A thresholds analysis of growth, convergence and structural change in the EU: insights for Portugal

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Abstract

Following the political turmoil and economic crisis of the 1970s, Portugal enjoyed some years of rapid (and above average) economic growth, accompanying the preparation and accession to the European Union and the participation as a founding member in the Euro Zone. This process, however, stopped since the beginning of the 21st century and this change in the growth rhythm was exacerbated by the Great Recession. From about 1999-2000 onwards, economic growth in Portugal slowed significantly, the non-tradables sector reinforced its role as the anchor of the economy, and productivity growth stagnated or even declined, depending on the productivity measured considered. This paper applies a thresholds regression approach to examine the growth and convergence process of fourteen EU member states over the period 1980-2011. Given the changes in the pattern of production towards a higher weight of the non-tradables sector that Portugal recorded throughout the period under analysis, we use the share of non-tradables as the threshold variable and derive some potential implications from our results for a better understanding of the Portuguese growth and convergence process in preparation for and after accession to the European Union. Threshold analysis allows us to identify those growth determinants that do not have the expected effect on growth and hence determine the specific policy implications for different non-tradables sector weight regimes.

Keywords: economic growth, convergence, Portugal, EU, thresholds analysis
JEL Classification: C23; O47; O52

1. Introduction

Following the political turmoil and economic crisis of the 1970s, Portugal enjoyed some years of rapid (and above average) economic growth, accompanying the preparation and accession to the European Union and the participation as a founding member in the Euro Zone. This process, however, stopped since the beginning of the 21st century and this change in the growth rhythm was exacerbated by the Great Recession (Simões, Andrade, & Duarte (2014); Andrade, Duarte, & Simões (2014)). From about 1999-2000 onwards, economic growth slowed significantly, the non-tradables sector reinforced its role as the anchor of the economy, and productivity growth stagnated or even declined, depending on the productivity measured considered. One of the main theoretical arguments supporting the negative growth impact of an expanding non-tradables sector poses that manufacturing, which produces tradable goods, is the driver of growth since this is the sector where technological advances and economies of scale, the basis for productivity improvements and thus faster growth, take place. On the other hand, non-tradables are mainly associated with services, viewed as technological stagnant sectors and with low potential for productivity improvements. In his seminal work, Baumol (1967) suggests that, due to differences in the rate of technological progress, the three major sectors grow at different rates, which means that changes in the composition of production and employment can determine important differences in the aggregate growth rate of an economy. Since the services sector was traditionally viewed as a low productivity/stagnant sector, increased specialization towards services would lead to a growth slowdown.

Alexandre & Bação (2013) examine the evolution of the non-tradables sector in the Portuguese economy since the mid-1950s. The authors conclude that, even though the pattern of change towards the dominance of services was similar to that of other EU countries, the shift to non-tradables in Portugal was fast and occurred at the expense of industry over the period 1995-2009. According to the authors (p.1) "(…) construction and services facing a strong Government demand were the main drivers of the increasing weight of non-tradables in the Portuguese economy since 1986." According to OECD (2014), the Portuguese economy has faced a structural weak competition problem in products markets, and in particular in the non-tradable sectors, that impact negatively on multi-factor productivity. This OECD report exemplifies with the cases of professional services and transport where Portugal remains more restrictive than the OECD average.

Additionally, OECD (2014), p.6, refers that "(…) Portuguese exporters continue to be at a potential disadvantage vis-à-vis international competitors across a number of dimensions, notably with respect to access to inputs from non-tradable sectors (…)" a situation that supports our concern with the negative growth impact of a fast growing and dominant non-tradables sector. The 2015 country report for Portugal by the IMF highlights the fact that productivity growth has declined over the past half-century with the less productive non-tradables sector offering opportunities for rent-seeking that lead to misallocation of resources so that "Steps to minimize rent-seeking would ensure that the country's scarce resources are channelled to productive activities and strengthen the clout of the pro-reform tradable sector companies." (p.33)

This paper applies a thresholds model to estimate a growth regression for a sample of fourteen EU member states over the period 1980-2011 in order to get a better understanding of the changes in the Portuguese growth rhythm and convergence process. Our aim is to identify the relevant growth determinants for Portugal, as a member of the EU, assuming that the sign and magnitude of relevant growth determinants will vary with the economic importance of the non-tradables sector. For this purpose we apply an estimation methodology that allows to capture non-linearities in the growth relationships, the Hansen thresholds model (Hansen (1999)). This estimation approach allows for the identification of different impacts of the explanatory variables according to different regimes defined by different values of the economic importance of the non-tradables sector. Given the fast growing non-tradables sector in Portugal and its potential negative growth impact through productivity declines this seems a suitable approach. Bruce Hansen (Hansen (1999)), proposed an estimation methodology for the identification of different regimes based on tests for the existence of "thresholds", with bootstrap. This method allow us to identify different non-tradables regimes selected according to statistical criteria. The threshold model splits the sample into different groups thus capturing a nonlinear effect of the different explanatory variables on growth. Threshold analysis therefore enable us to identify specific policy implications for different non-tradables sector weight regimes.

We first review the recent growth and convergence process of the Portuguese economy focusing on the period 1980-2011 comparing it with the average EU14 economy[1]. We start by presenting some descriptive data on convergence and growth for

[1] Together with Portugal this group, composed of the member countries in the European Union prior to the accession of the ten candidate countries on 1 May 2004, is usually known as EU15. The EU15 includes the following 15 countries:

Portugal relative to the aggregate of reference, the EU14. This comparison highlights the different phases in terms of growth and convergence that Portugal experienced in the period of preparation and after European integration. We next apply the Hansen thresholds model to estimate an empirical growth model for the EU14 sample where the thresholds are identified according to the economic importance of the non-tradables sector. The empirical model includes the factors driving growth and convergence highlighted by the theoretical predictions and empirical evidence developed in the economic growth literature over recent decades (e.g. Doppelhofer, Miller, & Sala-i-Martin (2004); Durlauf, Johnson, & Temple (2005); Sala-i-Martin (1997)). Finally, we derive some potential implications of our results for a better understanding of the Portuguese growth and convergence process from 1980 onwards highlighting the potential role of the increasing dominance of the non-tradables sector.

2. Growth and convergence: Portugal and the EU over the period 1980-2011

We begin by examining some quantitative information on output/income behaviour over the period under analysis, undertaking a comparative analysis of the performance of Portugal in terms of some basic indicators. Our reference is the aggregate which comprises the fifteen oldest member countries of the European Union (EU), except Luxembourg, known as the EU14. Annual output data was obtained from the PWT 8.1 database and refers to Gross domestic product (GDP) per capita/person engaged, at constant prices, constant purchasing power parities (PPPs), 2005 base year, in USD.

Figure 1 shows the behaviour over time of real GDP *per capita* and per person engaged relative to the aggregate of reference, the EU14, from 1980 until 2011. The figure suggests that the period we are analysing can be broken down into two sub-periods according to the behaviour of Portuguese per capita income. As can be seen, in 1980 Portugal recorded a low relative real GDP per capita standing at a little less than 58% of the EU14 average. From 1980 up until 1999 the situation improved with Portugal standing at 69% of the EU average. From 1999 onwards, however, Portugal embarked in a period of stagnation during which its GDP per capita remained largely unchanged relative to the EU average, and in 2011 it stood only at 64.7%. Figures 2 and 3 that contain distribution functions of real GDP per capita levels considering our entire sample of 14 EU member

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom. The EU14 includes all the previous countries except Luxembourg.

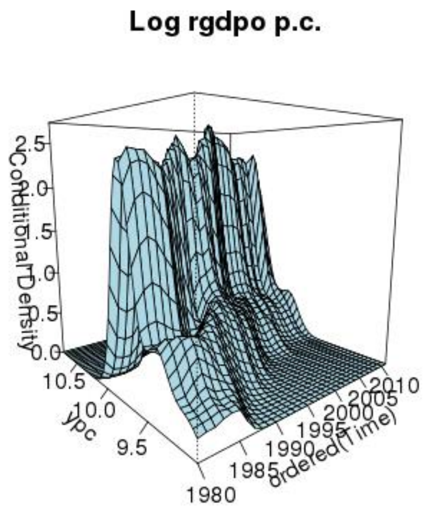
states over the period 1980-2011, show that the lack of convergence experienced by Portugal was not specific to this country since the output distribution maintains its multimodal pattern throughout the period under analysis.

As far as productivity growth and convergence is concerned, a driving force of output growth and convergence (e.g. Hall & Jones (1999); Jones (2002); Jones & Fernald (2014)), Figure1 presents the evolution of labour productivity relative to the EU14 using real GDP per person engaged. It is evident the low relative productivity levels of the Portuguese economy, and the almost absence of convergence over the period under analysis. Relative real GDP per person engaged increased from 59.9% in 1980 to 65.1% in 2011, reaching a maximum of 66% in 2010.

Figure 1: Real GDP *per capita* and per person engaged of Portugal relative to the EU14 (%) 1980-2011

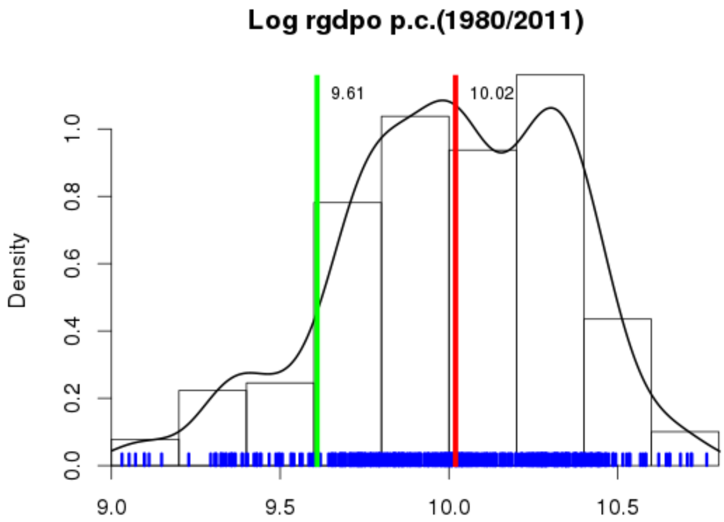
Source: authors' computations based on data from the PWT 8.1

Figure 2: Distribution function of real GDP per capita (logs) for the whole sample over the period 1980-2011



Source: authors' computations based on data from the PWT 8.1

Figure 3: Distribution function of real GDP per capita (in logs) for the whole sample: 1980-2011



Source: authors' computations based on data from the PWT 8.1

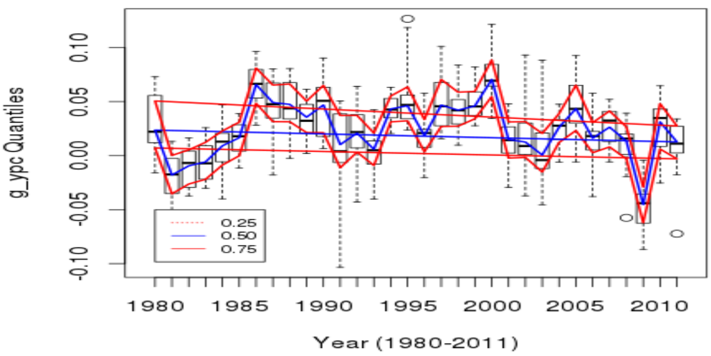
Table 1 contains information on real GDP *per capita* and per person engaged annual average growth rates for the period 1980-2011, detailing the previous information from Figure 1. For the whole period, Portugal grew faster than the EU14 average in terms of both measures considered. However, the Portuguese growth and convergence process in terms of real GDP *per capita* after EU membership was not uniform. In fact it can be divided into two periods: 1980-2000, a convergence period during which growth in the Portuguese economy accelerated and Portugal grew faster than the EU14 average, 3.81% and 2.85%, respectively; and a stagnation and divergence period from 2000 onwards when its growth rate slowed down to figures lower than the reference group average, 0.84% and 1.68%, respectively. Although the real GDP measures growth rates declined from one period to the next in Portugal and the EU14, the change in growth rhythms in Portugal additionally reversed the positive growth differential with the EU14 it had registered before 2000. Figure 4, that contains annual growth rates of real GDP per capita for our entire sample of 14 member states over the period 1980-2011, confirms that the growth slowdown was more intense since the beginning of the 21st century and is common to the growth quantiles considered (0.25-0.75; 0.5).

Table 1: Real GDP *per capita* and per person engaged annual average growth rates (%) 1980-2011

	Real GDP *per capita*		**Real GDP per person engaged**	
	Portugal	**EU14**	**Portugal**	**EU14**
Total Period				
1980-2011	2.75	2.37	2.38	2.10
1980-2010	2.90	2.41	2.46	2.12
10-year periods				
80-90	3.24	2.25	1.76	1.87
90-00	4.38	3.60	3.95	3.27
00-10	1.11	1.38	1.68	1.24
00-11	0.84	1.36	1.53	1.26

Source: authors' computations based on data from the PWT 8.1.

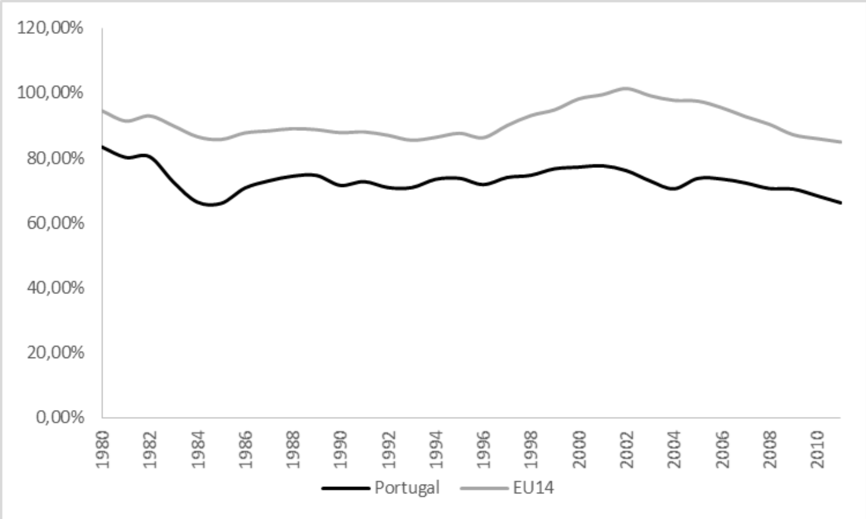
Figure 4: Annual growth rates of real GDP per capita by quantile 1980-2011



Source: authors' computations based on data from the PWT 8.1

Figure 5 contains TFP levels relative to the USA, the world technological leader, over the period 1980-2011, for Portugal and the EU14. In 1980, Portugal was 17 percentage points less productive than the USA, while the EU14 registered a relative TFP of around 95%. Until 1985, however, the situation in Portugal worsened at a fast pace, when it reached a value of 66%. The EU14 followed a similar negative trend recording a value of 85.7% in 1985. From then until around the year 2001 the situation improved, to values of 77.6% and 99.5%, respectively. Since the former year however the situation deteriorated, and in 2011 relative TFP stood at 66.2% in Portugal and 84.9% in the EU14. The potential for technological catch-up both for Portugal but also for the average EU14 country therefore does seem to exist.

Figure 5: TFP relative to the USA (%) 1980-2011



Source: authors' computations based on data from the PWT 8.1

3. Empirical model, methodology and results

We replicate here estimations of empirical growth models that have been carried out in a large number of previous empirical growth studies in order to identify the relevant growth determinants for our sample of fourteen EU member states taking into account parameter heterogeneity. We accomplish this by applying a thresholds methodology. The factors driving growth and convergence included in our empirical model are those highlighted by the theoretical and empirical literature on growth and convergence that developed over recent decades (e.g. Doppelhofer, Miller, & Sala-i-Martin (2004); Durlauf, Johnson, & Temple (2005); Sala-i-Martin (1997); Barreto & Hughes (2004); Crespo-Cuaresma, Foster, & Stehrer (2011)). Our ultimate goal is to derive potential implications of the results obtained for a better understanding of the growth and convergence process of Portugal as a member of the EU.

3.1 Growth regression specification

We estimate what is known in the literature as an *ad hoc* growth regression (e.g.Barro & Lee (1994); Crespo-Cuaresma, Foster, & Stehrer (2011)) that encompasses the neoclassical, technological diffusion, and endogenous growth models explanations. As Crespo-Cuaresma, Foster, & Stehrer (2011) point out this implies that it is not possible to establish a single clear link between the selected variables and a unique growth theory since the same variable can have an important role in different growth theories[2].

The estimated growth regression is given by equation (1):

$$g\_ypc_{it} = \alpha_0 + \beta_1 tfp_{it-1} + X_{it}^{'} \beta_x + \varepsilon_{it} \qquad (1)$$

where the real GDP per capita annual growth rate (g_ypc_{it}) depends on technological catch-up/convergence (*tfp*) and a vector *X* that includes a set of control variables found to be relevant growth determinants in previous theoretical and empirical growth models through factor accumulation and productivity and or efficiency gains[3]; α_0 is the constant term and ε the error term.

The choice of the explanatory variables was determined by theoretical predictions and previous empirical evidence. The expectations concerning growth and real convergence of the Portuguese economy after EU membership are supported by exogenous and technological diffusion growth models predictions (e.g. Solow (1956); Mankiw, Romer, & Weil (1992); Nelson & Phelps (1966); Barro & Sala-i-Martin (1997)). According to exogenous growth models, poorer countries grow faster than initially richer countries through faster factor accumulation since marginal productivities are higher in the former. However, catch-up only occurs if the countries possess the same structural characteristics. In technology diffusion models, real convergence occurs through technological catch-up of the followers, where imitation is less costly than innovation. This assumption implies that the growth rate of technology will be higher in the countries further away from the technological frontier. We consider the USA as the technological leader in order to emphasize the technological convergence mechanism for the sample, so the variable *tfp* corresponds to the level of technology in country *i* relative to the level

[2] For example, exogenous growth models emphasize the importance of human capital for growth through factor accumulation to be used in final goods production (see Mankiw, Romer, & Weil (1992)), while more recent endogenous growth models emphasize its importance for productivity growth (Lucas (1988); Romer (1990); Nelson & Phelps (1966)).

[3] We considered a wide set of potential control variables besides the ones retained in our preferred regressions, such as proxies of human capital, openness, the capital stock, different shares for non-tradables, and price deflators. Details on these variables and associated estimated regressions can be obtained from the authors.

of technology in the USA lagged one period. We expect the estimated coefficient to be negative.

The final vector of control variables X includes the investment rate, measured as GFCF as a percentage of GDP (csh_i) with a predicted positive growth impact; the Gini coefficient of income distribution (GINI) and its change (GINI_R) whose sign can be either positive or negative depending on the growth model under consideration; public consumption as a percentage of GDP (csh_g) with a predicted negative growth impact; the real exchange rate lagged one period (lRER1) with a predictive negative growth impact since an increase in this variable implies less price competitiveness in external markets; and the share of the non-tradables sector in total value added (NT) measured as the total value added share of all sectors except manufacturing. As explained in the introduction we expect that a higher share of non-tradables is detrimental to growth based on its negative impact on productivity. See Mankiw et al. (1992), Barro (1990); Barro (1991), Karras (1997); Sala-i-Martin (1997), Aghion, Caroli, & García-Peñalosa (1999); Barro (2000); Doppelhofer et al. (2004)). Table 2 summarizes the information on the whole set of variables initially considered in our baseline equation (1) and the variables included in our preferred regression and respective sources.

Table 2. Variables included in the preferred regressions

Notation	Description	Source
ypc	GDP per capita, PPP (constant 2005 international $)	PWT 8.1
tfp	TFP of country *i* relative to TFP in the USA	PWT 8.1
csh_i	Gross fixed capital formation as % of GDP	PWT 8.1
csh_g	Public consumption as a % of GDP	PWT 8.1
RER	Real exchange rate	PWT 8.1
GINI	Gini coefficient of income distribution	CANA
NT	Total value added share of all sectors except manufacturing	AMECO

3.2. Empirical Methodology

Our main objective is to identify non-linearities that might explain different growth regimes associated to the behaviour of productivity. For this purpose we implement a two stage econometric strategy: first we test for the existence of panel unit roots using CADF tests following Chang (2002); second, we estimate threshold models following the methodology proposed by Hansen (1999) since, as we will see, the unit tests results reject the presence of a non-stationary panel. The second stage is composed of two distinct phases: the identification of the static panel model that best fits our data and of the thresholds and different regimes associated with those models.

The first generation of panel unit root tests may produce inconsistent results since it ignores the presence of cross-sectional dependence. For this reason we apply the test suggested by Chang (2002) that, according to Hurlin & Mignon (2007), belongs to the second generation group of panel unit root tests). The test suggested by Chang (2002) starts from the well-known equation in the framework of the time series ADF test, with the unit root hypothesis corresponding to $\alpha_i = 1$,so that for any variable *y* we have:

$$y_{i,t} = \alpha_i \cdot y_{i,t-1} + \sum_{k=1}^{p_i} \alpha_{i,k} \cdot \Delta y_{i,t-k} + \epsilon_{i,t} \qquad (2)$$

Chang proposes an instrumental variable (IV) estimation method for this equation and, to solve for the presence of cross-sectional dependency, he uses a non-linear function *F* for the lagged level values of *y*. Finally, for the lagged difference, the augmented part of the ADF equation, he takes as instruments the variable *y* and respective lags in levels. These transformation is named the *instrumental generating function* (IGF). The average IV t-ratio statistic is defined as $S_n = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} Z_i$ for the N cross-sectional units and Z_i is the cross-sectional non-linear IV t-ratio statistic for testing $\alpha_i = 1$ for the i^{th} unit. Chang (2002) test presents several advantages: it is suited for balanced and unbalanced panels; it is asymptotically Normal; it is a standardized sum of individual IV t-ratios; and the non-linear transformations take into account the possibility of contemporaneous dependence among cross section units, (see Chang (2002); Hurlin & Mignon (2007); and Breitung & Pesaran (2005)).

Bruce Hansen, Hansen (1999), implemented an econometric methodology to estimate different economic regimes based on statistical tests using *bootstrap* techniques to account for the existence of different *thresholds*. Let us consider that the static panel model underlying the threshold model is a fixed effects model and suppose that the dependent variable is the growth rate of *y* (*Δly*) and that we have two kind of regressors: those that are independent from the regimes established by the thresholds: the x_k variables (with k=1, …,j) and those that depend on the regime defined by the threshold indicator variable, the z_m variables (with m=1, …, n), so that the respective impact can vary across thresholds. Additionally, consider that the threshold variable (D, in percentage) is not included in the equation as a regressor (but it could well be) and that we have three thresholds identified by ($\sigma_1, \sigma_2, \sigma_3$) and consequently we have four economic regimes. I denotes the indicator function that assumes the value 1 when its condition is respected and 0 otherwise. Under these assumptions the coefficients for the four economic regimes are given by $\beta_{1m}, \beta_{2m}, \beta_{3m}$ and β_{4m}, respectively, as represented in equation (3):

$$\Delta ly_{it} = \alpha_i + \sum_{k=1}^{j} \delta_k x_k + \sum_{m=1}^{n} \beta_{1m} z_m . I(D \leq \sigma_1) + \sum_{m=1}^{n} \beta_{2m} z_m . I(\sigma_1 < D \leq \sigma_2)$$
$$+ \sum_{m=1}^{n} \beta_{3m} z_m . I(\sigma_2 < D \leq \sigma_3) + \sum_{m=1}^{n} \beta_{4m} z_m . I(\sigma_3 < D) + \mu_{it} \quad (3)$$

We investigate the existence of three *thresholds*, at the most, for the whole sample, using Tsung-wu (2015) pdR package for R[4]. In order to test for the existence of the *thresholds* we apply the likelihood ratio test (F-test), where the null hypothesis accounts for the inexistence of *thresholds,* where LR denotes the test statistics and SL the level of significance associated to, respectively, 100, 200 and 300 (bootstrap simulations).

3.3. Results

As a preliminary step we tested the whole set of explanatory variables considered for the presence of unit roots in order to determine which ones could be included in our baseline regression to identify the most appropriate static panel model. The results indicate that all variables are stationary except for the ratio of exports to GDP which was thus not included in the baseline regression. Table 3 presents the results from the Cg(wc), Cg(c) and Cg(c,t) tests proposed by Chang (2002) including only the results for the variables retained in our preferred regression[5]. As we can see in Table 3, for the variables GINI, g_ypc, csh_i, tfp and csh_g we reject the null hypothesis of non-stationarity.

Table 3 - Unit root tests results using Chang (2012)

TESTS / VARS.	Cg(wc)	Cg(c)	Cg(c,t)
lRER	-2.549***	-4.608***	-4.608***
ΔlRER	-15.459***	-15.838***	-15.838***
Gini	-4.035***	-4.942***	-4.942***
g_ypc	-10.127***	-10.8667***	-10.887***
Δg_ypc	-16.115***	-16.447***	-16.447***

4 See also Robert Hansen’s homepage: http://www.ssc.wisc.edu/~bhansen/.
5 The results for the other variables are available from the authors.

tfp	0.619***	-0.364***	-0.364**
Δtfp	-10.777***	-11.570***	-11.570***
csh_i	-4.148***	-6.435***	-6.435***
Δcsh_i	-16.605***	-16.780***	-16.780***
csh_g	-0.200***	-1.510***	-1.510***
Δcsh_g	-12.081***	-12.407***	-12.407***
T1	1.280	-0.996	-0.996***
ΔT1	5.399***	-7.091***	-7.091***

Note: Cg(wc), Ch(c), Cg(c,t) – statistic of Chang (2002) unit root test for the unit root equation without constant, with constant and with constant and trend, respectively with H0 equivalent to the presence of a unit root in all series against the alternative that at least one of the series is stationary. (***), (**) and (*) stand for significant level at 1*, 5% and 10%, respectively, notice also that NT=1-T1.

In the second stage of our analysis we have started by choosing the appropriate static panel model by means of the appropriate statistical tests to then proceed to the implementation of Hansen's threshold model methodology. We first estimated equation (1) with Pooled OLS, fixed effects (FE) and random effects (RE) static panel models. The estimation methods applied can be distinguished according to the respective assumptions in terms of the heterogeneity of the behaviour of the sample under analysis, represented by the constant term and the error term. The Pooled OLS model assumes homogeneity in the constant. In turn, the model with fixed effects assumes heterogeneity in the constant considering that it is time invariant, that is, the constant terms capture different characteristics of the countries that can influence the respective growth behaviour but that remain constant over time. Finally, the random effects model assumes that the constant is a random variable with the individual effects not correlated with the explanatory variables. Thus, since it is assumed that the individual effects exist, but it is not possible to control for their influence on the dependent variable, the error term of this model corresponds to the sum of the residual idiosyncratic component for the panel and the fixed effect intrinsic to the individual. In order to be able to choose the most appropriate estimation method we applied three diagnostic tests: the F test for which H0 corresponds to the validity of Pooled OLS against the alternative hypothesis that FE is valid; the Breusch-Pagan test for which H0 corresponds to the validity of Pooled OLS against the alternative hypothesis that RE is valid; and the Haussmann test for which H0 corresponds to the validity of RE against the alternative hypothesis that FE is valid. We omit these results because the underlying tests are quite standard[6] in the literature. According to the

[6] These results are available upon request from the authors.

results the model selected was the fixed effects model with the variables described in Table 2.

After having selected the fixed effects model we tested for the existence of thresholds. We have chosen the share of the non-tradable sectors from our selected model as the variable indicator of the thresholds (D). This is an *a priori* choice that enables us to test whether or not structural change exerts different influences over real convergence and other growth regressors due to the existence of non-linearities between the indicator and the other explanatory variables. The division of variables in dependent (z) or independent (x) variables relative to our threshold variables was determined according to the results for the LR threshold tests and the minimum squared sum of errors. Based on these selection criteria we selected the thresholds that are associated with two combinations of independent and dependent threshold variables leading in this way to two threshold models, A and B. In model A the threshold independent variables are: the inequality variables, the gini coefficient (GINI) and its deviation (GINI_R). The threshold dependent variables for model A are the real exchange rate (lRER_1), technological convergence (tfp_1), the investment rate (csh_i), public consumption as a percentage of GDP (csh_g), and the value added share of the non-tradables sector (NT). The threshold growth regression for model A is thus given by equation (4):

$$\begin{aligned}\Delta ly_{it} = {} & \beta_i + \beta_1 GINI_{it} + \beta_2 GINI\_R_{it} + \\ & + \beta_{31} tfp_{it-1}.I(D \le \sigma_1) + \beta_{32} tfp_{it-1} I(\sigma_1 < D \le \sigma_2) + \beta_{33} tfp_{it-1}.I(\sigma_2 < D \le \sigma_3) + \beta_{34} tfp_{it-1}.I(\sigma_3 < D) + \\ & + \beta_{41} lRER_{it\_1}.I(D \le \sigma_1) + \beta_{42} lRER_{it\_1}.I(\sigma_1 < D \le \sigma_2) + \beta_{43} lRER_{it\_1}.I(\sigma_2 < D \le \sigma_3) + \beta_{44} lRER_{it\_1}.I(\sigma_3 < D) + \\ & + \beta_{51} csh\_i_{it}.I(D \le \sigma_1) + \beta_{52} csh\_i_{it}.I(\sigma_1 < D \le \sigma_2) + \beta_{53} csh\_i_{it}.I(\sigma_2 < D \le \sigma_3) + \beta_{54} csh\_i_{it}.I(\sigma_3 < D) + \\ & + \beta_{61} csh\_g_{it}.I(D \le \sigma_1) + \beta_{62} csh\_g_{it}.I(\sigma_1 < D \le \sigma_2) + \beta_{63} csh\_g_{it}.I(\sigma_2 < D \le \sigma_3) + \beta_{64} csh\_g_{it}.I(\sigma_3 < D) + \\ & + \beta_{71} NT_{it}.I(D \le \sigma_1) + \beta_{72} NT_{it}.I(\sigma_1 < D \le \sigma_2) + \beta_{73} NT_{it}.I(\sigma_2 < D \le \sigma_3) + \beta_{74} NT_{it}.I(\sigma_3 < D) + \mu_{it} \end{aligned} \quad (4)$$

Model B has four thresholds independent variables: the inequality variables, the gini coefficient (GINI) and its deviation (GINI_R) as in model A, and also the investment share (csh_i) and the public consumption share (csh_g). The threshold growth regression for model A is thus given by equation (5):

$$\begin{aligned}\Delta ly_{it} = {} & \beta_i + \beta_1 GINI_{it} + \beta_2 GINI\_R_{it} + \beta_{31} tfp_{it-1}.I(D \le \sigma_1) + \beta_{32} tfp_{it-1} I(\sigma_1 < D \le \sigma_2) + \beta_{33} tfp_{it-1}.I(\sigma_2 < D \le \sigma_3) + \\ & + \beta_{34} GINI_{it}.I(\sigma_3 < D) + \beta_{41} lRER_{it\_1}.I(D \le \sigma_1) + \beta_{42} lRER_{it\_1}.I(\sigma_1 < D \le \sigma_2) + \beta_{43} lRER_{it\_1}.I(\sigma_2 < D \le \sigma_3) + \\ & + \beta_{44} lRER_{it\_1}.I(\sigma_3 < D) + \beta_5 csh\_i_{it} + \beta_6 csh\_g_{it} + \beta_{71} NT_{it}.I(D \le \sigma_1) + \beta_{72} NT_{it}.I(\sigma_1 < D \le \sigma_2) + \\ & + \beta_{73} NT_{it}.I(\sigma_2 < D \le \sigma_3) + \beta_{74} NT_{it}.I(\sigma_3 < D) + \mu_{it} \end{aligned} \quad (5)$$

In what concerns the sign and statistical significance of the estimated coefficients in the fixed effects model (see tables 4 and 5), the results support the prediction that technological convergence is at work for the EU14 since the sign of tfp_1 is negative and significant (-0.090). The real exchange rate lagged one period (lRER_1) and the GDP share of government consumption (csh_g) also exert a negative influence on economic growth, (-0.051) and (-0.376), respectively, in accordance to the literature. The deterioration of external competitiveness jeopardizes economic growth and a negative impact on growth occurs also through unproductive public expenditures and or through public productive expenditures if the optimal government size is overcome. The value added share of the non-tradable sector (NT) exerts a negative and significant influence on economic growth (-0.290) as expected. The influence of the investment rate on economic growth is positive as expected (0.118). Finally, it should be stressed that inequality impacts positively on growth but inequality deviations are harmful for economic growth. A possible interpretation of the latter results is that, for developed economies such as the EU14, growth is driven by technological improvements, which in turn need higher levels of human capital. Higher levels of inequality in this type of countries are thus the result of the higher human capital inequality needed to drive growth. However, positive deviations of inequality from the equilibrium level harm growth because human capital accumulation becomes harder to accomplish.

Threshold Models A and B have both three thresholds corresponding to the following values of the *non-tradables* value added share: 0.7577; 0.8055; 0.8338 and 0.7577; 0.8338; 0.8524, respectively. The lower value is the same for both models but the second and third thresholds are higher for model B.

We start by analyzing the four regimes associated with model A. First, recall that the inequality variables are threshold independent. The remaining variables are threshold dependent. In what concerns external competitiveness, measured as the RER in logs lagged one period, if RER increases so that external competitiveness deteriorates, this harms growth (negative and statistically significant coefficient at least at the 5% level, except for the first regime). Additionally, this negative impact becomes stronger for the higher threshold regimes indicating that those countries with a higher weight of the non-tradables sector are those that are most affected in terms of reduced growth when external competitiveness deteriorates. Technological convergence is only supported for countries included in the first and second threshold regimes, for whom the estimated coefficient on relative TFP lagged one period (tfp_1) is negative as expected and statistically significant at the 1% level. For countries with a larger non-tradables sector, the estimated coefficient on technological convergence is not statistically significant, in particular for regimes three and four. This might be due to the fact the external competitiveness deterioration associated with the growing importance of the *non-tradables* sector might block or mitigate technology diffusion channels coming from imports and exports. Finally, the government size exerts also a negative influence on economic growth and this negative influence is higher for countries with a smaller *non-tradables* sector.

Except for model B 1st threshold the negative effect of the *non-tradables* sector is significant over economic growth like in model 1 but with a higher magnitude, but for the other regimes its negative influence is not statistically different from zero and is felt indirectly through the deterioration of external competitiveness along the regimes. As for the investment share only the 2nd regime presents an estimate significant and positive.

Table 4 – Threshold Model A estimation results

RHS variables	**Model 1**	**1st Regime NT<=0.7577**	**2nd Regime 0.7577 <NT<=0.8055**	**3rd Regime 0.8055<NT<=0.8338**	**4th Regime 0.8338<NT**
GINI	0.004*** (3.27)	0.003*** (2.71)	0.003*** (2.71)	0.003*** (2.71)	0.003*** (2.71)
GINI_R	-0.005*** (3.72)	-0.003*** (2.85)	-0.003*** (2.85)	-0.003*** (2.85)	-0.003*** (2.85)
lRER_1	-0.051*** (2.60)	0.029 (0.57)	-0.056** (2.05)	-0.077*** (3.23)	-0.077** (2.07)
tfp_1	-0.090*** (4.44)	-0.118*** (-3.25)	-0.170*** (4.00)	-0.079 (1.46)	-0.036 (0.76)
csh_i	0.188*** (3.68)	-0.028 (0.16)	0.462*** (4.25)	0.081 (0.71)	0.118 (1.62)
csh_g	-0.376*** (4.22)	-0.672*** (3.37)	-0.263** (2.25)	-0.199 (-1.23)	0.154 (0.64)
NT	-0.290*** (3.27)	-0.398* (1.74)	-0.093 (0.58)	0.022 (0.09)	-0.167 (0.65)
Model 1	R2=0.21 F(7,427)=16.3*** N=14, T=32, Obs=448				
Thresholds identification	NrT:3; 0.7577; 0.8055; 0.8338 LR: 54.24; BSL=0.00				

Note: Model 1 is the fixed effects model without thresholds. LR likehood ratio statistic, H0 – no thresholds; BSL – bootstrap significance levels of the LR statistics; NrT – number of thresholds and values of the thresholds. (***), (**) and (*) indicate that the coefficients are statistically significant at the 1%, 5% and 10% levels, respectively. Portugal is included in the 3rd and 4th regimes.

Threshold model B takes as *threshold* independent variables inequality, both the Gini coefficient and the Gini deviation, the investment rate and public consumption as a share of GDP. The results regarding the proxies for inequality do not change relative to the ones for model A. The estimated coefficient on the investment rate is never statistically significant and in the case of public consumption as a share of GDP the estimated coefficient is still negative but with a slightly reduced magnitude in line with model 1, the fixed effects model without thresholds. Compared with threshold model A, the estimation results for model B present the same pattern observed for the estimates of external competitiveness in model A. The impact is negative whatever the threshold (except for the first) and the magnitude is increasing with the thresholds. On the other hand, the estimates for technological convergence are negative and statistically significant for all the thresholds except the third, and the magnitude of the estimate increases for countries with a larger *non-tradables* sector.

In what concerns NT the influence is significant and negative for model 1 and for the model B 4rd threshold and the magnitude is much higher in the latter case, but for the 2nd regime the influence is positive. So the growing share of the *non-tradables* sector penalizes, at an increasing rate across thresholds the rate of output growth with a negative estimated coefficient that is fifty times higher (in absolute terms) in the 4th regime relative to the 2nd regime.

Table 5 – Threshold Model B estimation results

RHS variables	**Model 1**	**1st Regime NT<=0.7577**	**2nd Regime 0.7577 <NT<=0.8338**	**3rd Regime 0.8338<NT<=0.8524**	**4th Regime 0.8524<NT**
GINI	0.004*** (3.27)	0.003*** (3.08)	0.003*** (3.08)	0.003*** (3.08)	0.003*** (3.08)
GINI_R	-0.005*** (3.72)	-0.004*** (3.51)	-0.004*** (3.51)	-0.004*** (3.51)	-0.004*** (3.51)
lRER_1	-0.051*** (2.60)	-0.018 (0.48)	-0.056*** (2.74)	-0.098*** (2.92)	0.112*** (3.01)
tfp_1	-0.090*** (4.44)	-0.094*** (3.41)	-0.149*** (4.69)	-0.015 (0.32)	-0.207*** (3.02)
csh_i	0.188*** (3.68)	0.099 (1.60)	0.099 (1.60)	0.099 (1.60)	0.099 (1.60)
csh_g	-0.376*** (4.22)	-0.350*** (3.84)	-0.350*** (3.84)	-0.350*** (3.84)	-0.350*** (3.84)
NT	-0.290*** (3.27)	-0.232 (1.39)	0.016*** (0.14)	-0.062 (0.32)	-0.840*** (3.74)
Model 1	$R2=0.21$ F(7,427)=16.3*** N=14, T=32, Obs=448				
Thresholds identification	NrT=3; 0.7577; 0.8338;0.8524 LR= 42.74; BSL=0.00				

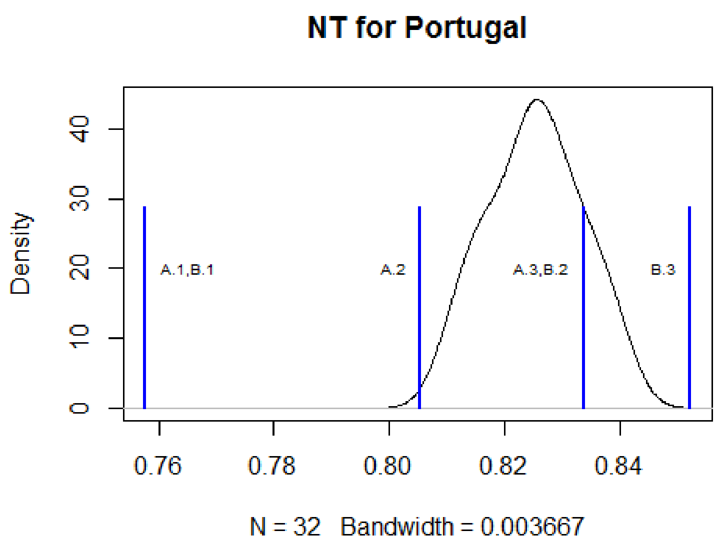
Notes: see the notes to table 8; Portugal is located in the 2nd or 3rd regimes.

3.4. Potential implications for the Portuguese economy

Based on the values of the *non-tradables* sector value added share series for the Portuguese economy and the threshold intervals corresponding to the different regimes identified in threshold models A and B we can identify the threshold regimes where the

Portuguese economy is located over the period under analysis.[7] Figure 6 presents the *non-tradables* sector value added share density function for the Portuguese economy from 1980 to the year 2011.

Figure 6: Non-tradables sector value added share density function for the Portuguese Economy 1980-2011



Source: Authors' own elaboration
Notes: A1, A2, A3 and B1, B2 and B3 denote the 1st, 2nd and 3rd. thresholds values for models A and B, respectively.

According to the information contained in Figure 6 and the results for model A, Portugal is located in the 3rd and 4th regimes of this model, with 26 observations located in the 3rd regime and 6 observations in the 4th regime. In the case of model B, Portugal is located in the 2nd and 3rd regimes, with 26 observations located in the 2nd regime and 6 observations in the 3rd regime . These results indicate that the dominant situations imply the inclusion of Portugal in the 3rd regime of model A and in the 2nd regime of model B.

For both the 3rd regime of model A and the 2nd regime of model B we were unable to identify a direct negative effect of the *non-tradables* sector share on economic growth (see tables 4 and 5): the coefficient estimate is not statistically significant in the 3rd regime of model A and it is even positive in the 2nd regime of model B. However, the value added share the *non-tradables* sector matters for growth and its influence through the real exchange rate impairs growth in both cases. As for the size of government the results are

[7] These results are available from the authors.

mixed: there is no influence in 3rd regime of model A but in the 2nd regime of model B the influence is negative. Additionally, inequality impacts positively on growth but inequality deviations are harmful for economic growth in both threshold regimes of models A and B.

Technology convergence is of special interest for the Portuguese economy and the results for the 3rd regime of model A and the 2nd regime of model B are mixed. In the former, technological convergence does not occur indicating that countries with an important *non-tradables* sector are unable to benefit from the mechanism of technology diffusion. In the case of threshold model B technological convergence occurs in the economies located in the 2nd regime. These two results raise serious concerns when applied to the Portuguese economy since Portugal is integrated in a group of countries that, on average, is closer to the technological frontier than Portugal and so Portugal might be unable to speed up growth by benefitting from its relative technological backwardness because of the high share of the non-tradables sector. Since growth based on innovation activities is still in its infancy in the Portuguese economy, technology diffusion should act as the main driver of long-run growth through productivity improvements.

4. Conclusion

We investigated the existence of thresholds, defined according to the economic importance of the non-tradables sector, for the verification of the convergence hypothesis and the confirmation of the predicted nexus between other potentially important growth determinants and output growth using annual data for fourteen EU countries from 1980 to 2011 and applying the Hansen methodology. We have identified different non-tradables regimes, characterized by different relationships between growth and its determinants based on two different thresholds models, designated as A and B according to the identification of the variables that are independent of the threshold or not. The results suggest that, in the framework of the results for the *threshold* model A, the influence of our threshold variable over growth is essentially felt through external competitiveness. The estimated coefficient on the real exchange rate is not statistically significant when the weight of the non-tradables sector is weaker (less than 75.77% of total value added) and then becomes negative for higher shares of *non-tradables*. In addition, for the 3rd and 4th regimes (non-tradables share higher than 80.55% of total value added) the external competitiveness negative effect increases by 50%. In the framework of the results for threshold model B, we highlight the result concerning the growing share of the *non-tradables* sector that penalizes, at an increasing rate across thresholds the rate of output growth with a negative estimated coefficient that is fifty times higher (in absolute terms) in the 4th regime relative to the 2nd regime. Additionally, a more important non-tradables sector also amplifies the negative impact of a loss of external competitiveness (measured as an increase in the real exchange rate), whose negative effect on growth in the 4th regime is twice that obtained for the 2nd regime.

Based on the previous results for our whole sample, we then derived some potential implications of our findings for understanding the particular situation of the Portuguese economy. From the values of the series on the threshold indicator for the Portuguese economy we concluded that Portugal is located in the 3rd and 4th regimes of threshold model A and in the 2nd and 3rd regimes in the case of threshold model B. In model B, technological convergence does not occur in neither of these regimes indicating that countries with an important *non-tradables* sector are unable to benefit from the mechanism of technology diffusion. However, in the case of threshold model B, technology diffusion might occur but only if we consider that the Portuguese economy is located in the 2nd regime, which is the dominant situation for Portugal over the period under analysis. However, there is still a negative growth influence of the *non-tradables* sector working in this case through external competitiveness that impacts growth negatively in both regimes of model B.

The most pressing policy measures that follow from our results thus involve incentives that allow for a change in the specialization pattern away from the non-tradables sector in order to allow Portugal to fully benefit from the technological convergence mechanism and reduce the negative impact of external competitiveness deterioration.

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