next, OLS regression results with the measures of resilience previously computed as dependent variable indicate 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 the pre-crisis (2002–2007) determinants of resilience, assessed based on employment changes during 2008–2013, to economic crisis across 268 NUTS-2 regions of the EU-28 using a multilevel logistic regression model. From the 15 predictor variables used, education, measured as 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 the fact 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 – Área Metropolitana de Lisboa) to 21% (PT20 – Região Autónoma dos Açores)." (p. 1405). Another country specific study is that by Kitsos and Bishop (2018) which also focus on employment to study the impact of a number of determining factors (initial economic conditions, sectoral specialisation, industrial diversification, human capital, entrepreneurship, demographics, urbanisation and geographical variables.) on local 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, while there was a lack of consistently significant results for industrial structure, diversity and entrepreneurship. Cappelli et al. (2020) provide a more encompassing analysis, again for the EU NUTS-2 regions, but 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.

From the perspective of Portugal, previous studies of resilience at the regional level are scarce. 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 focusing on the situation of the 16 NUTS-3 rural regions after the 2008-09 crisis. From the bivariate analysis carried out applying 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 with regional employment resilience. The correlation coefficient with education, measured as the share of labour force with tertiary education, was positive but not statistically significant.

3. Empirical Analysis

The literature on economic resilience identifies several applied methodologies that might be grouped into two broad groups, notwithstanding intra-group differences. One is the *cyclical* methodology, that approaches the measurement of the business cycle through the turning points and then evaluates changes as well the speed of those changes in the vicinity of those points for different regions, (Martin et al. (2016), Martin and Gardiner (2019) and Han and Goetz (2019)). The other is the “complete information” methodology that makes use of all the information concerning the business cycle to implement the empirical analysis. The SUR method proposed by Fingleton et al. (2012) and a SVAR - Local Projections (LP) method for typical time series or longitudinal data are examples of methods included in the latter, Jordà (2005). The LP method 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 on the aftermath of 2007-2008 crisis, (Auerbach and Gorodnichenko (2012); Jordà and Taylor (2015); Gechert and Rannenberg (2018); Banerjee and Zampolli (2019)).This methodology has also been applied to the analysis of the role played by credit availability on asset prices bubbles (Jordà et al. (2015)), to identify key characteristics of the business cycle in the presence of financial crises, (Jordà et al. (2013)) and to monetary policy (Miranda-Agrippino and Ricco (2018)).

In this study we also use the LP method based on the estimation of a SVAR model to find evidence of labour market resilience in the seven Portuguese NUTS2 regions and take into consideration that in a downturn the economy might react more to positive shocks than in the expansionary phase, although our focus is not on the role of stabilization policies *per se* on economic resilience but rather on the (distinct) impact of a shock to GDP on regional employment during the recessionary and the expansionary regimes. Labour market resilience can thus be assessed by comparing the effects of those shocks on employment under each regime. In addition, we also study the effects of education/human capital shocks on employment. The originality of our work consists in applying this new methodology to the study of labour market resilience. We apply the LP method to typical time series in order to test for determinants of labour market resilience for the seven Portuguese NUTS-2 by considering regional VAR models with three variables - employment (proxied by hours worked and by levels of educational attainment), human capital (average years of schooling of the employees) and real GDP - and by estimating the response of regional employment to an impulse/shock to GDP considering the two distinct phases of the business cycle, using the output gap as a switching variable. Through impulse-response analysis we identify how employment reacts to a shock to GDP and in this way we pinpoint the regions where the labour market is resilient. This methodology allows us to test for the presence of jobless recoveries by comparing employment multipliers in the recession phase with employment multipliers in the recovery phase over the period under analysis. If this phenomenon is confirmed this constitutes an indication of medium to long-run factors in motion in determining employment at the regional level. We also analyse how employment reacts to human capital shocks and how the latter reacts to a shock to GDP shock.

3.1 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 that includes information on real GDP, *GDP*; the (real GDP) output gap, *GAP*; total hours worked, *HT*; the number of employees by levels of educational attainment with, respectively, 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*. These variables/proxies 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)).

We next briefly describe the evolution of key indicators that provide a synthetic picture of the relative economic importance and dynamics of the seven Portuguese NUTS2 regions over the period under analysis. We consider average values for 1995-1998, the initial four years, and similarly for 2015-2018, the last four years of data. According to Table 1, *Lisboa*, *Norte* and *Centro* are the most important regions from an economic point of view: 89.4% (87.8%) of the Portuguese employment in private sector firms is located in these three regions, and at the beginning (end) of the period 84.4% (84.42%) of the Portuguese GDP is created there. Among the remaining regions, *Algarve* is the one that recorded the highest average annual growth rate of employment but *Açores* and *Madeira* were the two regions that 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 over the last decades of public educational policies aimed at reducing the Portuguese educational gap (total and by levels) relative to the average European Union (EU) and Economic and Monetary Union (EMU) member state. The increase is thus important although the gap is still high due to the low relative initial levels of schooling in 1986, when Portugal became a member of the European Economic Community (EEC). It should be noticed that *Lisboa* is always the first in the HC ranking, and that an upward re-re-ranking followed 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.

[1] "Quadros de Pessoal (Personnel Records) is a compulsory survey of all firms, conducted 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, as well as on their employers (firm-level and establishment-level). Data cover information on each establishment and firm, such as size, location, economic activity, and employment, as well as information on each employee, such as gender, age, education, skills, occupation, tenure, monthly wages, and hours worked." Citation from http://datalab.novasbe.pt/index.php/datalab-resources/27-databases-list/66-quadros-de-pessoal

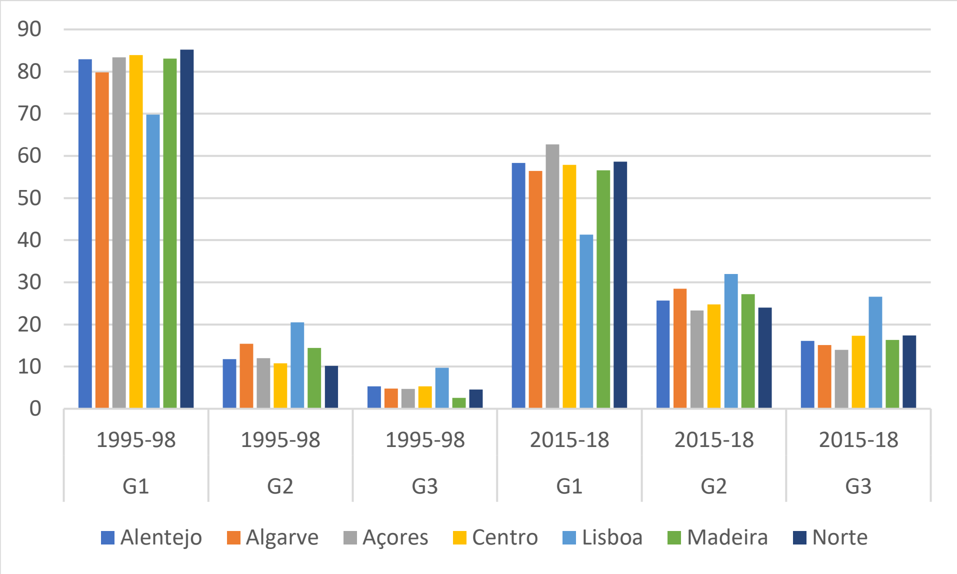
Table 1. Human capital, employment and GDP for the Portuguese NUTS-1 and NUT2, 1995-1998 (average) and 2015-2018 (average)

	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 at work; NFT – number of full-time equivalent employees engaged by private firms; GDP – real GDP at 2005 prices, unit=10^6.
Sources: authors' calculations based on data from *Quadros de Pessoal*.

Figure 1 contains the evolution of employment composition by levels of schooling at the regional level. The relative importance of G3 and G2 has increased from 1986-98 to 2015-2018 and the opposite applies to G1. *Lisboa* is the best performing region, *Norte* follows the trend above mentioned but when compared to the performance of the remaining regions it is the increase of the G3 share that is impressive, leading this region to a re-ranking from the 6th to the 2nd position, however the G1 share remains high, the 2nd highest share against the 1st position at the beginning. *Centro* ends up with a situation comparable to that of *Norte* but it performs better in terms of the G1 share while the remaining two shares are quite similar to those of *Norte*. Finally, it should be noticed that *Açores* is the region that performed worst, at the end of the period it has the highest G1 share and the smallest G2 and G3 shares. Educational policies implemented in Portugal during this period explain the increase in the supply of more educated workers. Those policies focused mainly on secondary and tertiary education, in the former case the policies were aimed at increasing the average years of schooling with the extension of compulsory schooling from 9 to 12 years in 2009, and in the latter case to increase the number of individuals with a Bachelor's degree and with a PhD degree. These supply-side policies together with an increase in the demand for more educated employees help to explain the dynamics of the composition of employment in terms of educational levels.

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



Source: authors based on data from *Quadros de Pessoal*.

The (regional) GAP is a fundamental variable for our empirical analysis of regional resilience since it is the switching variable allowing the estimation and comparability of the impulse-responses of employment to an initial GDP shock over the period under analysis, divided according to the two business cycle regimes, recessions and expansions. Labour market resilience corresponds to the situation when during recessions the employment effects are in absolute value at least equal to the effects (also in absolute values) during expansions.

In order to compute the regional GAP, the cyclical component of GDP (the difference between actual and trend GDP), we started by computing regional real GDP (at 2015 prices) and in order to apply the H-P filter (Hodrick & 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 apply 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)). By selecting this value for lambda the resulting Portuguese business cycle series matches the dates for the turning points and the cycles proposed by the Portuguese Business Cycle Dating Committee *(Fundação Francisco Manuel dos Santos)* (CDCEFFMS (2020)) with quarterly data.

Table 2 contains information that allows the characterisation of the regional business cycles in Portugal from 1995 to 2018. Business cycles are measured from trough to trough. *Açores, Algarve, Centro, Lisboa* and *Norte* record the same number of cycles, 3, the same as Portugal, although the dates are not the same: *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* that presents the same dates for the 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*). In the later cases it means that on average current GDP is 1.13% and 5.2% below the H-P GDP trend, respectively. *Alentejo* and *Madeira* show different business cycle patterns in terms of the number of cycles and duration relative to the remaining five regions. These regions exhibit a higher number of cycles with a shorter duration. *Alentejo* presents five cycles (1995-1999; 1999-2005; 2005-2009; 2009-2013; 2013-2016) with an average duration of 4.2 years; as for *Madeira* the number of cycles is four (1997-2001; 2001-2003; 2003-2009; 2009-2012) and for both regions the average amplitude is 1.91%.

The data presented in Table 2 shows that the regional business cycles cannot be *proxied* by the Portuguese business cycle although all regions share common institutions, rule of law and official language (Cooke et al. (2015)). Almost all the regions present the same number of cycles but starting and ending dates are different from those for the national economy as well as the respective amplitude. To avoid mismeasurement of employment resilience we thus compute and work with the regional output gap series and not with the national output gap series.

Table 2 – Portuguese 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

3.2 Methodology

We apply the Local Projection (LP) method proposed by Òscar Jordà (see Jordà (2005); Montiel and Plagborg-Møller (forthcoming)), a new and simple way of obtaining impulse responses based on local projections, to each of the seven Portuguese NUTS2 regions. For each region we estimate four models, one for each of the four employment proxies, and we consider a forecast horizon of five years (h=1,2,3,4,5) to estimate the impulse responses for our variables, human capital, real GDP and employment. This empirical strategy fits our main research purposes of identifying and distinguishing the effects of shocks on regional employment according to the level of educational attainment of the employees aiming to find evidence of labour market resilience and jobless recoveries at the regional level.

VAR's estimations (see equation 2) approximate the data globally and impulse-responses are functions of multi-step forecasts. The LP methodology proposed by Jordà (2005)suggests instead the use of local approximations for each forecast horizon. One advantage of LP is that they are robust to misspecification. Contrary to VAR's impulse-responses they are not asymmetric, not shape invariant and not history independent.

A SVAR model can be represented by equation (2):

$$\boldsymbol{A}.\boldsymbol{Y}_t = \boldsymbol{\alpha}_t + \boldsymbol{B}(L).\boldsymbol{Y}_t + \boldsymbol{\varepsilon}_t \tag{2}$$

where the square matrix ***A*** is composed of the contemporaneous effects between a set of endogenous variables represented by ***Y***, ***B(L)*** is a polynomial of lags of order ***p,*** and **α** and ***ε*** are vectors of constant values and of unobservable error terms, respectively.

The reduced form of the previous SVAR model is given by equation (3):

$$\boldsymbol{Y}_t = \widetilde{\boldsymbol{\alpha}} + \widetilde{\boldsymbol{B}}(L).\boldsymbol{Y}_t + \boldsymbol{\mu}_t \tag{3}$$

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

Jordà (2005) proposes to estimate impulse-responses (IR) using OLS for each forecast horizon, *h*=1,…,H (Adämmer (2019)):

$$\boldsymbol{y}_t = \boldsymbol{\alpha}^h + \boldsymbol{B}_1^h.\boldsymbol{y}_{t-1} + \cdots + \boldsymbol{B}_p^h.\boldsymbol{y}_{t-p} + \boldsymbol{\mu}_{t+h}^h, \tag{4}$$

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 desired white noise characteristics. Jordà (2005) has named the collection of all regressions in (4) local projections (LP).

The structural IR are estimated as:

$$\widehat{IR}(t, h, \boldsymbol{d_i}) = \widehat{\boldsymbol{B}}_1^h.\boldsymbol{d}_i \tag{5}$$

with the shock matrix $\boldsymbol{d}_i = \boldsymbol{A}^{-1}$ that must be identified from a linear VAR (like in usual SVARs). Considering the more than 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. Auerbach and Gorodnichenko (2012) instead of using dummy variables to identify different regimes proposed computing state probabilities with a logistic function which allows us to use all observations of our database. $F(Z_{i,t})$ is the probability of an economy being in a recession, where *i* represents the economy and *t* the time period, see equation (6):

$$F(Z_{i,t}) = \frac{\exp(-\gamma Z_{i,t})}{1+\exp(-\gamma Z_{i,t})} \tag{6}$$

with a normalization of $Z_{i,t}$ with 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 of $Z_{i,t}$ are derived from the output gap computed with the Hodrick-Prescott filter corresponding to deviations from trend output with λ =6.25. Values of F close to zero imply a period of economic expansion. The values of the logistic function depend on the choice of the parameter γ. This parameter 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. Adämmer (2019) using values of 1. 5 and 10 arrives at the conclusion that it is almost indifferent which value to retain. Very different is the situation for the parameter λ of the H-P filter. Adämmer (2019) proposes a very careful choice of its value taking in account the history of business cycles.

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

R.1: $\boldsymbol{y}_{t-l}.(1 - F(z_{t-1}))$

R.2: $\boldsymbol{y}_{t-l}.\,F(z_{t-1})$ (7)

The IR of equation (5) takes the form:

$$\widehat{IR^{R_j}}(t, h, \boldsymbol{d_i}) = \widehat{\boldsymbol{B}}^h_{1,R_j}.\boldsymbol{d}_i \quad (8)$$

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

The coefficients of the matrices $\widehat{\boldsymbol{B}}^h_{1,R_j}$ are calculated from LP's according to equation (9):

$$\boldsymbol{y}_{t+h} = \boldsymbol{\alpha}^h + \sum_{l=1}^{p} \boldsymbol{B}^h_{l,R_1}.\boldsymbol{y}_{t-l}.(1 - F(z_{t-1})) + \sum_{l=1}^{p} \boldsymbol{B}^h_{l,R_2}.\boldsymbol{y}_{t-l}.F(z_{t-1}) + \boldsymbol{\mu}^h_{t+h} \quad (9)$$

This extension to nonlinear representations can also be applied to the calculation of IR to an exogenous shock. In this case we need to add to (9) the new variable and its coefficient, β_h , is the response of $\boldsymbol{y}_{t+h}$ to this variable and the IR is no more than the sequence of all estimated β_h values.

We estimate the coefficients of the matrices $\widehat{\boldsymbol{B}}^h_{1,R_j}$ for each region (*Alentejo*, *Algarve*, *Centro*, *Lisboa e Vale do Tejo*, *Madeira* and *Norte)* for the period between 1996 and 2018 by using equation (9) in accordance to the LP methodology. The notations are the following: $\boldsymbol{y}$ – the vector of the endogenous variables that includes employment measured using different proxies such as the number of employees by levels of educational attainment with, respectively, 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 total hours worked (regular plus overtime hours), HT; real gross domestic product, GDP; and human capital, the average years of schooling of the employees, HC. The switching variable is the output gap transformed with mean zero and unit variance, *z*; $F(z_t)$ measures the probability of an economy (region) to be in a recession and its complement, (1- $F(z_t)$), measures the probability of an economy (region) to be in an expansion and $\boldsymbol{\mu}^h_{t+h}$ denotes the error term for the forecast horizon *h* (=1,2,3,4,5).

4. Results

In what follows we start by explaining and interpreting the results concerning the order of the VAR models based on which we perform the impulse-responses (IR) analysis with LP. Next, we explain the forecast horizon selected and present the R-squared from the OLS diagnostics for the first impulses-responses, and finally we present the results for the IR from a GDP shock on employment and on human capital and from a human capital shock on employment. Based on the effects of the GDP shocks on employment at the level of the Portuguese regions we identify the ones where there is evidence of labour market resilience and also where there is evidence of the phenomenon of jobless recovery.

Table 3 presents the results of the selection of the optimal number of lags to include in each of our four VAR models according to the Schwarz information criterion (SC). For most of the models the optimal lag order is 1, although some qualifications apply. Model 1 is a 1st order VAR for all the regions except for *Lisboa*, where a 3rd order VAR model applies. Model 4 is 1st order VAR whatever the region and in the cases of models 2 and 3 the exceptions to a 1st order VAR are *Açores* and *Madeira*, both with 2nd- order VAR models. Based on these results we finally decided to use 1st-order VAR models in all the regions since 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).

One of the problems with impulse-responses functions (IRFs), especially when it comes to variables in levels, is to define the forecast horizon for comparisons. By sequencing the values of the negative and positive output gaps, we obtained the results shown in Table 4. Based on these figures, we chose IR values originating in the 5th year after the initial identified shock to compare both economic regimes. But that length is obviously uncertain, so we decided to include as additional information the sum of the 1st to 5th impulses and the maximum and minimum values of the 5th-year impulses, with the respective confidence intervals.

Table 4. Maximum number of consecutive years of recession and 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

Table 5 presents the R-squared from the OLS diagnostics for the first IR. The R-squared are obtained by applying OLS estimators separately to each equation of the LP system (equation 9) considering that the time horizon for the impulses is one. Considering model 1 and the first column, HC, for each region the R-squared values are always higher than 90% indicating the goodness of fit of the HC equation to estimate the value of the 1st 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		
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

By labour market resilience we mean that the employment effect (sum of employment impulses over a time horizon of five years) due to a GDP shock in recessions (S1) is not smaller than the employment effects in expansions (S2). Since employment effects during recessions might be lower but very close to the effects during expansions, we assume that they are equal if the absolute gap between the employment effect during recessions and that during expansions is less than 5% of their average.

Notice that we considered a time horizon of five years after a shock to compute the employment responses in recessions and in expansions, a choice justified by 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 highly concentrated.

A labour market situation characterised by a jobless recovery means that the additional employment created in expansions due to a GDP shock is lower than the one created during recessions.

In what follows, we present the main results associated with the impact of a GDP shock on employment, see Figures 2.1 to 29.1 and Tables 6 and 7.

When employment is measured in terms of hours worked (HT) 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, the phenomenon of jobless recovery might be observed in *Açores* and *Norte*. Three of the seven regions, among which *Lisboa* is included, seem not to be flexible enough in terms of hours worked. This might explain why in some Portuguese regions there no labour market resilience is found.

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Labour market resilience is confirmed for employment of less educated workers (G1) for six of the seven Portuguese 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 due to education policies, among others, might be in motion leading private sector firms to decrease their labour demand for less educated workers.

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In what concerns labour market resilience in terms of G2 employment, we should mention that *Alentejo*, *Açores* and *Norte* experience employment effects due to the GDP shock that are negative, both in recessions and 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.

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We find labour market resilience in terms of the most educated workers (G3) in all the Portuguese regions. *Lisboa* and *Norte* are the only regions where the employment effects due to the GDP shock are equal in recessions and expansions, in the remaining regions there is evidence of jobless recoveries.

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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.

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

In what follows we present the main results associated with the impact of the HC shock on employment according to the information presented in Figures 2.2 to 29.2 and Tables 8 and 9.

In what concerns the impact of a shock to HC on HT, we observe that the employment effect is negative whatever the phase of the business cycle 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 higher availability of more educated workers result in less hours worked.

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A shock on HC leads to a decrease in G1. This effect is more important in absolute terms in recessions than in expansions in all the Portuguese regions, except for *Centro* where the employment effect in expansions is slightly more important.

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A shock on HC reduces G2 employment 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*.

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A shock on 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*.

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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.

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

In what follows we focus on the model that uses an aggregate measure of employment, HT, to illustrate the main results associated with a shock to GDP on human capital, see Figures 2.3 to 8.3, and Tables 10 and 11. For similar results associated with the other proxies of employment, G1, G2 and G3 see figures 9.3 to 29.3 and tables 10 and 11.

The effects of the GDP shock 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 less chances to find a job and decide to continue their studies aiming at individual educational benefits associated to higher levels of educational attainment. This phenomenon is particularly relevant in the case of *Norte*, in the second position after *Lisboa* in terms of employment and GDP but in the last position in terms of the initial availability of human capital.

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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 response	l	U	HC response	l	U	HC response	l	U	HC response	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	-0.11	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.

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

5. Conclusion

In this study we used the Local Projections method to find evidence of labour market resilience in the seven Portuguese NUTS2 regions over the period 1995-2018 considering regional SVAR models with three variables, employment (proxied by hours worked and by levels of educational attainment), human capital (average years of schooling of the employees) and real GDP, and by estimating responses of regional employment to shocks for the two phases of the cycle, using the output gap as a switching variable and taking into account that in a downturn the economy might react more to positive shocks than in the expansionary phase of the business cycle. We assess labour market resilience by comparing the effects of GDP shocks on employment under each regime. This methodology also allows us to test 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, although *Lisboa* does not show evidence of resilience in terms of hours worked. In our opinion, this is due to more important increases in productivity as this region is resilient in terms of G1, G2 and G3. The absence of jobless recovery in terms of total hours worked prevails even though it exists in a large region, *Norte*. This phenomenon is dominant in terms of G1 since most regions and among them two large regions, *Lisboa* and *Norte*, show evidence of this phenomenon. The same is true for G2 but *Norte* is now replaced by *Centro*. The situation of jobless recovery in terms of G3 is quite specific because in the majority of regions we found evidence of this phenomenon and only in two big regions, *Lisboa* and *Norte*, this result does not apply.

The most relevant conclusion that we draw is the resilience of employment, whether measured by the total hours worked or by the different levels of employment according to levels of education. The growth of the economy will clearly lead to increases in the level of human capital that will imply reductions in total hours worked. These last implications confirm a stylized fact in a context in which we conclude for the existence of resilience at regional level which per se is an important fact in terms of welfare of Portuguese employees and with positive implications over the sustainability of fiscal policy. Evidence of labour market resilience in the

Portuguese regions for the highest levels of education recommends education policies aimed at raising the level of education of the median employee.

Additionally, the effects from a shock on human capital on employment, specifically, on HT, G1 and G2 are in general negative, although in a small number of situations the effect is positive in the expansionary phase. The effects of a shock to human capital on G3 are always positive. Due to the way our human capital measure is computed, we should focus on the human capital effects on hours worked (HT), an effect that is clearly negative. Only in the case of *Alentejo* and *Algarve* is there a positive effect in the expansionary phase, which may 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 less chances to find a job and decide to continue their studies aiming at individual educational benefits associated to higher levels of educational attainment. This phenomenon is particularly relevant in the case of *Norte*, in the second position after *Lisboa* in terms of employment and GDP but in the last position in terms of the initial conditions of human capital availability.

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Fig. 2.1 HT responses to a GDP shock in Alentejo

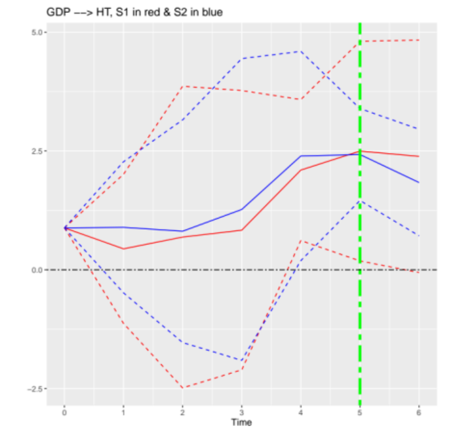


Fig. 2.2 HT responses to a HC shock in Alentejo

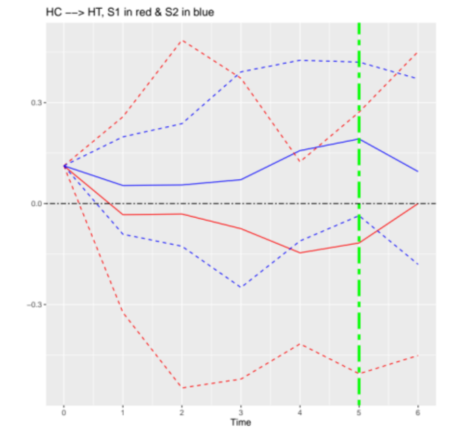


Fig. 2.3 HC responses to a GDP shock in Alentejo

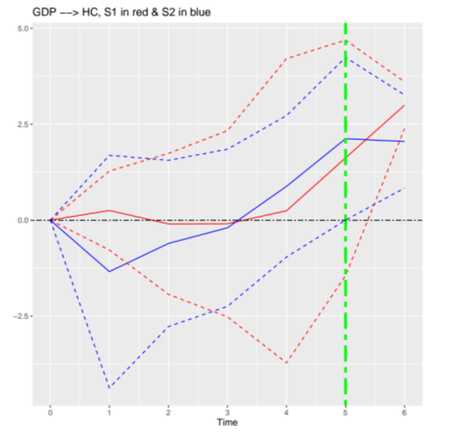


Fig. 3.1 HT responses to a GDP shock in Algarve

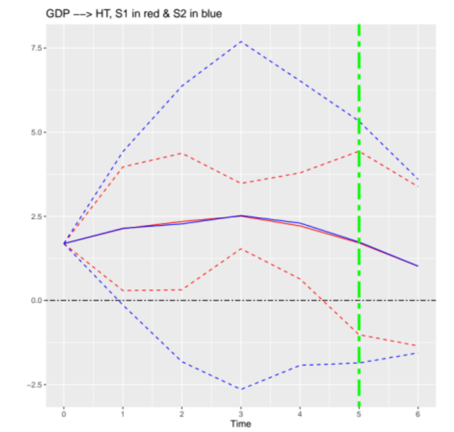


Fig. 3.2 HT responses to a HC shock in Algarve

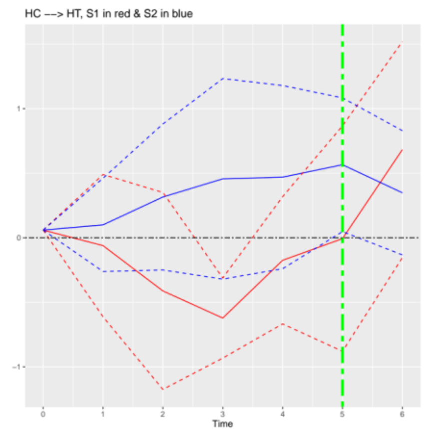


Fig.3.3 HC responses to a GDP shock in Algarve

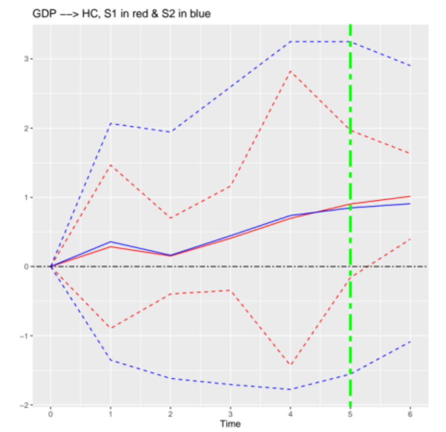


Fig.4.1 HT responses to a GDP shock in Açores

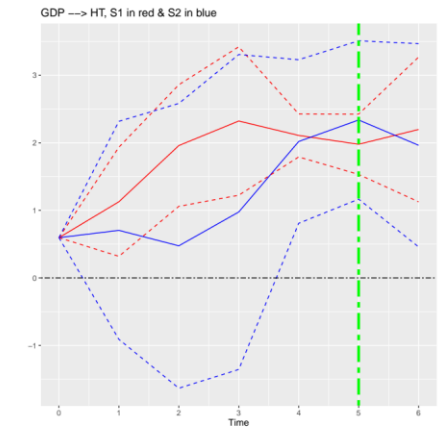


Fig. 4.2 HT responses to a HC shock at Açores

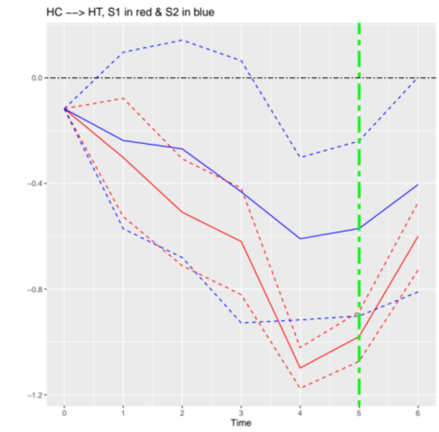
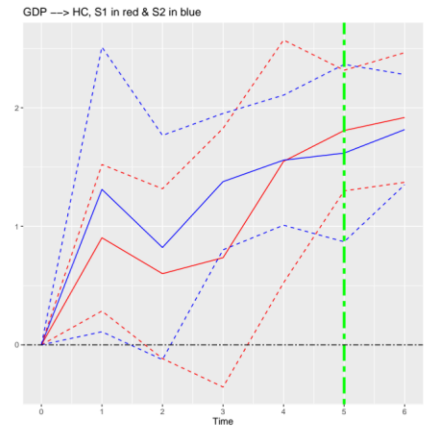


Fig.4.3 HC responses to a GDP shock in Açores



Notes to Figures 1.1 to 4.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

Fig. 5.1 HT responses to a GDP shock in Centro

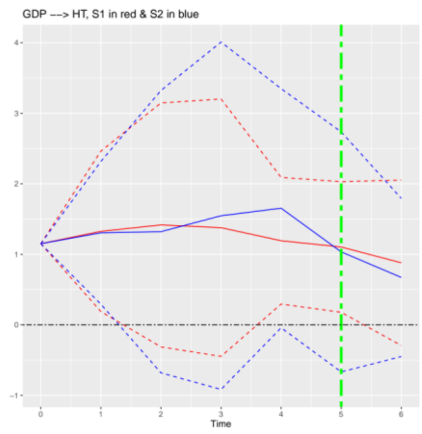


Fig.5.2 HT responses to a HC shock in Centro

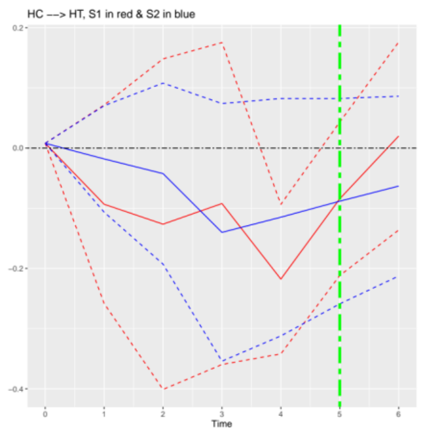


Fig. 5.3 HC responses to a GDP shock in Centro

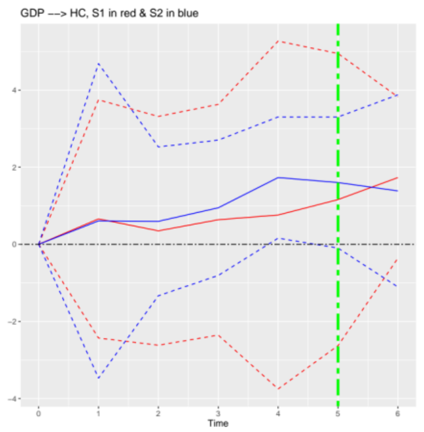


Fig. 6.1 HT responses to a GDP shock in Lisboa

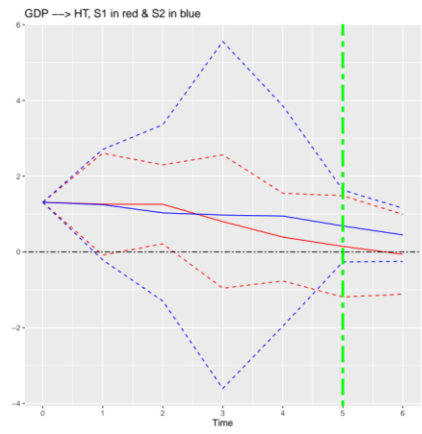


Fig. 6.2 HT responses to a HC shock in Lisboa

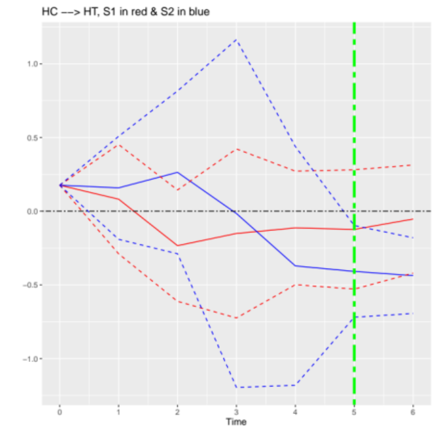


Fig. 6.3 HC responses to a GDP shock in Centro

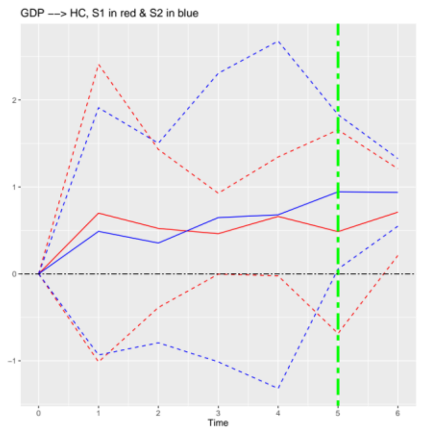


Fig. 7.1 HT responses to a GDP shock in Madeira

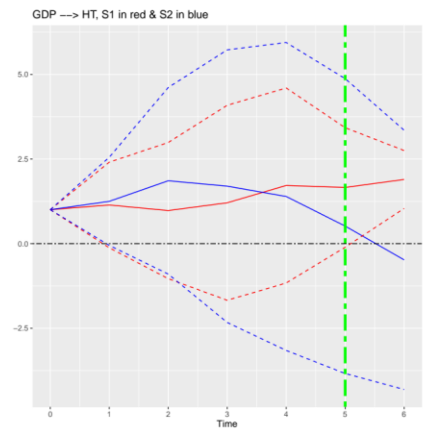


Fig. 7.2 HT responses to a HC shock in Madeira

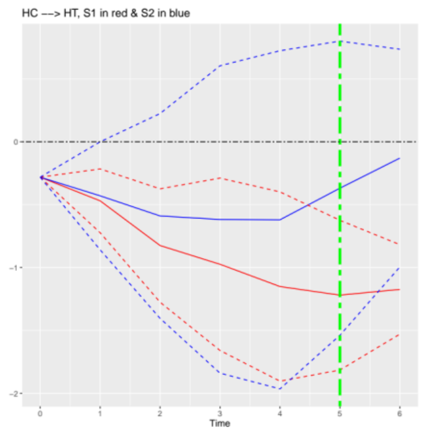
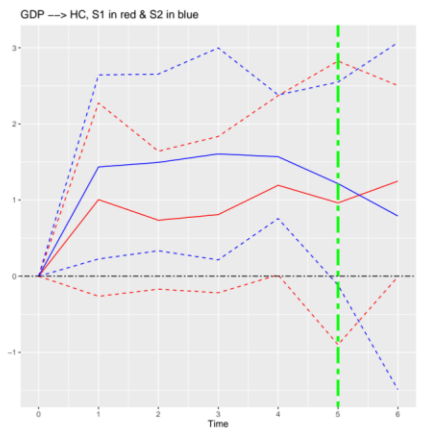


Fig. 7.3 HC responses to a GDP shock in Madeira



Notes to Figures 5.1 to 7.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

Fig. 8.1 HT responses to a GDP shock in Norte

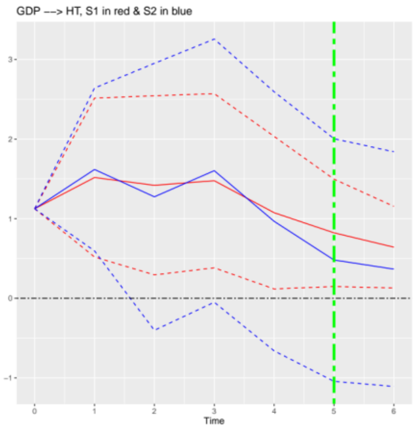


Fig. 8.2 HT responses to a HC shock in Norte

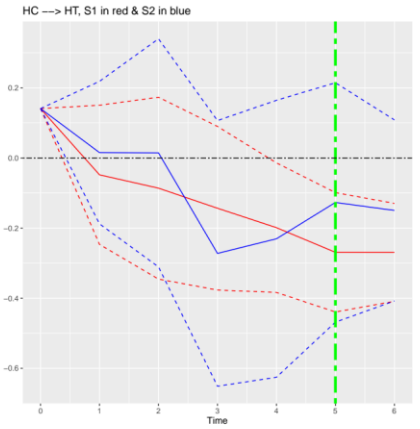


Fig. 8.3 HC responses to a GDP shock in Norte

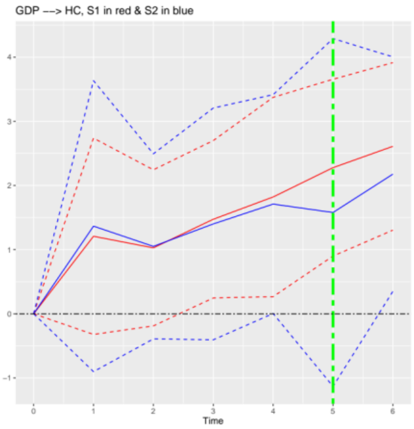


Fig. 9.1 G1 responses to a GDP shock in Alentejo

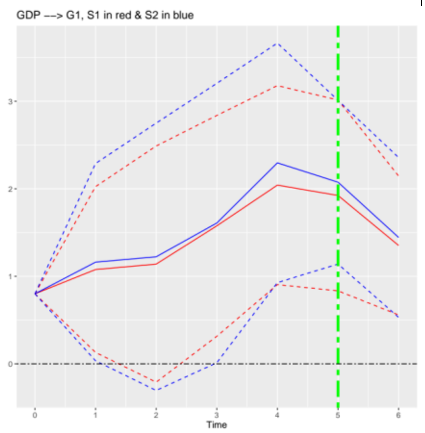


Fig. 9.2 G1 responses to a HC shock in Alentejo

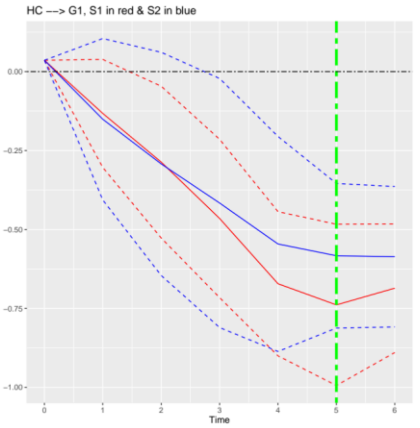


Fig. 9.3 HC responses to a GDP shock in Alentejo

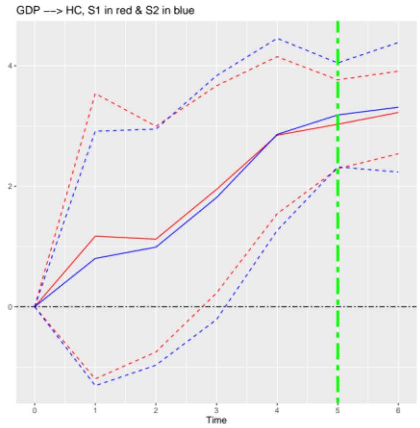


Fig. 10.1 G1 responses to a GDP shock in Algarve

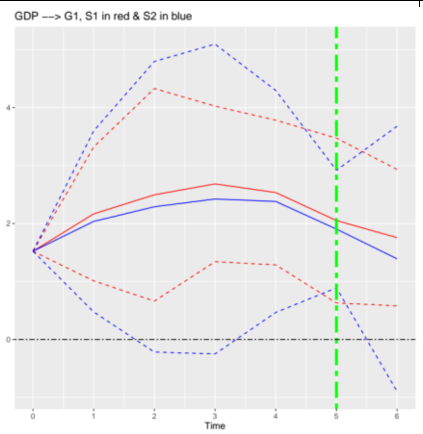


Fig. 10.2 G1 responses to a HC shock in Algarve

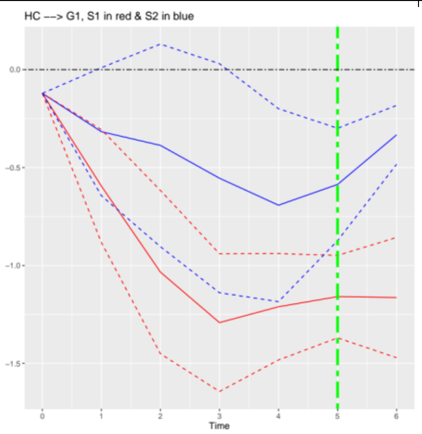
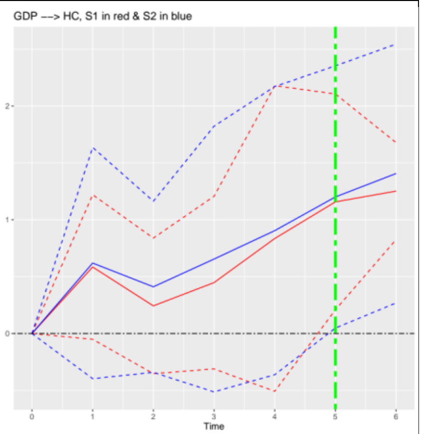


Fig. 10.3 HC responses to a GDP shock in Algarve



Notes to Figures 8.1 to 10.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

Fig. 11.1 G1 responses to a GDP shock in Açores

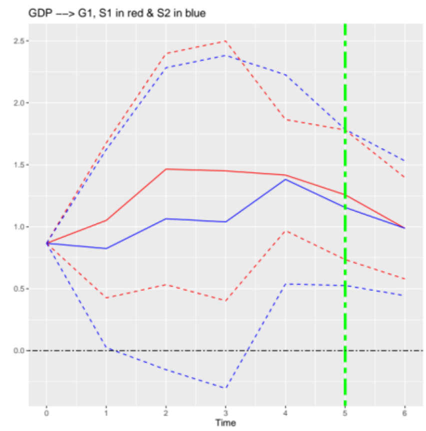


Fig. 11.2 G1 responses to a HC shock in Açores

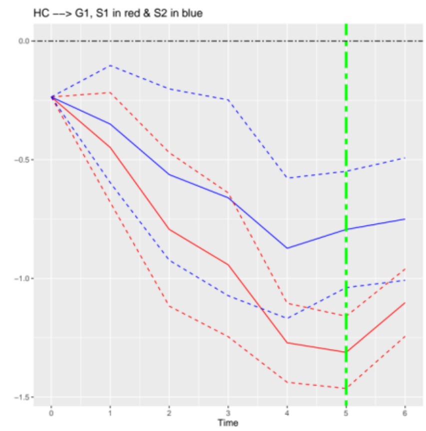


Fig. 11.3 HC responses to a GDP shock in Açores

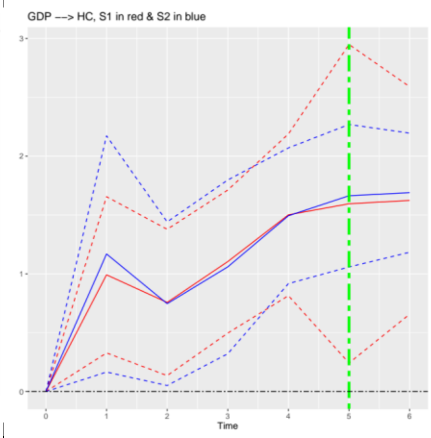


Fig.12.1 G1 responses to a GDP shock in Centro

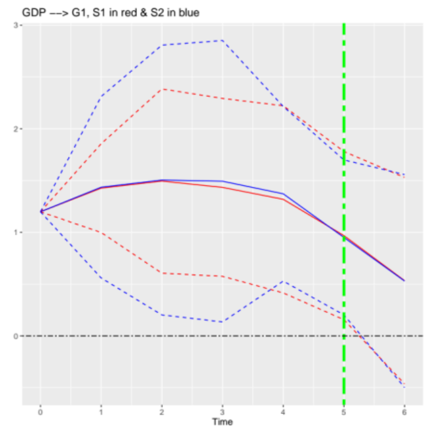


Fig. 12.2 G1 responses to a HC shock in Centro

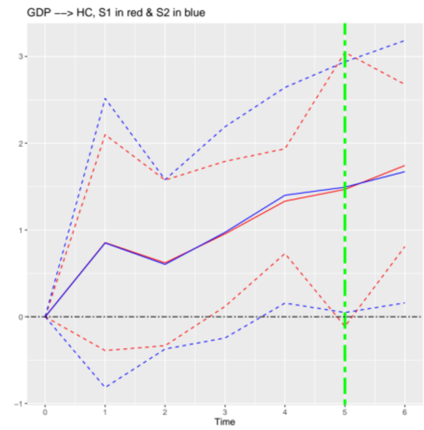


Fig. 12.3 HC responses to a GDP shock in Centro

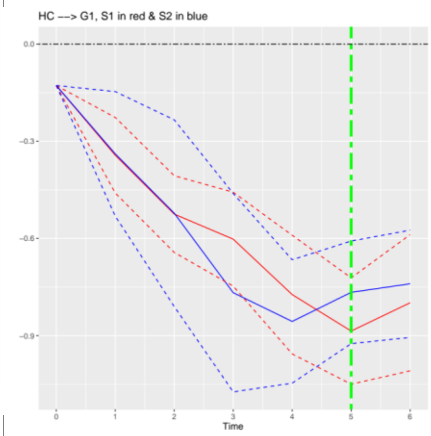


Fig. 13.1 G1 responses to a GDP shock in Lisboa

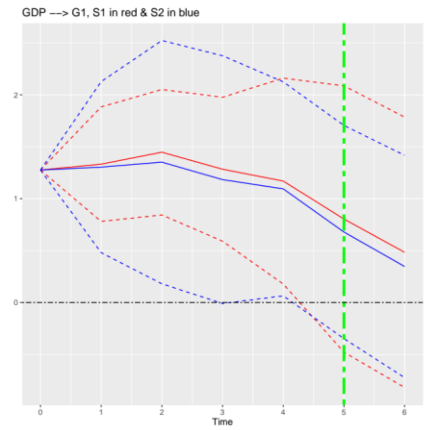


Fig. 13.2 G1 responses to a HC shock in Lisboa

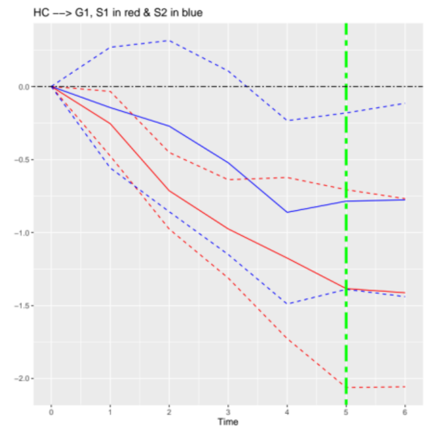
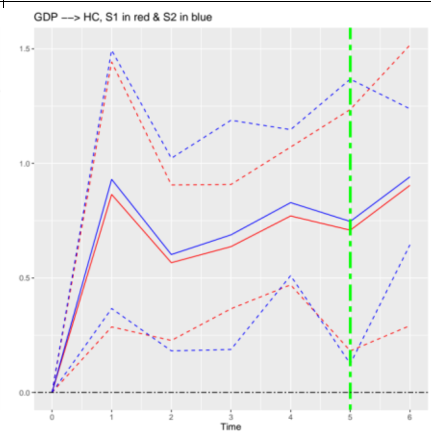


Fig. 13.3 HC responses to a GDP shock in Lisboa



Notes to Figures 11.1 to 13.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

Fig. 14.1 G1 responses to a GDP shock in Madeira

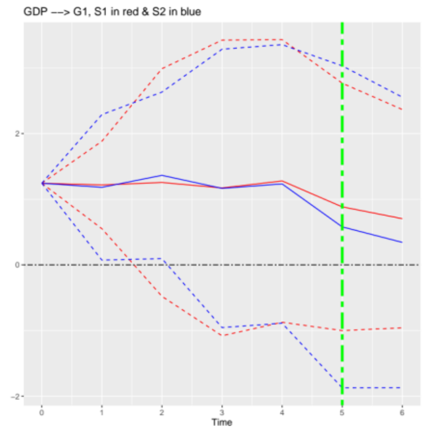


Fig. 14.2 G1 responses to a HC shock in Madeira

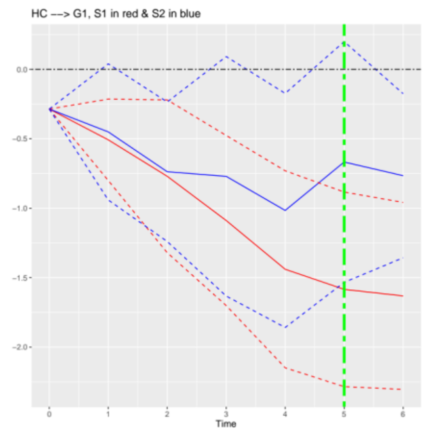


Fig. 14.3 HC responses to a GDP shock in Madeira

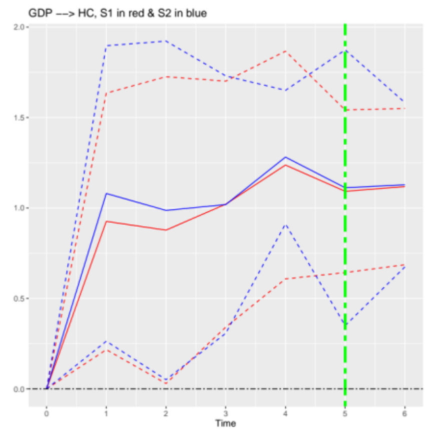


Fig. 15.1 G1 responses to a GDP shock in Norte

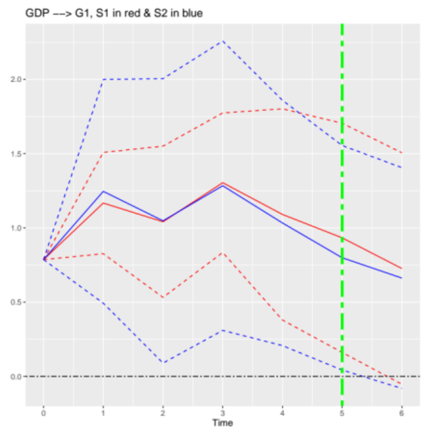


Fig. 15.2 G1 responses to a HC shock in Norte

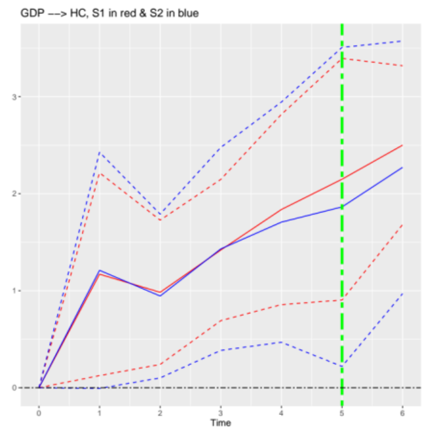


Fig. 15.3 HC responses to a GDP shock in Norte

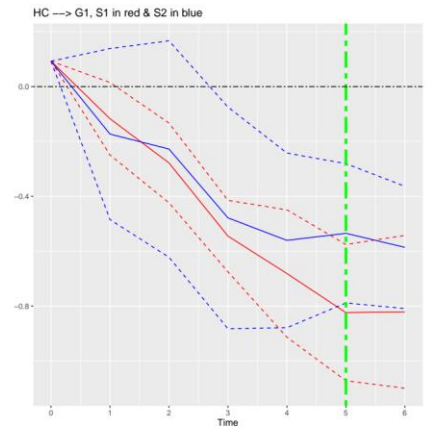


Fig. 16.1 G2 responses to a GDP shock in Alentejo

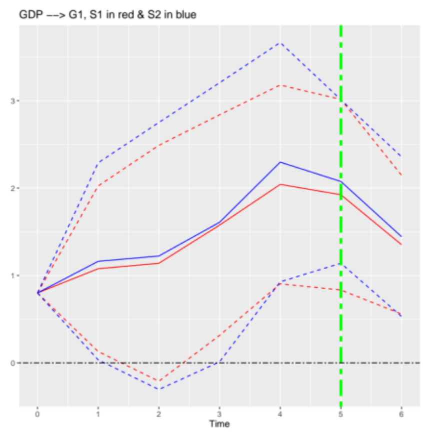


Fig. 16.2 G2 responses to a HC shock in Alentejo

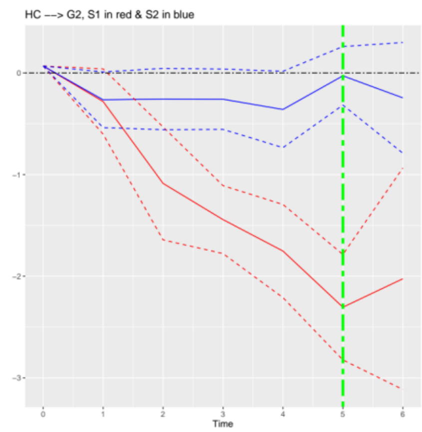
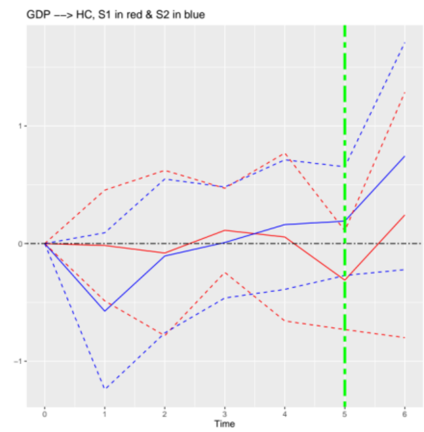


Fig. 16.3 HC responses to a GDP shock in Alentejo



Notes to Figures 14.1 to 16.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

Fig. 17.1 G2 responses to a GDP shock in Algarve

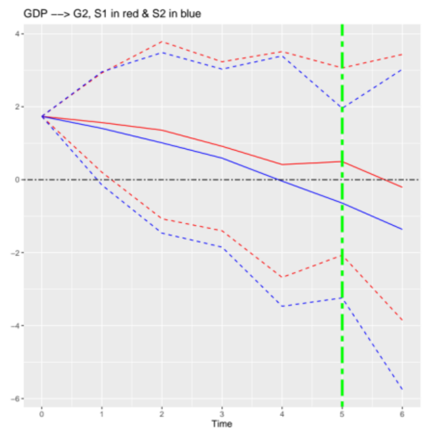


Fig. 17.2 G2 responses to a HC shock in Algarve

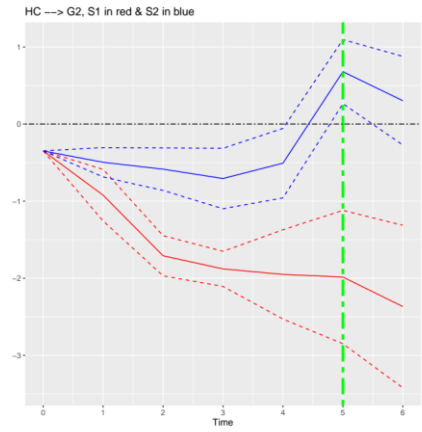


Fig. 17.3 HC responses to a GDP shock in Algarve

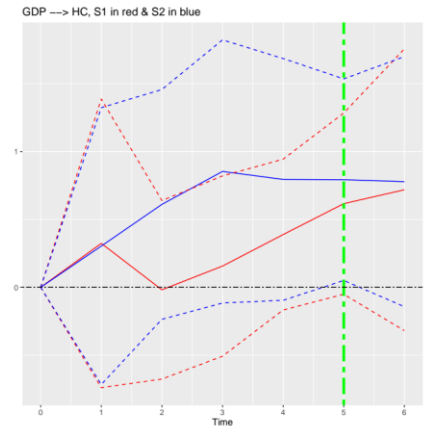


Fig. 18.1 G2 responses to a GDP shock in Açores

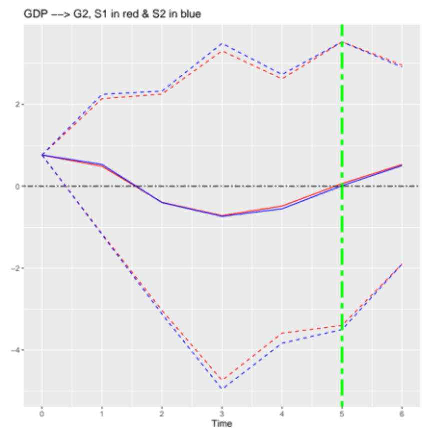


Fig. 18.2 G2 responses to a HC shock in Açores

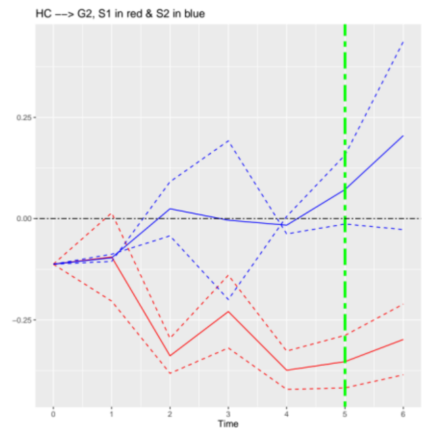


Fig. 18.3 HC responses to a GDP shock in Açores

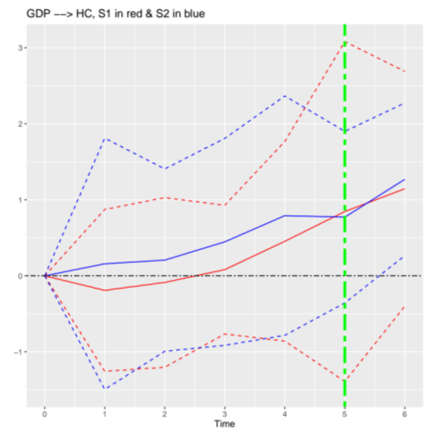


Fig. 19.1 G2 responses to a GDP shock in Centro

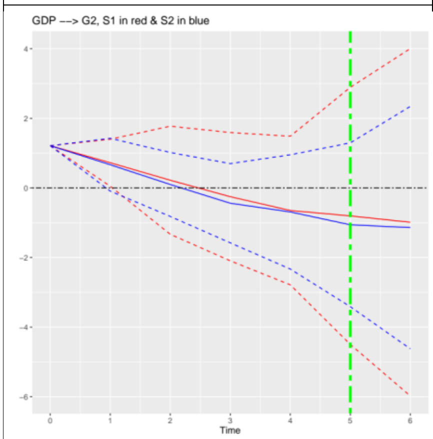


Fig. 19.2 G2 responses to a HC shock in Centro

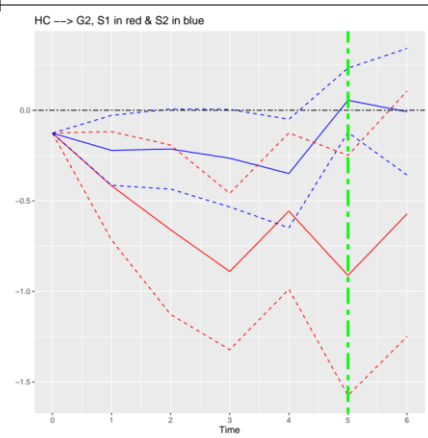
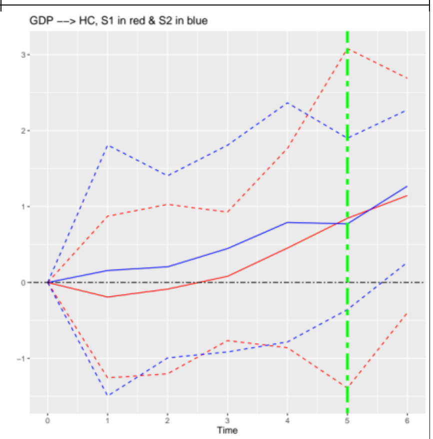


Fig. 19.3 HC responses to a GDP shock in Centro



Notes to Figures 17.1 to 19.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

Fig. 20.1 G2 responses to a GDP shock in Lisboa

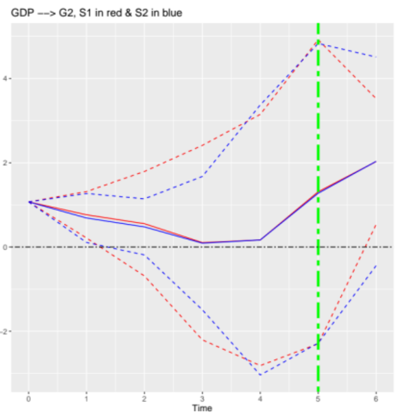


Fig. 20.2 G2 responses to a HC shock in Lisboa

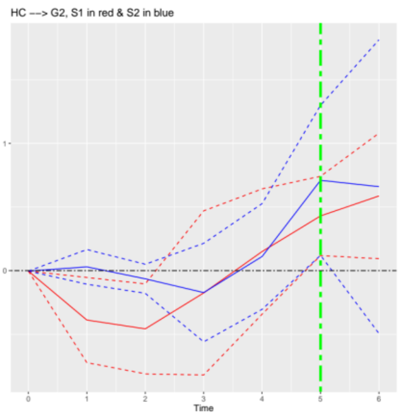


Fig. 20.3 HC responses to a GDP shock in Lisboa

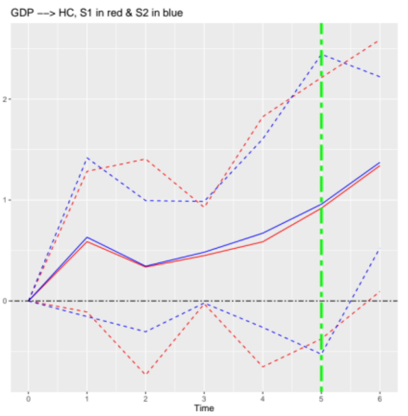


Fig. 21.1 G2 responses to a GDP shock in Madeira

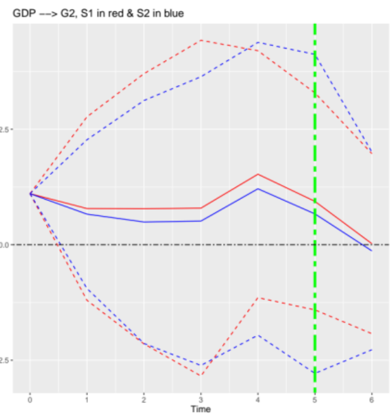


Fig. 21.2 G2 responses to a HC shock in Madeira

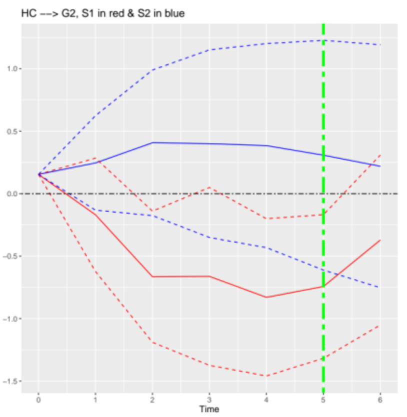


Fig. 213 HC responses to a GDP shock in Madeira

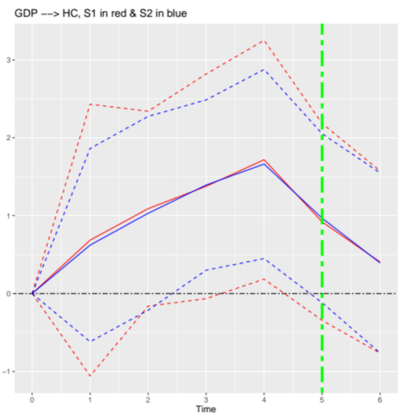


Fig. 22.1 G3 responses to a GDP shock in Norte

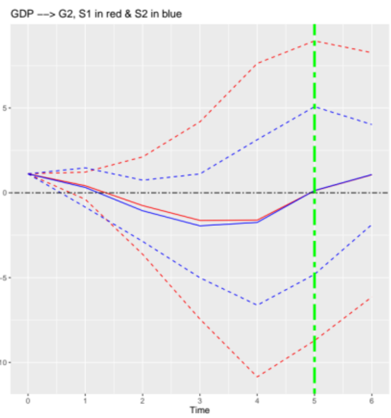


Fig. 22.2 G3 responses to a HC shock in Norte

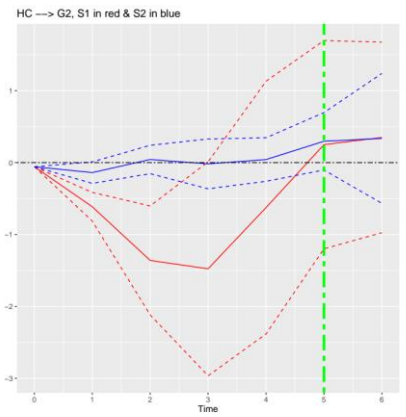
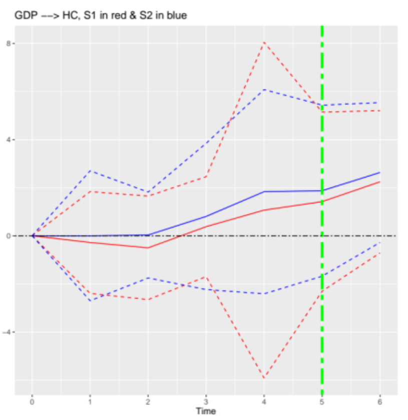


Fig. 22.3 HC responses to a GDP shock in Norte



Notes to Figures 20.1 to 22.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

Fig. 23.1 G3 responses to a GDP shock in Alentejo

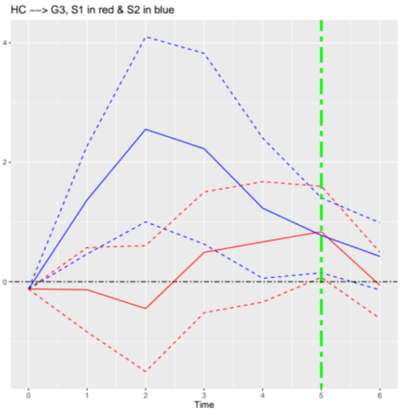


Fig. 23.2 G3 responses to a HC shock in Alentejo

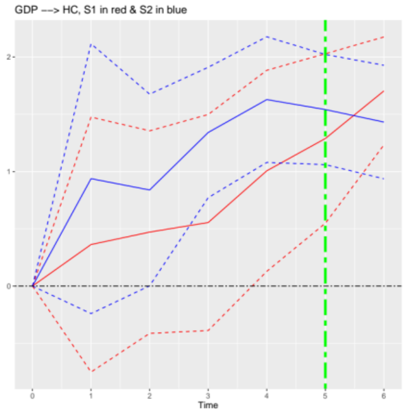


Fig. 23.3 HC responses to a GDP shock in Alentejo

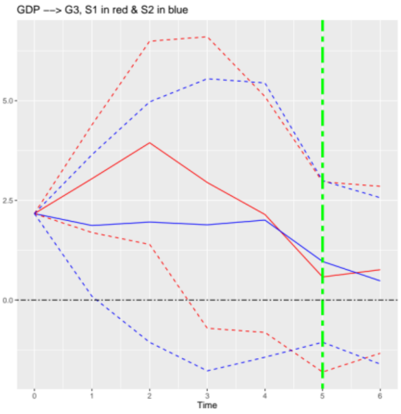


Fig. 24.1 G3 responses to a GDP shock in Algarve

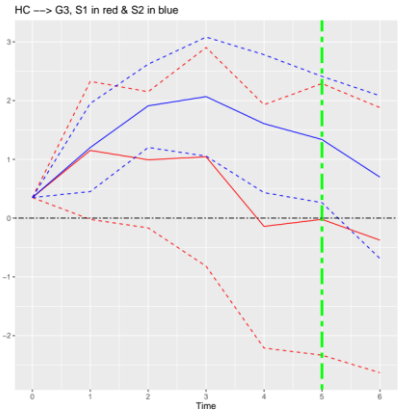


Fig. 24.2 G3 responses to a HC shock in Algarve

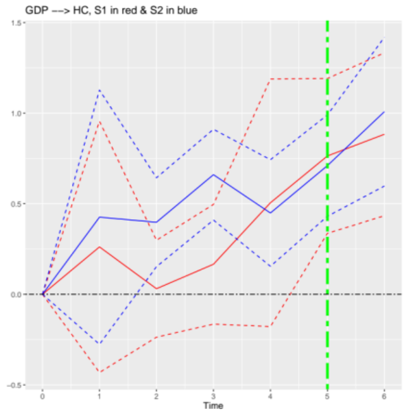


Fig. 24.3 HC responses to a GDP shock in Algarve

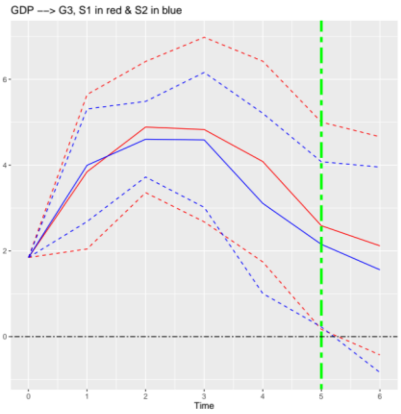


Fig. 25.1 G3 responses to a GDP shock in Açores

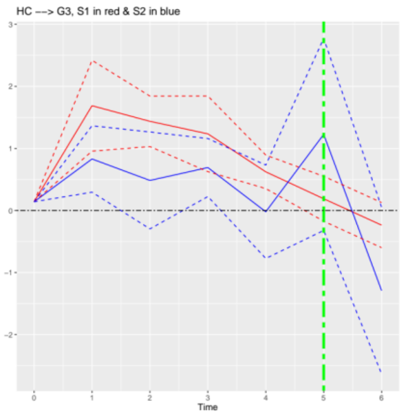


Fig. 25.2 G3 responses to a HC shock in Açores

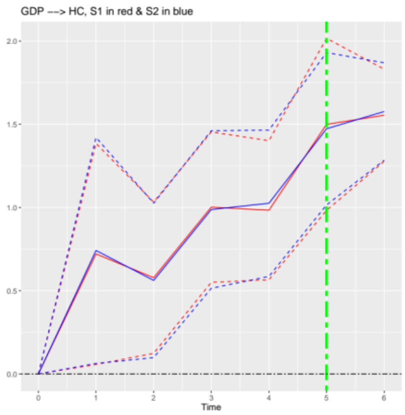
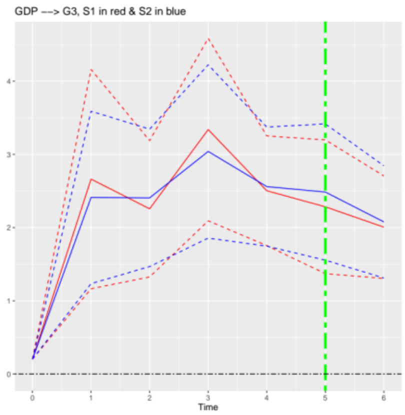


Fig. 253 HC responses to a GDP shock in Açores



Notes to Figures 24.1 to 25.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

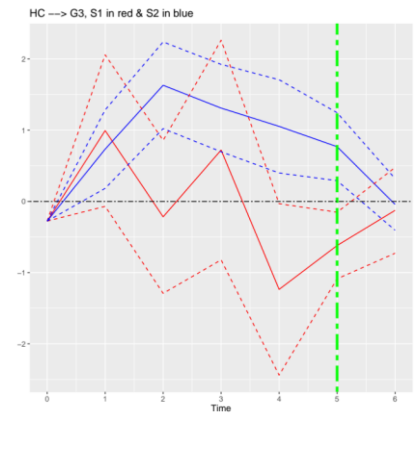
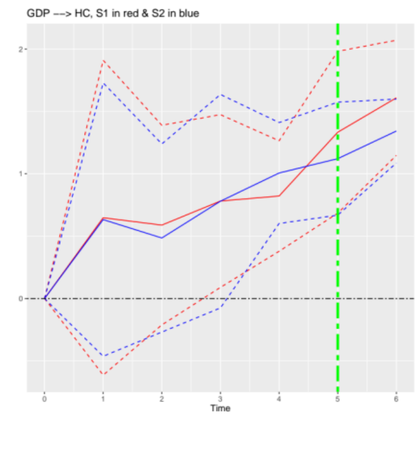
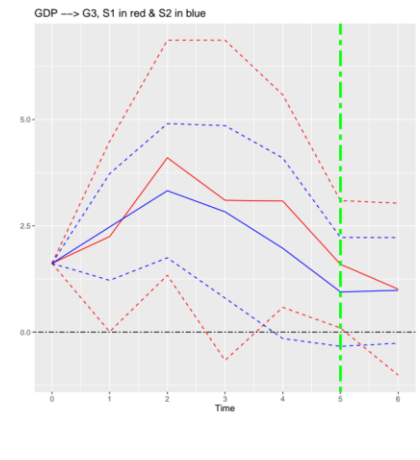
Fig. 26.1 G3 responses to a GDP shock in Centro	Fig. 26.2 G3 responses to a HC shock in Centro	Fig. 26.3 HC responses to a GDP shock in Centro
		

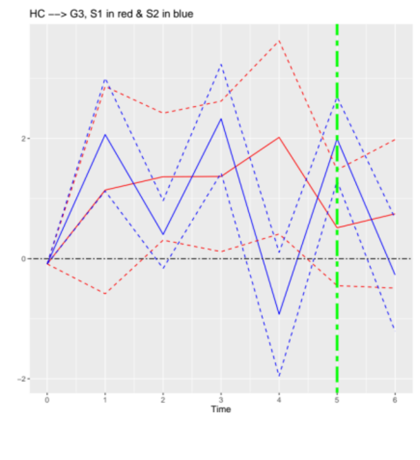
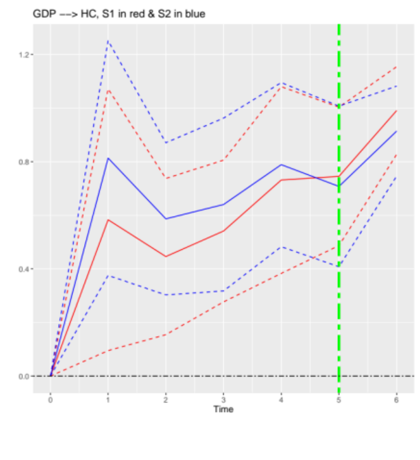
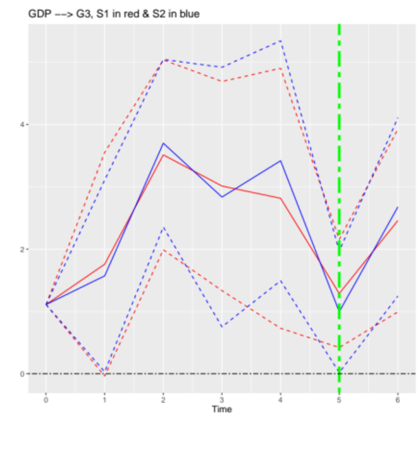
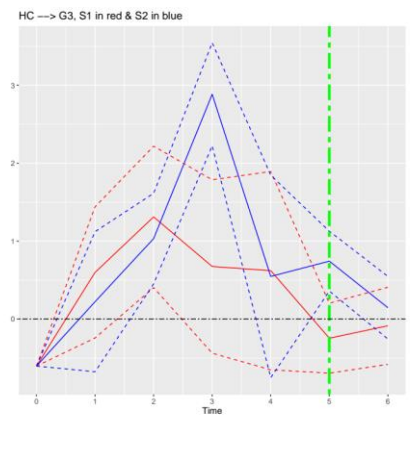
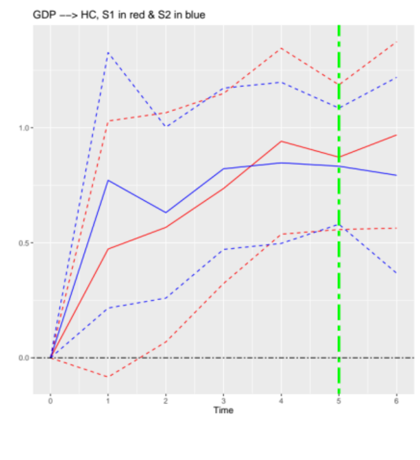
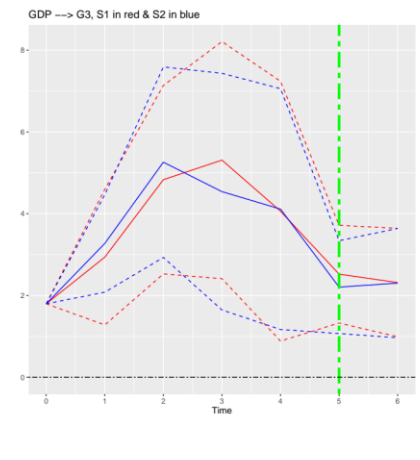
Fig. 27.1 G3 responses to a GDP shock in Lisboa	Fig. 27.2 G3 responses to a HC shock in Lisboa	Fig. 27.3 HC responses to a GDP shock in Lisboa
		

Fig. 28.1 G3 responses to a GDP shock in Madeira	Fig. 28.2 G3 responses to a HC shock in Madeira	Fig. 28.3 HC responses to a GDP shock in Madeira
		

Notes to Figures 26.1 to 28.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.

Fig. 29.1 G3 responses to a GDP shock in Norte

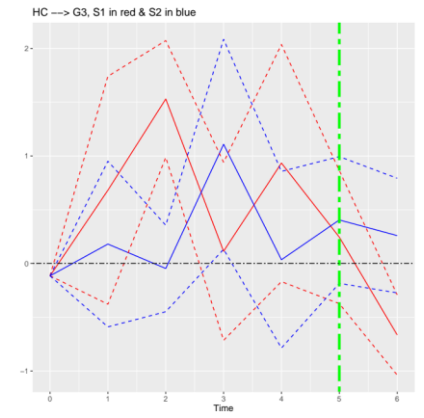


Fig. 29.2 G3 responses to a HC shock in Norte

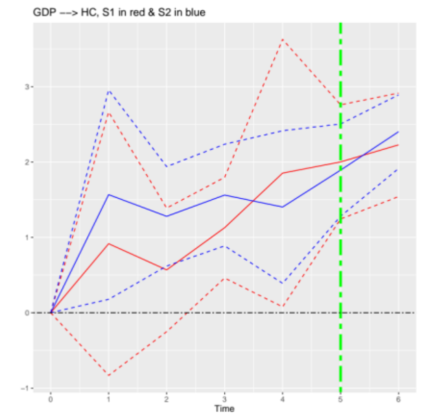
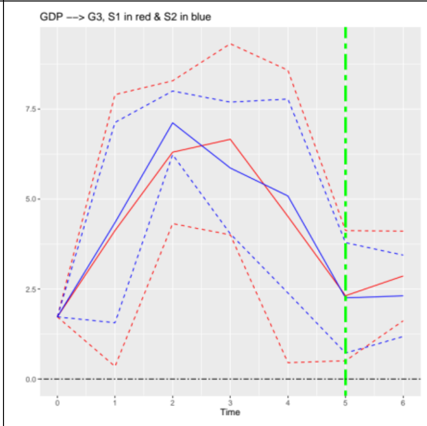


Fig. 29.3 HC responses to a GDP shock in Norte



Notes to Figures 29.1 to 29.3 – S1 denotes the recessionary regime and S2 denotes the expansionary regime. Source – Authors' own computations.