Threshold Conditions' and Regional Convergence in European Agriculture

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Abstract
Convergence across regional economies has spurred one of the most debatable issues in contemporary research in economics. In this paper we seek to address the question of whether, during the period 1995-2004 the NUTS-2 regions of EU-26 exhibited a tendency to converge in terms of agricultural labour productivity. The approach used in this paper is mainly quantitative, with emphasis on empirical results. However, it is hoped that this paper will be able to isolate some interesting views on the issue of regional convergence in Europe. Application of a series of models indicates that the NUTS-3 regions follow a pattern of club-convergence. This pattern is attributed to initial 'threshold conditions' that determine the composition of the convergence-club.

Keywords: Conditional and Club-Convergence, Agriculture, European Union

JEL Classification: Q10, O47, C2

1. Introduction

The publication of the ground breaking work of Baumol (1986) was the spark that ignited an enormous interest to the issue of convergence across national economies. This issue can also be tackled with respect to different areas within a country, that is to say, *regions*. In the context of *regional convergence*, the term 'region' refers either to areas determined according to similarities in geographical characteristics or areas corresponding to, somehow arbitrary, administrative divisions.

As perhaps anticipated, recent years have witnessed a growing number of attempts to assess regional convergence using extensive datasets, such as the regions of the European Union (hereafter EU). This focus of interest is not entirely unexpected given the concern about regional convergence or what the European Commission calls 'regional cohesion'. As Button and Pentecost (1999) point out '[…] if the growth rates of regions deviate significantly this, it is feared, can generate instabilities. Those in the poorer regions feel resentment at the prosperity of others' (p. 2).

Cohesion is one of the primary targets in the context of the EU. Indeed, the question of regional convergence, expressed in terms of economic and social cohesion, is mentioned in the Preamble of the Treaty of Rome and has become one of the major goals of the EU. This is formulated in the Single European Act (title XIV, currently title XVII).

According to article 158 of the Rome Treaty 'reducing disparities between the levels of development of the various regions' is one of the primary objectives of EU development policies (as is evident in European Commission, 1996, 1997 and 1999). According to the third report of the European Commission (2004) on social cohesion, regional convergence or 'regional cohesion' is seen as vital to the success of several other key policy objectives, such as the single market, monetary union, EU competitiveness and enlargement.

However, in the relevant, literature[1], agriculture is a sector that has rarely received any attention[2] and still remains a virtually unexploited mine of research for regional economists. Indeed, while the literature on the agriculture sector, and in particular on its general implications for economic growth and on social change, is relatively extensive, it is only comparatively recently that interest has been shown in the

[1] See for example Button and Pentecost (1995), Neven and Gouyette (1995), Sala-i-Martin (1996), Cardoso (1993), Álvarez-Garcia *et al*. (2004), Ezcurra *et al*. (2005) among others. These refer to the regional economy as a whole while fewer studies conducted with explicit reference to specific sectors, usually the manufacturing (Pascual and Westermann, 2002; Gugler and Pfaffermayr, 2004) or the services sector (e.g. Button and Pentecost, 1993).

[2] Some notable exemptions are the studies by Soares and Ronco (2000), Bivand and Branstad (2003, 2005).

implications of the agriculture sector activity for regional convergence. Thus, this paper aims to shed some further light on that issue. To be more specific, the objective of this paper is to look at the extent to which there has been convergence in terms of regional agricultural labour productivity (hereafter RALP) across the NUTS-2 regions of EU-26.

This effort is organised in the following manner. The context, in which the paper’s main question emerges, is discussed in Section 2. Section 3 offers a detailed discussion of the empirical ways to assess regional convergence while Section 4 presents the econometric results. Finally, Section 5 summarises the arguments and considers the lessons for policy making.

2. Regional Convergence: A Conceptual Framework

A useful starting point is provided by the standard neoclassical model[3], usually identified with Solow’s (1956) model of growth[4]. The reason for the appeal of this model is that this framework not only provides a theoretical background but also a practical and flexible approach to the measurement of convergence in conjunction with an expression for the speed at which convergence takes place[5]. According to this model, economies (countries or regions) converge towards ‘*steady-state*’ equilibrium provided that the growth rate of technology, rate of investment and rate of growth of the labour force are identical across regions. According to the neoclassical model the further a region is ‘below’ its ‘steady-state’, the faster this region should grow. In this framework, it is anticipated that relatively ‘poor’ regions will exhibit a higher rate of growth than relatively ‘rich’ regions. This is described as *absolute convergence*; a process leading eventually to eradication of regional disparities[6].

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[3] Although this model does not include an explicit spatial dimension, nevertheless its structure is flexible enough and allows its application to several contexts. Explicit regional versions of the neoclassical model were developed by Romans (1965), Borts (1960), Borts and Stein (1964), Williamson (1965), etc and more recently by Barro and Sala-i-Martin (1992), Barro *et al*. (1995), King and Rebelo (1990, 1993) and Knight *et al*. (1993).

[4] A similar formulation has been developed independently by Swan (1956) while Meade (1961), Cass (1965) and Koopmans (1965), based on Ramsey (1928), extend Solow’s model with refinements on optimal growth.

[5] It should be noted, however, that the early ‘seeds’ of the convergence question can be found in Kuznets (1955, 1964, 1965), Rostow (1960), Gerschenkron (1962) and Gomulka (1971).

[6] This is the opposite prediction to that of the pure Harrod – Domar model where if the conditions for steady growth are not satisfied the most likely results is a widening of regional growth rates. For a more detailed discussion see Richardson (1973). Similarly, Myrdal (1957) and Kaldor (1970) argue that market forces tend to generate persistent and cumulative differences in per capita incomes between regions.

The interesting question is, of course, which mechanisms are behind this process. Assuming perfect competition, zero transportation costs, full employment, a single homogenous product and constant returns to scale production functions, which are identical across regions, factors are paid the value of their marginal products. Hence, the wage (equal to marginal product of labour) is a direct function of the capital-labour ratio and the marginal product of capital (return to capital) is an inverse function of the capital-labour ratio. The standard neoclassical model can be summarised in the following set of equations (Richardson, 1978):

$$y_i = \alpha_i k_i + (1-\alpha_i) l_i + t_i \tag{1}$$

$$k_i = \frac{s_i}{v_i} \pm \sum_j k_{ji} \tag{2}$$

$$l_i = n_i \pm \sum_j m_{ji} \tag{3}$$

$$k_{ji} = f_k (r_i - r_j) \tag{4}$$

$$m_{ji} = f_l (w_i - w_j) \tag{5}$$

where the subscript $i(j)$ refers to a region, y, k, l and t denote the growth rates in output, capital, labour and technological progress, respectively, α denotes the share of capital, s is the savings/income ratio, v is the capital-output ratio, w is the wage, r denotes the rate of return, m_{ji} measures the net migration of workers from region j to region i and k_{ji} the annual net capital flow from region j to region i.

Equations (2) to (5) merely modify the aggregate neoclassical definitional equation (1) to reflect the important contribution of interregional factor flows to growth. Equations (4) and (5) imply the critical hypothesis that capital and labour flow in response to interregional differentials in factor returns and, to increase the probability of convergence, that marginal factor returns are inversely related intra-regionally.

Within this model, movements of factors between regions are induced by differences in the returns to factors of production. This arises from an overriding emphasis on the assumption of diminishing marginal productivity of capital; an assumption that ensures that regions with a high (low) capital-labour ratio will exhibit low (high) marginal product of capital. Similarly, regions with a high (low) capital-labour ratio offer high (low) wages. One straightforward implication of this assumption is that labour will have an incentive to migrate away from low wage regions towards high wage regions while capital will move in the opposite direction, away from the more prosperous regions where its marginal product is low, towards lagging regions where additional capital investment is more profitable.

These factor flows will boost growth in labour productivity in lagging regions. Thus, capital and labour migrate in response to interregional differences in factor returns and these factor movements will continue until factor returns are equalised in each region.

The overall outcome is, therefore, one in which an interlocking and mutually – reinforcing set of processes (i.e. diminishing returns, labour migration, capital mobility and access to the same level of technology), leading to regional convergence.

In spite of long-established objections[7], the neoclassical model of regional growth continues to be employed by regional economists and to breed dozens of empirical papers[8]. Such results are more likely to occur in a regional context, as it is reasonable to assume that labour and capital can more easily migrate between regions rather than across nations. It might be argued, therefore, that a network of regional economies provides an appropriate 'laboratory' for testing the neoclassical predictions of convergence. Barro and Sala-i-Martin (1995), note that convergence is more likely to occur between regions rather than national economies for precisely this reason.

Moving away from these abstract considerations, so as to get closer to the complications of real situation, account has to be taken of the way by which regional convergence can be measured empirically. According to the neoclassical model convergence is identical to an inverse relation between growth rate and initial level of labour productivity. This will be the starting point for a more elaborated analysis in Section 3.

3. Empirical Measures to Regional Convergence

According to the neoclassical model, absolute convergence requires that regions with relatively low initial labour productivity grow faster that those with relatively high labour productivity, indicating that low-productivity regions catching up with high-productivity regions. Consider a distribution of regional labour productivity, i.e. $\mathbf{Y_{i,0}} = \{Y_{\min,0}, \cdots, Y_{\max,0}\}$ and the associated rates of growth, i.e. $\mathbf{g_{i,T}} = \{g_{\min,T}, \cdots, g_{\max,T}\}$. Absolute convergence occurs when $g_{i,T} \to g_{\min,T}$ as $Y_{i,0} \to Y_{\max,0}$; a condition shown in Figure 1:

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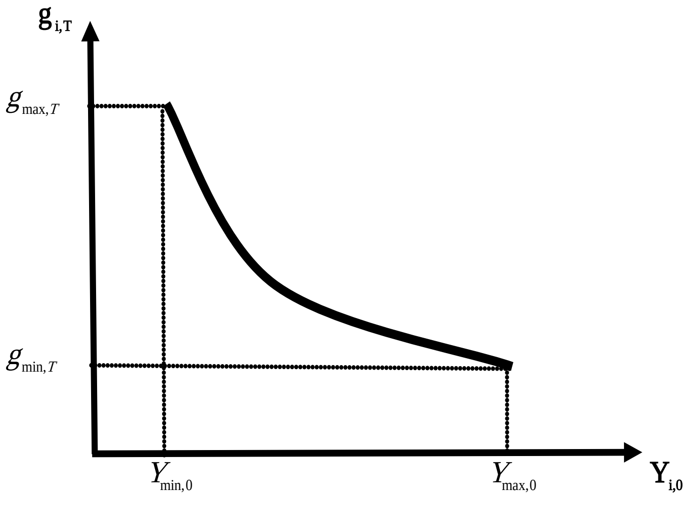
[7] A critical assessment of the neoclassical mechanisms of regional growth is provided by McCombie (1988a, b).

[8] Testing convergence in the context of the neoclassical model is an exercise that a number of authors, including Mankiw *et al*. (1992), Barro and Sala-i-Martin (1992a, 1995), have undertaken.

Figure 1: Absolute Convergence



It is possible to translate this view into a dynamic regression equation, as follows[9]:

$$g_{i,T} = a + by_{i,0} \tag{6}$$

where a is the constant term[10] and $g_{i,T}$ represents the growth rate[11] over a given time period $T = 0, \ldots, t$.

In general, absolute convergence occurs if

$$f'_{g_{i,T} y_{i,0}} < 0 \tag{7}$$

The parameter b, i.e. the partial correlation between $g_{i,T}$ and $y_{i,0}$, indicates whether convergence or divergence prevails across a set of observational units. In particular, absolute convergence requires that $b \in [-1 \quad 0]$ while if $b \in [0 \quad 1]$ then this is an indication that $g_{i,T} \to g_{\max,T}$ as $y_{i,0} \to y_{\max,0}$, i.e. high-productivity regions grow faster than low-productivity regions increasing the gap between these two regional

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[9] This equation is based on the premise that growth is a function of the initial level of labour productivity, $Y_{i,0}$, i.e. $g_{i,T} = f(Y_{i,0})$.

[10] This term, essentially, represents the steady-state growth rate. See Barro and Sala-i-Martin (1995) for an elaboration of this argument.

[11] Assuming that labour productivity ($Y_{i,T}$) grows as $Y_{i,T} = e^{g_{i,T}} Y_{i,0}$, then taking logarithms and solving for $g_{i,T}$ yields: $g_{i,T} = y_{i,t} - y_{i,0}$.

groupings. If $b = 0$, it follows that $g_{i,T} = a$, i.e. regions grow at a given rate which can be considered as an indication of an autonomous growth rate that maintains productivity differences across regions. There is, of course, the case when $b = -1$, which Romer (1996) describes as 'perfect convergence' while $b = 1$ can be conceived as 'perfect divergence'[12].

In this context, it is possible (and necessary given the concerns of this paper) to construct a precise measure of the *speed* at which regions converge. Following Barro and Sala-i-Martin (1995) the convergence coefficient b may be expressed as follows:

$$b = -\left(1 - e^{-\beta T}\right) \qquad (8)$$

It is possible to obtain an expression for the speed at which regions approach the steady-state value of labour productivity or the average rate of convergence over the given time period. Thus,

$$\beta = -\ln(b+1)/T \qquad (9)$$

Given that $b \in [-1 \quad 0]$ signifies convergence, it is expected that $\beta \in [0 \quad 1]$. A value of $\beta = 0$ indicates absence of absolute convergence while if $\beta = 1$, this indicates a rate leading to perfect convergence. Obviously, if $\beta \in [-1 \quad 0]$, then this indicates the speed at which regions diverge. It follows, therefore, that a higher β corresponds to more rapid convergence.

Estimating equation (6) using various data sets, Sala-i-Martin (1996a) concludes that for both regional and national economies: '[…] the estimated speeds of convergence are so surprisingly similar across data sets, that we can use a mnemonic rule: *economies converge at a speed of about two percent per year*.' (p. 1326) [Emphasis in the original]

Nevertheless, absolute or β-convergence is not the only notion of convergence. Absolute convergence occurs when *all* regions converge to the same steady-state. If different regions have different structural characteristics, then convergence is conditional on these parameters, giving rise to different steady states. This outcome is known as *conditional* convergence. The most frequently used test for conditional convergence has been put forward by Barro and Sala-i-Martin (1992), which is based upon the argument that different regional characteristics will lead to different steady-states. The hypothesis of conditional convergence can be thought of as:

$$g_{i,T} = f\left(Y_{i,0}, \mathbf{X_i}\right) \qquad (10)$$

where $\mathbf{X_i}$ represents a vector that includes a set of variables to control for differences in various structural characteristics across regions.

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[12] It is worth mentioning that if estimates of b are available for a set of time periods, let $\tau = \tau_1, \tau_2, \ldots, \tau_m$, then the condition $b_\tau \to -1$ as $\tau \to \tau_m$ signifies a process of moving towards perfect convergence while $b_\tau \to 1$ as $\tau \to \tau_m$ indicates a movement towards perfect divergence.

The general function in equation (10) can be written in a linear form as follows:

$$g_{i,T} = a + by_{i,0} + b_{\mathbf{X}}\mathbf{X_i} \tag{11}$$

Absolute (unconditional) convergence is signalised by $b < 0$ and $b_{\mathbf{X}} = 0$ while conditional convergence depends upon $b < 0$ and $b_{\mathbf{X}} \neq 0$. Having selected appropriate variables to represent the institutional, structural, preference and environmental variables that characterise the steady-state value of labour productivity it remains the case that convergence is said to be occurring when higher initial levels of labour productivity are associated with lower rates of growth, over a given time period, i.e. $f'_{g_{i,T}, y_{i,0}} < 0$. Consider two groups of regions, let $i = k, l$, that differ not only in terms of initial labour productivity but also in terms of their structural characteristics, i.e. $\mathbf{\Delta y_{kl,0}} \equiv y_{k,0} - y_{l,0} \neq 0$ and $\mathbf{\Delta X_{kl}} \equiv \mathbf{X}_k - \mathbf{X}_l \neq 0$. Assume further that $\mathbf{\Delta y_{kl,0}} > 0$ and $\mathbf{\Delta X_{kl}} > 0$.

An implication of this assumption is that a superior (inferior) structure of the regional economy, approximated in terms of a high (low) $\mathbf{X_i}$, is associated with a high (low) level of initial level of labour productivity. Absolute convergence amongst these groups is possible[13] if $g_{k,T} - g_{l,T} < 0$. However, given that $\mathbf{\Delta X_{kl}} > 0$, it is expected that $\beta_k - \beta_l \neq 0$. Furthermore, given that $\mathbf{\Delta y_{kl,0}} > 0$ and $\mathbf{\Delta X_{kl}} > 0$, then $\beta_k \in [-1 \quad 0]$ and $\beta_l \in [0 \quad 1]$, which implies that

$$\beta_k - \beta_l > 0 \tag{12}$$

According to equation (12) convergence is faster among regions with similar structural characteristics. A fast process of convergence is feasible only among regions with similar structural characteristics; a process that is accelerated as regions become more similar in their structural characteristics. This condition can be stated as follows:

$$(\mathbf{\Delta X_{kl}})_t \to 0 \text{ as } t \to \infty \tag{13}$$

This leads to an alternative notion of convergence, that of *club-convergence*. Although club convergence was introduced by Baumol in his seminal paper (1986), nevertheless this notion is acknowledged as being a more probable outcome across regional economies[14]. Although different authors propose various methods of detecting

[13] Divergence amongst such regional groupings is, of course, a strong possibility since an inferior structure might lead to a lower growth path, which sustains initial differences in labour productivity. This possibility is explored in Alexiadis and Tomkins (2006).

[14] See for example Canova (2004), Corrado *et al*. (2005), Fischer and Stirböck (2006), among others.

convergence-clubs[15], a test used extensively in empirical applications is provided by Baumol and Wolff (1988). According to Baumol and Wolff (1988), the standard test for absolute convergence is augmented by the introduction of a quadratic term to allow the possibilities of non-linearities in the convergence pattern. Thus,

$$g_{i,T} = a + b_1 y_{i,0} + b_2 y_{i,0}^2 \tag{14}$$

The expression in equation (14) has several important implications. The quadratic function is illustrated in Figure 2 and is drawn on the assumption that $b_1 > 0$ and $b_2 < 0$, which are the conditions required for the existence of a convergence-club. Growth reaches a maximum (g^*) when

$$f'_{g_{i,T} y_{i,0}} = 0 \tag{15}$$

or more specifically

$$b_1 + 2b_2 (y_{i,0}) = 0$$

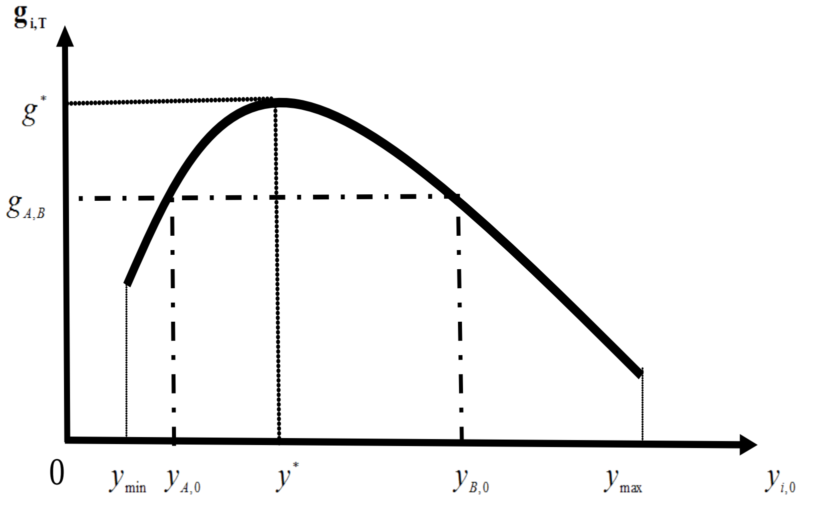
(16)

Solving equation (16) for $y_{i,0}$ yields a level of initial labour productivity which corresponds to maximum growth. Thus,

$$y^* = -b_1 / 2b_2 \tag{17}$$

[15] See for example Chatterji (1992), Chatterji and Dewhurst (1994), Durlauf and Johnson (1995), Alexiadis and Tomkins (2004) among others.

Figure 2: Club Convergence



It is this turning point which is used to identify members of the convergence-club. For regions with $y^* - y_{i,0} < 0$, growth is inversely related to the initial level of labour productivity:

$$f'_{g_{i,T} y_{i,0}} < 0 \quad \forall i \in [y^*, \ldots, y_{\max,0}] \tag{18}$$

It may be argued that these regions constitute a 'convergence club' by exhibiting absolute or β-convergence. The opposite holds for regions with $y^* - y_{i,0} > 0$. In this case, provided that $b_1 > 0$ of course, growth is positively related to initial labour productivity:

$$f'_{g_{i,T} y_{i,0}} > 0 \quad \forall i \in [y_{\min,0}, \ldots, y^*] \tag{19}$$

The following example is illustrative. Consider two regions, A and B, each with an identical growth rate ($g_{A,T} = g_{B,T}$) with $y_{A,0} - y^* < 0$ and $y_{B,0} - y^* > 0$, implying that $y_{A,0} - y_{B,0} < 0$. If these two regions continue to grow at the same rate, i.e. if $(g_{A,T} - g_{B,T})_\tau = 0$, then $(y_A - y_B)_\tau < 0$ as $\tau \to \infty$, which indicates that region A is unable to close the gap with region B. Convergence between these two regions is feasible only if region A grows faster than region B, i.e. if $(g_{A,T} - g_{B,T})_\tau > 0$, as $\tau \to \infty$.

In this context it is reasonable to assume that the rates of convergence will differ between the regions included in a convergence-club and the regions excluded from the club, i.e. $b_c - b_{nc} \neq 0$ and $\beta_c - \beta_{nc} \neq 0$. Given that $f'_{g_{i,T} y_{i,0}} < 0$ implies β-convergence, then it follows that the regions in the club exhibit a rate of convergence faster compare to the regions excluded from the club, i.e. $b_c - b_{nc} < 0$, which implies that

$$\beta_c - \beta_{nc} > 0 \qquad (20)$$

A relatively high (low) level of initial labour productivity, defined as $y^* - y_{i,0} < 0$ ($y^* - y_{i,0} > 0$), ensures β-convergence (divergence). Once this knowledge is introduced, it comes as no surprise that the initial conditions, as expressed in terms of labour productivity, determine the composition of the convergence-club. Stated in alternative terms, a convergence-club is unlikely to consist of regions with markedly different levels of labour productivity[16]; all must lie within a range that is equal to, or above, the *threshold* value y^*:

$$y_{i,0} - y^* \geq 0 \qquad (21)$$

A pattern of club-convergence can be attributed not only to conditions related to the initial level of labour productivity, that is to say initial economic conditions, but also to certain structural characteristics. These characteristics can be conceived as '*threshold conditions*' that determine the composition of a convergence-club.

It is possible to augment the test for club-convergence by introducing a vector that includes a set of variables to control for differences in various structural characteristics across regions, let $\mathbf{X}_{i,0}$. Thus, equation (14) can be written as follows:

$$g_{i,T} = a + b_1 y_{i,0} + b_2 y_{i,0}^2 + b_3 \mathbf{X}_{i,0} \qquad (22)$$

Having outlined the main features of the absolute, conditional and club-convergence models, this paper will proceed to evaluate the pattern of regional convergence across the NUTS-2 regions of the EU-26.

4. EU-26 Regions: Testing for Convergence in RALP

The empirical part of this paper is focused upon agricultural regional productivity in European Union. Agricultural productivity can be approximated in various ways. In this paper we exploit data on Gross Value Added (hereafter GVA) per worker[17] since this

[16] This is consistent with Baumol's description of the convergence-club as 'a very exclusive organisation' (p. 1079).

[17] More formally, this is defined as $y_{i,t} = \frac{Y_{i,t}}{L_{i,t}}$, where $Y_{i,t}$ is agricultural GVA and $L_{i,t}$ is average work units in agriculture, hunting, forestry and fishing in each region i during a given time period, t, usually a fiscal year.

measure is a major component of differences in the economic performance of regions and a direct outcome of the various factors that determine regional 'competitiveness' (Martin, 2001).

The regional groupings used in this paper are those delineated by EUROSTAT and refer to 258 NUTS-2 regions. The EU uses NUTS-2 regions (Nomenclature Units for Territorial Statistics) as 'targets' for convergence and defined as the 'geographical level at which the persistence or disappearance of unacceptable inequalities should be measured' (Boldrin and Canova, 2001, p. 212). Despite considerable objections for the use of NUTS-2 regions as the appropriate level at which convergence should be measured, the NUTS-2 regions are sufficient small to capture sub-national variations (Fischer and Stirböck, 2006)[18].

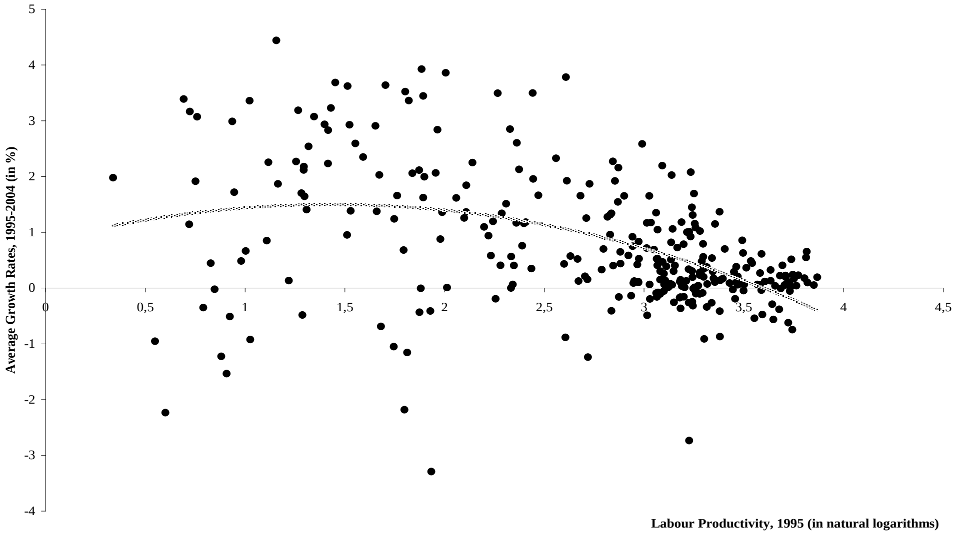
The time period extends from 1995 to 2004, a time period that might be considered as somehow short. However, Islam (1995) and Durlauf and Quah (1999) point out that convergence-regressions, such as equation (4), are valid for shorter time periods as well, since they are based on an approximation around the 'steady-state' and supposed to capture the dynamics toward the 'steady-state'.

In terms of RALP, about 46% of the EU-26 regions are below the European average with the majority of them located in Southern Mediterranean and Eastern Europe. Northern regions, especially in the UK and the Netherlands display a level of labour productivity two times higher than regions located in Southern and Eastern countries, which are generally characterised by relatively high shares of labour force employed in agriculture.

Nevertheless, the potential for absolute convergence is indicated in Figure 3, which shows a scatterplot of the average annual growth rate against the initial level of labour productivity.

[18] Several formal models have been developed to tackle with problems associated with spatial units. See Alexiadis and Tsagdis (2006) for a review of these models.

Figure 3: β-convergence in RALP, EU-26 regions, 1995-2004



Casual inspection of the data in Figure 3 provides some indication of an inverse relationship between the average annual growth rate and initial level of RALP. Nevertheless, this property does not appear to be uniform across all the NUTS-2 regions of the EU-26. As Figure 3 makes visible, this property seems to be constrained in a certain group of regions with a relatively high initial level of RALP. Several regions, on the other hand, appear to diverge, in the sense that relatively low initial levels of labour productivity are associated with relatively low rates of growth and vice versa. The trend curve in Figure 3 is similar to that in Figure 2, implying that club convergence might be a strong possibility across the regions of the Europe.

The presence of absolute convergence (or divergence), however, cannot be confirmed by visual inspection alone. A formal test for absolute convergence can be expressed in terms of the following regression equation:

$$g_{i,T} = a + b_1 y_{i,t_0} + \varepsilon_i \qquad (23)$$

where $t_0 = 1995$ and $T = 10$.

In equation (23) ε_i is the random error term, assumed to have zero mean and variance, and to be independent and identically distributed over time $\left(E[\varepsilon_t \varepsilon_t'] = \sigma_t^2 \mathbf{I}\right)$ and across the observational units and uncorrelated with y_{i,t_0}.

Equation (23) is estimated using Ordinary Least Squares (hereafter OLS), for the NUTS-2 regions of EU-26 while separate regressions are carried out for the regional divisions of EU-12, EU-15 and the new and ascending countries[19].

A similar approach is applied for the empirical assessment of regional conditional convergence. In this case, of particular importance is the choice of appropriate variables that approximate structural differences in the agricultural sector of the European regions. Subsequent analysis deploys two variables. The first variable attempts to approximate the impact of the size of holdings in the growth of RALP while the second attempts to capture the effects of the degree of 'entrepreneurial' agriculture. More specifically, the first variable is constructed using the percentage of holdings with over 50 hectares of agricultural land in each region (S_{i,t_0}) and the second the percentage of non-family labour force in agriculture in each region (NF_{i,t_0}).

A way to assess the impact of the *combined* effect of these two conditional variables is to include S_{i,t_0} and NF_{i,t_0} as explanatory variables in equation (23). More formally, the 'full' model of conditional convergence in RALP can be expressed as follows:

$$g_{i,T} = a + b_1 y_{i,t_0} + b_2 S_{i,t_0} + b_3 NF_{i,t_0} + \varepsilon_i \qquad (24)$$

In equation (24), the conditional variables are expressed in initial values. There are two primary reasons for such an approach. The first is related to the fact that the current conditions of agricultural structure in a region, normally, have future or long-run effects on regional growth. Stated in alternative terms, future growth is affected by current efforts to enhance the structure of agriculture. Therefore, including such variable at the initial time captures these long-run effects on regional growth over a specific time period. A second reason for using initial values is that it tests the hypothesis that initial conditions 'lock' regions into a high or low position, for example, high (low) levels of S_{i,t_0} or NF_{i,t_0} might lead to high (low) rates of growth. Before considering the regression results, it is important to note that, from an econometric point of view, inclusion of conditional variables measured at the initial time helps to avoid the problem of endogeneity.

Following the discussion in section 3, the empirical test for club-convergence is specified as follows:

$$g_{i,T} = a + b_1 y_{i,t_0} + b_2 y_{i,t_0}^2 + \varepsilon_i \qquad (25)$$

A pattern of club-convergence can be attributed not only to conditions related to the initial level of labour productivity, that is to say initial economic conditions, but also to certain structural characteristics. These structural characteristics are approximated in

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[19] These are Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia, Slovak Republic and Bulgaria.

terms of the conditional variables S_{i,t_0} and NF_{i,t_0}. Introducing these variables in a test for club-convergence transforms equation (25) as follows:

$$g_{i,T} = a + b_1 y_{i,t_0} + b_2 y_{i,t_0}^2 + b_3 S_{i,t_0} + b_4 NF_{i,t_0} + \varepsilon_i \quad (26)$$

Despite its simplicity, this model aims to highlight the importance of initial conditions regarding spatial technology in the process of regional growth and convergence. While this approach has the virtues of rigour and precision but it easily leads to a neglect of spatial factors. In other words, equations (23), (24), (25) and (26) treat regions as ‘closed’ economies.

It is possible to overcome this, clearly unrealistic, assumption by introducing in these equations the effects of spatial interaction. Indeed, in the light of recent literature it may be argued that any empirical test for regional convergence is misspecified if the spatial dimension is ignored (Rey and Montouri, 1999; Lall and Yilmaz, 2001), the presumption being that the extent of regional interactions, such as technology spillovers, are significantly dependent upon the location of regions relative to each other.

According to Rey and Montouri (1999) the potential for spatial interaction can be incorporated within convergence analysis by means of the spatial-error model. In this model, the key feature is that spatial interaction occurs through the error term of equation (22), and hence the usual assumption of independent error terms is not sustainable. Following Rey and Montouri (1999), the error term incorporating spatial dependence is shown as follows:

$$\varepsilon_i = \zeta \mathbf{W} \varepsilon_i + u_i = \left(\mathbf{I} - \zeta \mathbf{W}\right)^{-1} u_i \quad (27)$$

where ζ is the spatial error coefficient and u_i is a $n \times 1$ vector for the new independent error-term with $u \sim N\left(0, \sigma^2 \mathbf{I}\right)$. Inter-regional spatial dependence is generated by means of the $n \times n$ spatial-weights matrix ($\mathbf{W}$) the elements of which (w) may be devised in various ways. For example, a common practice is to allow these weights to take the value of 1 if a region is contiguous to another and 0 otherwise (a first order continuity matrix). Alternatively, the spatial weights may be continuous variables (Cliff and Ord, 1981), constructed so as to produce declining weights as distance between regions increases. Thus:

$$w_{ij} = \frac{1/d_{ij}}{\sum_j 1/d_{ij}} \quad (28)$$

where d_{ij} denotes the distance between two regions i and j, as measured by the distance between the major urban centres where the majority of economic activities are located. The denominator is the sum of the (inverse) distances from all regions surrounding region i. This approach is used in the empirical analysis in section IV. Taking into account the effects of spatial interaction, equations (23), (24), (25) and (26) are transformed as follows:

$$g_i = a + b_1 y_{i,t_0} + (\mathbf{I} - \zeta\mathbf{W})^{-1} u_i \qquad (29)$$

$$g_i = a + b_1 y_{i,0} + b_2 S_{i,t_0} + b_3 NF_{i,t_0} + (\mathbf{I} - \zeta\mathbf{W})^{-1} u_i \qquad (30)$$

$$g_i = a + b_1 y_{i,t_0} + b_2 y_{i,t_0}^2 + (\mathbf{I} - \zeta\mathbf{W})^{-1} u_i \qquad (31)$$

$$g_i = a + b_1 y_{i,t_0} + b_2 y_{i,t_0}^2 + b_3 S_{i,t_0} + b_4 NF_{i,t_0} + (\mathbf{I} - \zeta\mathbf{W})^{-1} u_i \qquad (32)$$

It should be noted that contemporary empirical literature on regional convergence is based on models that combine conditional variables with spatial terms (that is to say ‘spatial conditional convergence’ models) focused mainly on the EU regions (e.g. Maurseth, 2001; Lopez-Bazo *et al*., 2004) with fewer studies referring to individual countries (e.g. Funke and Niebuhr, 2005). Equations (30) and (32) are consistent with this literature and can be applied to the regional context of any individual country, provided that the required data are available.

At this stage, however, it is important to comment on the estimation methods for these spatial econometric models. Thus, estimation of the spatial error model is carried out by the maximum likelihood method, as OLS may result in problems of bias. To be more specific, the presence of spatial interaction in the error term leads to the following non-spherical covariance matrix (Rey and Montouri, 1999, p. 149):

$$E[\varepsilon_t \varepsilon_t'] = (\mathbf{I} - \boldsymbol{\zeta}\mathbf{W})^{-1} \sigma^2 \mathbf{I} (\mathbf{I} - \boldsymbol{\zeta}\mathbf{W})^{-1'} \qquad (33)$$

The presence of non-spherical errors results in unbiased OLS estimators but biased estimations of a parameter’s variance. Bernat (1996) notes that the presence of spatial autocorrelation invalidates the standard tests in OLS regressions in a way similar to heteroscedasticity[20]. Thus, all inferences based on that model are invalid. Hence, the recommended estimation method is through maximum likelihood (Anselin, 1988; Anselin *et al*., 1996; Anselin and Florax, 1995a).

The results from estimating equations (23), (24), (29) and (30) are set out in Table 1 and show that the convergence coefficient (b_1) to be negative and statistically significant at the 95% level in the case of the NUTS-2 regions of the EU-26. The presence of absolute convergence in the form of a negative relationship between the rate of growth and initial level of labour productivity is suggested by this evidence, and the NUTS-2 regions of the EU-26 have, on average, shown a tendency to converge over the period 1995-2004, albeit at a relatively slow rate; 0.54% per annum.

Given this slow rate of convergence, it would take a very long time for all the EU-26 regions to reach a common level of labour productivity, as predicted by the

[20] Heteroscedasticity occurs when the disturbance variance is not constant and arises due to measurement problems, inadequate specification or omitted variables. See also Stewart and Gill (1998) and Gujarati (1995).

absolute convergence model. As argued in section 3, a low rate of absolute convergence must undoubtedly be sought to differences in structural characteristics across regions.

Earlier in this section, two variables were introduced to approximate structural differences in the agricultural sector of the NUTS-2 regions of Europe. It is quite interesting that in all cases the introduction of conditional variables has a positive impact on regional convergence. That is to say that the estimated rate of convergence is higher compared to that obtained using the absolute convergence model. Thus, the results lend clear support to a perspective that emphasises the importance of structural characteristics in the process of regional convergence across Europe. In all specifications the estimation results yield $b_2 > 0$ indicating that the size of the holdings has a positive impact on the growth of RALP.

Broadly speaking, this it is anticipated, since regions with high initial levels of holdings size are normally associated with high levels of growth and vice versa. However, it is not automatically the case that this condition promotes convergence. In other words, if low productivity regions have a high initial level of holdings size, then this will have positive impacts on convergence, by enhancing their growth rates. On the other hand, if such regions have a low initial size of holdings, then no significant impacts on growth are anticipated and, hence, it may be difficult to converge with high productivity regions. The latter case is the more likely, which might explain the relatively low rate of convergence across the EU-26 regions.

The estimated value of b_2 for the EU-26 regions, suggests that a 1% increase in the percentage of holdings with agricultural area over 50 hectares, or in the size of holdings in general terms, induces an increase in a region's growth in the range between 1.5% and 2.4%, ceteris paribus. In all cases the econometric results show that $b_3 < 0$, which indicates that regions with a high initial NF_{i,t_0}, normally high-productivity regions, exhibit relatively low rates of growth; a condition which can be conceived as a source of promoting convergence. Indeed, the rate of convergence increases almost to 1% after introducing the conditioning variables.

This rate increases with the introduction of the spatial-error term. To be more specific, the spatial specification of the absolute convergence model yields a rate of convergence about 8% while the spatial conditional model indicates that the NUTS-2 regions of the EU converge at an average rate equal to 1.2% per annum.

Turning to the alternative hypothesis of club-convergence, the results of estimating the various specifications of club-convergence are presented in Table 2. The obtained results are consistent with the presence of a sub-group of regions demonstrating convergence properties in that the signs of the coefficients are as expected; $b_1 > 0$ and $b_2 < 0$, and both statistically significant.

The *Akaike* and the *Schwartz-Bayesian* (hereafter AIC and SBC, respectively) information criteria have been used for the model selection. As a rule of thumb, the best fitting model is the one that yields the minimum values for the AIC or the SBC criterion, calculated as

$$AIC = -2L + 2K \quad (34)$$

and

$$SBC = -2L + K \ln(T) \quad (35)$$

where L is the value of the log likelihood function, T is the number of observations and K stands for the number of parameters estimated.

The SBC test has superior properties and is asymptotically consistent, whereas the AIC is biased towards selecting an overparameterized model (Enders, 1995). According to the AIC criterion, equation (32) is superior from the other specifications, since the values of this criterion are minimized.

This is also confirmed by the superior SBC criterion, which indicates that in all cases equation (32), i.e. a specification that combines initial economic and 'threshold structural' conditions, explains the process of convergence in RALP to a more satisfactory degree.

An important conclusion to emerge from the discussion is that the results lend clear support to a club-convergence perspective in agriculture across the NUTS-2 regions of Europe. Equally important is the fact that a pattern of club-convergence due to 'threshold conditions' is more obvious in an explicitly spatial model.

Therefore, the next important step forward is to examine the composition of the convergence-club in more detail. The members of the convergence-club can be identified by calculating the threshold point (y^*) at which $f'_{g_{i,T} y_{i,0}} < 0$.

According to the estimated value of y^* (about 9,000 Euros) this club includes 198 regions. It might be argued that these regions have reached a situation of steady-state equilibrium. These regions grow with less than 0.5% per annum while the average growth rate of all regions is 0.6%. On the other hand, the excluded regions exhibit a rate of growth about 1% annually.

The set of non-converging regions exhibits a rate of growth about 1% annually while their average level of initial productivity, in 1995, amounts to 5,300 Euros, less than the average level of productivity in 1995 of all EU regions (17,000 Euros) and that of the convergence-club (23,000 Euros). Hence, it is confirmed that the convergence-club includes relatively 'rich regions' (above-the-average) that exhibit relatively low rates of growth (below-the-average) while a reverse situation appears for the regions excluded from the club, i.e. 'poor' regions with initial level of productivity below the average and exhibiting a relatively higher growth rate (above-the-average).

The convergence-club includes, almost exclusively, regions from EU-12 countries. Fewer regions are included from EU-15 countries (about 7% of the convergence club) whilst only 3% of the club refers to regions from new and ascending countries-members, such as Slovakia and Czech Republic. The set of the non-converging regions includes, to a great extend (65% of the set), regions from new member-sates (e.g. Poland, Latvia, Lithuania, Bulgaria) and some regions from EU-12 Mediterranean countries (Greece, Spain and Portugal). The diverging regions are all located around the ‘edge’ of the EU, as shown in Figure 4.

Table 1: Absolute and Conditional Convergence in RALP

Depended Variable: g_{iT}	Equation (23)	Equation (29)	Equation (24)	Equation (30)
a	0.3016* (5.018)	0.3652* (6.545)	0.4420* (5.898)	0.5105* (7.384)
b_1	-0.0527* (-2.569)	-0.0752* (-3.944)	-0.0085* (-3.389)	-0.1147* (-4.922)
b_2			0.0154 (1.288)	0.0226* (2.051)
b_3			-0.0444* (-2.298)	-0.0416* (-2.355)
ζ		0.5731* (7.0201)		0.5852* (7.107)
Implied β	0.0054	0.0078	0.0088	0.0121
LIK	0.7553	23.5188	5.6586	29.1155
AIC	2.4893	-41.0377	-3.3173	-48.2311
SBC	9.5952	-30.3789	10.8945	-30.4663

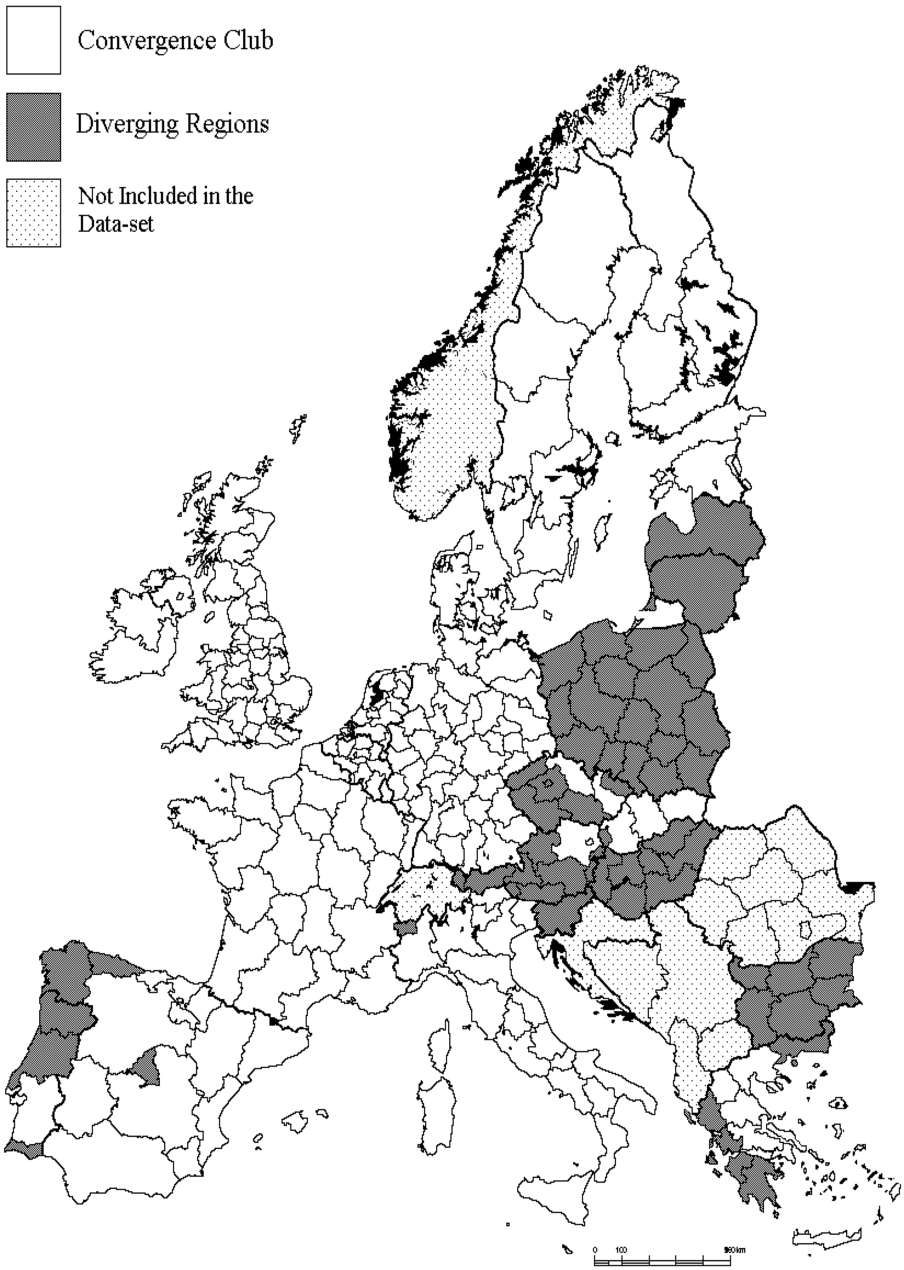
<u>Notes</u>: Figures in brackets are t-ratios. * indicates statistical significance at 95% level of confidence. AIC and SBC denote the *Akaike* and the *Schwartz-Bayesian* information criteria

Table 2: Club Convergence in RALP

Depended Variable: g_{iT}	Equation (25)	Equation (31)	Equation (26)	Equation (32)
a	-0.2997* (-2.341)	-0.2556* (-2.135)	-0.1602 (-1.144)	-0.1005 (-0.770)
b_1	0.5115* (4.682)	0.4977* (4.878)	0.4531* (4.113)	0.4301* (4.193)
b_2	-0.1163* (-5.251)	-0.1171* (-5.659)	-0.1109* (-5.005)	-0.1109* (-5.379)
b_3			0.0182 (1.588)	0.0230* (2.147)
b_4			-0.0304 (-1.626)	-0.0320 (1.844)
ζ		0.5281* (6.158)		0.5342* (6.294)
Implied y^*	2.1982	2.1249	2.0422	1.9377
LIK	13.9852	31.9193	17.8318	36.6534
AIC	-21.9704	-55.8386	-27.6637	-61.3068
SBC	-11.3115	-41.6267	-13.4519	-39.9890

<u>Notes</u>: Figures in brackets are t-ratios. * indicates statistical significance at 95% level of confidence. AIC and SBC denote the *Akaike* and the *Schwartz-Bayesian* information criteria

Figure 4: Club Convergence in European Agriculture



5. Conclusions and Policy Implications

In the case of the EU, and although an increasing number of empirical studies have paid attention to issues of economic convergence, the empirical assessment of agricultural productivity convergence has not so far received due attention. To remedy this, convergence in agricultural labour productivity is tested empirically using data for 258 NUTS-2 regions of the EU-26 over the period 1995-2004. What is clarified by the econometric results is that the property of convergence is restricted to an exclusive convergence-club.

From a policy perspective, this evidence is useful at two levels. Firstly, given a general focus at national and EU level upon support for lagging regions and the promotion of convergence, the identification of a convergence-club clearly assists in drawing a dividing line between regions which might be deemed eligible for assistance and those which are not. Regional assistance should, to a substantial extent, be diverted towards those regions that do not belong to the convergence-club. Secondly, the greater part of effort and assistance should be directed to improve the underlying conditions of lagging regions and thereby generate an environment that more closely resembles the combination of characteristics found in the convergence-club. Moreover, any tendencies towards regional convergence are affected by certain structural characteristics prevailing in the agricultural sector. The econometric analysis in this paper has identified two structural characteristics that have positive effects on the process of regional convergence. Obviously, more characteristics can be identified by introducing more conditional variables in the model, such as product-mix, adoption of new techniques and innovations in agriculture and so forth. These findings suggest that, until much more detailed investigation of the specific impacts on particular types of regions is undertaken, convergence in RALP will remain a contentious issue.

While the empirical results are serious in their own right, they must be placed in perspective. There is a little pretence that the forgoing analysis provides an exhaustive account of all factors that affect the process of regional convergence in terms of agriculture productivity. For example, additional complications arise from the multidimensional nature of the institutional and political structure of the CAP; a factor that, indubitably, has important spatial implications. Considerably more research, therefore, is required before the issue of regional convergence in agricultural productivity can be discussed with confidence. What then is the purpose of this paper? Perhaps the main purpose of this paper should be to provoke interest in further work on the underlying mechanisms of convergence in regional agricultural labour productivity.

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