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The Role of Regional Innovation Systems (RIS) in Translating R&D Investments into Economic and Employment Growth

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Abstract

The emergence of the so-called "European Paradox" shows that increasing Governmental R&D Investment is far from being a 'panacea' for stagnant growth. It is worth noting that Governmental R&D Investment does not have a statistically significant impact on employment, indicating the need to assess the trade-offs of policies that could lead to significant increases in government expenditure. Surprisingly, Governmental R&D Employment does not contribute to 'mass-market' employment, despite its quite important role in reducing Youth-Unemployment. Despite the negative side-effects of Governmental R&D Employment on both GVA and GDP, University R&D Employment appears to have a quite important role in reducing Unemployment, especially Youth-Unemployment, while it also does not have a downside in terms of economic growth. Technological Capacity enhancement is the most effective instrument for reducing Unemployment and is a policy without any downside regarding sustainable economic development.

Keywords: innovation management; regional innovation systems; economic policy; r&d policy.

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1.Introduction

Over the last three decades, European regions have experienced considerable industrial restructuring towards a more decentralised and flexible industry structure in order to harness the forces of technology and globalization (Audretsch, et. al., 2000), shifting from traditional manufacturing towards new and more complex industries, such as Information and Communications Technologies (ICT), Biotechnology and Big-Pharma (Aldridge and Audretsch, 2011; Audretsch, D., Grilo, I., Thurik, A., 2012). In this process, Regional Innovation Systems (RIS) – "a set of networks between public and private agents that interact and give mutual feedback in a specific territory by taking advantage of their own infrastructure to adapt, generate and extend knowledge and innovation" (Lau and Lo, 2015: 100) – thus seen as spatially organized systems, in place at the regional level, that may increase and leverage entrepreneurial knowledge and innovation for increased regional growth, employment, and generally increasing regional well-being (see Stam, 2007, for a discussion of locational behaviour) – play an important role for two main reasons. The first is that the use of new technologies such as software, e-commerce and Enterprise Resource Planning (ERP) has reduced the importance of scale economies in many sectors (Audretsch, D., Grilo, I., Thurik, A., 2012; Piore and Sabel, 1984). The role of new business formation in technological change is enhanced by reductions in economies of scale and by increasing global economic uncertainty (Audretsch, et. al., 2000; Audretsch and Thurik, 2001). Small and Medium Enterprises (SME) rely on their regional economies to cope with this volatile market environment through access to specialised knowledge sources and technology transfer networks, enabling them to develop innovative, high value-added and marketable products at competitive prices (Audretsch and Lehmann, 2005; Gilbert, B., McDougall, P., Audretsch, D., 2008; Lindic, J., Bavdaz, M., Kovacic, H., 2012). The second reason concerns the increasing pace of innovation associated with the shortening of technology and product life-cycles (Adner and Levinthal, 2001; Auerswald, 2010). This development appears to favour new entrants, in particular, the industry spin-offs and knowledge-based start-ups that have greater flexibility than established corporations in coping with decreasing time-to-market and other disruptive changes (Pe'er and Vertinsky, 2008). In light of the above considerations, the main purpose of this study is to fill in the gap between R&D efforts and the attainment of measurable, sustained and sustainable outcomes in terms of economic and employment growth. Based on the assumption that innovation is a 'located phenomenon', this study seeks to address the following research questions:

(a) Is it possible to identify the composite dimensions of RIS that can be adopted and managed as independent economic policies and that are generalizable to all regions, despite the idiosyncrasies of different regions?

(b) Is it possible to map the overall RIS architecture by identifying underlying mediatory variables and by measuring their influence on the attainment of statistically significant outcomes at the macro-economic level (i.e., Unemployment, Youth-Unemployment, Gross Value Added and Gross Domestic Product)?

The paper proceeds as follows: In Section 2 we provide a review of the literature. Section 3 illustrates the formulation of the dataset and methodology used in the study. Section 4 documents the methods applied for the analysis of innovation strategies as economic policies. Section 5 then presents the results and describes the proposed RIS integrated model. Section 6 provides a discussion of the major theoretical and policy issues brought up by the study. This article thus provides a platform for the discussion of investments and capital outlays at the European level.

2. Literature Review

Knowledge is seen as a source of competitive advantage for nations, and, as observed by David and Foray, "Economic historians point out that nowadays disparities in the productivity and growth of different countries have far less to do with their abundance (or lack) of natural resources than with the capacity to improve the quality of human capital and factors of production: in other words, to create new knowledge and ideas and incorporate them in equipment and people" (2002: 9–10). If so, what are the mechanisms through which knowledge and ideas can be converted into economic activity in measurable, sustained and sustainable ways? R&D intensity generates new ideas and expands the technological opportunity set; the increased knowledge endowment in turn enhances the profitability of entrepreneurial activity by facilitating recognition and exploitation of new business opportunities (Auerswald, 2010; Fritsch, 2008; Wersching, 2010). Hence, the industrial sectors with the largest shares of R&D employment tend to include many new fast-growing companies (Eckhardt and Shane, 2011), while firms with high "technological-competence-enhancing capabilities" can translate knowledge accumulation into sustained growth when knowledge is leveraged by the initial scale of such firms' technological endowments (Lee, 2010). It has been found that firms located in research-driven clusters tend to exhibit greater innovation, higher rates of growth and higher survival rates than firms not located within such geographical boundaries (Gilbert, B., McDougall, P., Audretsch, D., 2008). Empirical evidence suggesting that University-Industry-Government pathways have a regional scope can also be found in the Knowledge Spillover Theory of Entrepreneurship literature. Regions characterised by higher R&D investment also tend to experience greater knowledge spillover (e.g., Audretsch and Lehmann, 2005), and venture sustainability is influenced not only by traditional economic factors, such as market potential (e.g., Pires, 2005) or demand sophistication (e.g., Buesa, M., Heijs, J., Baumert, T., 2010; Lindic, J., Bavdaz, M., Kovacic, H., 2012), but also by the opportunity to access the knowledge and technology generated by surrounding universities (Audretsch and Lehmann, 2005). Thus, the knowledge environment can be a source of regional competitive advantage (e.g., Fritsch, 2008; Pe'er and Vertinsky, 2008; Tappeiner, G., Hauser, C., Walde, J., 2008).

Nevertheless, despite high uncertainty, asymmetric information and difficulties in appropriating returns from investments in newly-created knowledge, all of which characterise innovation-driven markets, R&D intensity positively influences access to financing (Brown and Petersen, 2010; Ciftci and Cready, 2011). Indeed, even SMEs benefit from better access to financing compared with their larger counterparts in less knowledge-intensive industries (Audretsch and Weigand, 2005). R&D intensity presumably provides an environment in which SMEs can grow through continuous investment in innovation and by attracting external capital (Harhoff, 2000; Huynh and Petrunia, 2010). An improved technological environment is also associated with the enhanced market power of firms (Wersching, 2010). As noted by Auerswald, "in industries where production processes are more complex, persistent profits accrue to surviving firms. Such profits are greatest in the early stages of industries where technology is of intermediate complexity – that is, where learning is rapid enough to confer a competitive advantage, but imitation is sufficiently uncertain to deter later entry" (2010: 578).

However, despite the importance of knowledge complexity or sophistication, innovation policies should combine different technological levels and maturities in order to improve their effectiveness. If the main goal is to improve overall RIS quality, medium-technology manufacturing has a much greater impact than high-tech production because it supports the establishment of local synergies by increasing University-Industry-Government "stickiness" within a cluster or geographical unit. High-tech manufacturing, in contrast, does not provide "structure" to local knowledge environments because, apart from being small-scale, it focuses on internal, centralised and "globalised" production within multinational corporations, often taking the form of spin-offs of highly specialised research institutions and involving global markets more than local human capital or knowledge sources. From an industrial organization perspective, medium-tech manufacturing can function as a seedbed for high-tech production, as it allows for maintenance of absorptive capacity, so that knowledge and technologies developed elsewhere can be better understood, more easily disseminated and adapted to local circumstances (Leydesdorff and Fritsch, 2006; Pessoa, 2010; Teixeira and Fortuna, 2010). Knowledge-intensive services are usually decoupled from local economies, but high-tech services have the potential to shape the underlying knowledge-base configuration. Despite "size" and "location" issues, if stimulated on the high-tech end, the knowledge-intensive services may also contribute to the improvement of absorptive capacity in economically peripheral areas and thus reduce asymmetries in manufacturing technologies by spreading and disseminating specialised know-how across regions (Leydesdorff and Fritsch, 2006; Teixeira and Fortuna, 2010).

"Most experts agree that innovation is the most important factor for organizational effectiveness and long-term survival" (Nam, et. al., 2014: 91), thus the importance we have attached to it in our discussion. In attempting to sum up the main theoretical and empirical contributions in this research field we have reached the conclusion that regional innovation capacity depends above all on the effort made in allocating resources, regardless of whether the latter is measured via expenditure or staff employed in R&D (Audretsch and Lehmann 2005; Furman and Hayes 2004; Tappeiner, G., Hauser, C., Walde, J., 2008). The core elements of RIS that are highlighted in the theoretical and empirical literature are summarized in Table 1. These 8 core elements are the Independent or Input variables in our integrated model, which is described in Section 3 (Formulation of the Dataset and Methodology). As we can see, in Table 1, technology and various forms of R&D, in tandem with the effective use and leveraging of knowledge, for promising markets which have some sophistication on the demand side, lead to an innovation capacity which is critical for economic growth, in Europe.

As we shall also see below, the Dependent or Output variables in our integrated model, signifying that productive growth is occurring in advanced societies, are, unemployment, youth-unemployment, gross value added and gross domestic product – giving, in turn, a good perspective of what counts to policy makers (i.e., both job and value creation), now and into the future (Brousseau, E., Garrouste, P., Raynaud, E., 2011). Undoubtedly "firms' innovations vary across countries" (Nam, et. al., 2014: 91) and, as we have discussed herein, we intend to put forth an explanation but also a solution so that a greater understanding of the economics of innovation, at the regional level, may result. Much as Nam et. al. (2014: 91) stated, "despite the significant effort to conceptualize innovation, we note several gaps in extant literature that form the basis of our study […] the vast majority of past research has focused on understanding innovation solely in the United States". By including a sample from European countries we thus hope to contribute to the innovation capacity, so essential for economic development (Nam, et. al., 2014; Porter 1990), in this region in particular.

3. Formulation of the Dataset and Methodology

Taking into account the above mentioned theoretical dimensions (Table 1) we revised the availability of the existing data sources (Eurostat, OECD, UN, UNESCO and World Bank), to guarantee the inclusion in our integrated model of the maximum number of aspects or elements of a RIS. Our choice of the data source is based on some complementary criteria.

The most important one is the level of decentralisation of statistical information to the regions. We selected for each country the administrative level with comparable policy making competences in the case of R&D and innovation policies (European Commission 2012; OECD, 2013). Of course, another important criterion, in this case from a practical point of view, is the effective availability of statistical data. Therefore, we collected all statistical information from the OECD Regional Statistics Database, comprising a total of 231 regionally standardised variables, as our initial dataset (Table 2). The sample, selected from a dataset of 396 regions across 34 OECD countries, consists of 158 regions that form parts of 18 European countries (Table 3). The sample includes all European countries with data available in the OECD Regional Statistics Database. We considered only European countries because their RIS are not comparable, for example, with North-American ones, as shown by the emergence of the so-called "European Paradox" (Aldridge and Audretsch 2011; Ejermo, O., Kander, A., Henning, M., 2011).

Main Theoretical and Empirical Contributions	
Core elements	RIS references
Corporate R&D	Ciftci and Cready (2011); Eckhardt and Shane (2011); Huynh and Petrunia (2010); Lee (2010)
Market Potential	Krugman (1991); Pires (2005); Porter (1990)
Demand Sophistication	Buesa, M., Heijs, J., Baumert, T. (2010); Kim and Mauborgne (2005); Lindic, J., Bavdaz, M., Kovacic, H. (2012)
Governmental R&D Investment	Furman and Hayes (2004); Hewitt-Dundas and Roper (2011); Pessoa (2010)
Technological Capacity	Audretsch and Weigand (2005); Auerswald (2010); Wersching (2010)
Knowledge Intensity	Friedman (2005); Leydesdorff and Fritsch (2006); Piore and Sabel (1984)
University R&D Employment	Audretsch and Lehmann (2005); Gilbert, B., McDougall, P., Audretsch, D. (2008); Tappeiner, G., Hauser, C., Walde, J. (2008)
Governmental R&D Employment	Audretsch, D., Grilo, I., Thurik, A. (2012); Maassen and Stensaker (2011); OECD (2013)

Table 1. Substantiation of the RIS Concept. Source: Own Preparation.

Variables Segmentation	
Themes available in OECD Database	Number of variables
Economics	44
Demographic Statistics	15
Innovation Indicators	61
Regional Labour Market	101
Social Indicators	10
Total Variables included in Dataset	231

Table 2. Themes Available on OECD Regional Statistics Database. Source: Own Preparation and OECD Regional Statistics Database.

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European Countries Covered		Territorial Level	Number of Regions
Austria		Level II OECD	7
Belgium		Level II OECD	3
Czech Republic		Level II OECD	8
Finland		Level II OECD	4
France		Level II OECD	21
Germany		Level II OECD	16
Greece		Level II OECD	4
Hungary		Level II OECD	7
Ireland		Level II OECD	2
Italy		Level II OECD	21
Netherlands		Level II OECD	4
Norway		Level II OECD	7
Poland		Level II OECD	9
Portugal		Level II OECD	4
Slovakia		Level II OECD	4
Spain		Level II OECD	17
Sweden		Level II OECD	8
United Kingdom		Level II OECD	12
Total number of regions			158

Table 3. European Countries Covered: Territorial Level and Number of Regions. Source: Own Preparation and OECD Regional Statistics Database.

On the other hand, the regional variables were collected over the period from 1998 to 2008 to maximise the fit of the series to the available data. The regions included in the sample are only a portion of all of the regions included in the OECD Regional Statistics Database because only series that have reasonable numbers of original values (i.e., at least five years' worth of original data) were considered for inclusion. This procedure is justified by the need to obtain yearly variation-rates to estimate an unbiased geometrical average for each region over the studied period. The original dataset (i.e., the value of each year for the corresponding region) was converted into yearly variation-rates. Factor Analysis only allows working with one number per observation (i.e., each region), so the only available possibility – for anyone that uses Factor Analysis in this scenario – was to apply the geometrical average. Applying the geometrical average also has several additional advantages: (1) It summarizes a long-term trend for each region through a single value; (2) The long-term perspective can be seen as being more reliable and interesting from a scientific point-of-view; (3) It balances and disperses the outlier effect (i.e., the unusual years); (4) It is the best method to apply – from a statistical point of view – when dealing with variation-rates. In this sense, the time span was also chosen to take into account the fit with the original information available to maximise the use of unprocessed data. The remaining missing values were filled in, using various methodologies, depending on the nature of the missing data: (1) Single intermediate values were calculated using the arithmetical mean of the two nearest years; (2) Whenever the data were missing a sequence of two or more values in the middle years, we estimated the yearly variation-rate by matching the previous and subsequent existent values, thus filling the 'gap'; (3) If a missing value fell near the beginning or end of the series, a geometrical average of the variation-rates between the available value sequences was applied. Because values were missing for all studied variables, we applied these procedures for each of the 231 variables available in the OECD Regional Statistics Database. After data collection and missing values estimation procedures were complete, we calculated the yearly variation-rates and the corresponding geometrical averages for each region over the ten-year time span.

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In order to identify a clear set of composite dimensions that constitute the input layer of RIS, we applied Factor Analysis. Factor Analysis is a generic name given to a multivariate statistical method whose objective is to define the underlying structure in a data matrix in order to reduce a broad set of variables into a small number of factors that can be considered as hypothetical or non-observable variables that summarise the explanatory capacity of the original set of variables (Manso and Simões 2009). In addition, extracted factors are less sensitive to potential data recording errors than single variables are because the bias is dispersed by the full set of original variables represented by each factor. The assumptions of normality, homoscedasticity and linearity are not required (i.e., or can be applied in a less restrictive manner) under this methodology. Indeed, multicollinearity, which causes serious difficulties in other types of statistical analysis, in this case is desirable, given that the main goal is to identify sets of interrelated variables. Whenever clearly differentiated subgroups of variables emerge where, on the one hand, within each subgroup, variables are highly interrelated while on the other hand, variables of different subgroups show no significant relationships at all, the original group of indicators can be reduced to several factors. The latter will summarise the information held in common by groups of several variables included in each factor. Each of those indicators – although highly correlated – gives a different view of apparently the same subject (Pestana and Gageiro 2008). In this sense, it is worthwhile treating the concept and the key elements of an RIS as something which is not directly observable. Innovation capacity is a critical 'input' for the European Union's economic growth (Audretsch and Thurik 2001; OECD, 2013), especially if we take into consideration that an important part of productive growth in advanced nations – as measured in terms of Unemployment Rate, Youth-Unemployment Rate, Gross Value Added and Gross Domestic Product – corresponds to innovation (e.g., Audretsch, et. al., 2000; European Commission 2012; Furman and Hayes 2004), so we may consider it to be one of the main drivers of employment and economic growth. Regarding the identification of mediating variables and the measurement of their latent effects on the attainment of measurable outcomes at a macro-economic level, we applied the ordinary robust least squares procedure (OLS), being a procedure that shows normally the best level of robustness (Audretsch and Lehmann, 2005; Buesa, M., Heijs, J., Baumert, T., 2010).

Before computing the integrated model (Table 4), the RIS components generated through Factor Analysis are assumed to be Independent or Input variables, while Unemployment (UNE), Youth-Unemployment (YUN), Gross Value Added (GVA) and Gross Domestic Product (GDP) are designated as Dependent or Output variables.

4. Innovation Strategies as Economic Policies

The outcome of a successful Factor Analysis reduces the number of data one is working with, while maintaining the highest level of their explanatory and predictive capacity (Pestana and Gageiro 2008). Using Factor Analysis, the original dataset of 231 variables (Table 2) was reduced, through an exploratory process, to only 25 variables, generating 8 factors or underlying dimensions that are linear combinations of the original variables (Table 5).

(a) Independent or Input Variables:	(b) Dependent or Output Variables:
Elements of RIS (Not Directly Observable)	Macro-economic Indicators (Directly Observable)
Corporate R&D (CRD)	Unemployment (UNE)
Market Potential (MKP)	Youth-Unemployment (YUN)
Demand Sophistication (DES)	Gross Value Added (GVA)
Governmental R&D Investment (GRI)	Gross Domestic Product (GDP)
Technological Capacity (TEC)	
Knowledge Intensity (KIT)	
University R&D Employment (URE)	
Governmental R&D Employment (GRE)	

Table 4. Integrated Model to be Tested. Source: Own Preparation. Statistical data from the OECD Regional Statistics Database.

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Table 5. Hypothetical Components: Components, Communalities and Theoretical Dimensions. Source: Own Preparation. Asterisks* Indicate Communalities that are Less than 0.750.

Matrix of Rotated Components	RIS Hypothetical Constructs		
	Components	Communalities	Theoretical Dimensions
1. Corporate R&D Expenditures (% of GDP)	.943	.910	Corporate R&D
2. Corporate R&D Expenditures (USD, PPP)	.938	.911	
3. Corporate R&D Employment (Number)	.895	.834	
4. Corporate R&D Employment (% of total employment)	.820	.727*	
5. Corporate R&D Expenditures (USD)	.815	.689*	
6. Population (Number)	.920	.911	Market Potential
7. Density (Persons per square kilometre)	.914	.909	
8. Labour Force (Number)	.914	.926	
9. Employment (Number)	.847	.839	
10. GDP per worker (USD)	.914	.899	Demand Sophistication
11. GDP per Capita (USD)	.907	.870	
12. Primary Income per Household (USD)	.890	.908	
13. Disposable Income per Household (USD)	.759	.791	
14. Governmental R&D Expenditures (% of GDP)	.960	.955	Governmental R&D Investment
15. Governmental R&D Expenditures (USD, PPP)	.957	.988	
16. Governmental R&D Expenditures (USD)	.952	.979	
17. High and Medium Technology Employment (% of total employment)	.947	.945	Technological Capacity
18. High and Medium Technology Employment (Headcount)	.936	.927	
19. High and Medium Technology Manufacturing (% of total manufacturing)	.910	.840	
20. Knowledge Intensive Services Employment (% of total employment)	.908	.879	Knowledge Intensity
21. Knowledge Intensive Services (% of total services)	.905	.884	
22. University R&D Employment (% of total employment)	.897	.890	University R&D Employment
23. University R&D Employment (Number)	.726	.720*	
24. Governmental R&D Employment (% of total employment)	.804	.806	Governmental R&D Employment
25. Governmental R&D Employment (Number)	.745	.790	

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These factors better reflect the core components of the RIS than each of the individual variables could independently, as they not only group together all related variables but also reflect interactions between factors, as the integrated model correlates each variable to all factors, not just the one in which it is included. The communalities (i.e., the correlations of each variable with each of the other variables composing the factor) of the variables are relatively high, most above 0.750, which indicates a high degree of preservation of variance, ensuring reliability of the findings. Moreover, the 8 factors retain nearly 87 per cent of the original variance, leaving just a 13 per cent loss of information contained in the original dataset.

Another important dimension by which to assess the outcome of a Factor Analysis is qualitative validation (Manso and Simões 2009). Here, we take into account two important principles:

(1) Parsimony: Factor Analysis aims to explain correlations among an original set of variables with as few factors as possible while retaining most of the variability in the initial dataset in order to make theoretical constructs more interpretable, measurable and operational for policy purposes;

(2) Interpretability: Factor Analysis should be used only if the outcomes cohere with the theoretical background and with previous empirical findings within the respective research domains or complementary fields, thus generating clear but consistent 'interpretability gains'.

The 25 original variables were integrated into 8 composite dimensions, significantly improving the 'interpretability' of the RIS construct. That is, the extracted factors are not only consistent but also interpretable in terms of the theoretical framework of the research field, in this case, that of RIS. Interrelated variables belong to the same 'subsystems' of the overall RIS in which variables belonging to a certain structural component are located just within that factor. Therefore, each factor can be labelled by a 'name' that expresses the nature of the set of variables that compose it. Following Pestana and Gageiro (2008), we selected Factor Analysis by Principal Components with VARIMAX rotation and KAISER normalization, as this approach allows us to extract more interpretable factors and, in addition, has other statistical advantages such as predetermination of the angles between axes. Factorial patterns obtained through this specific rotation procedure tend to be more robust than those obtained using alternative methods, assuring maximum orthogonality between factors, which is important for the statistical analyses below.

Bartlett's test of sphericity is used to test the null hypothesis that variables are uncorrelated. The observed significance level is 0.000, which is sufficiently small to reject the null hypothesis for all core-dimensions of RIS (Table 6). On the other hand, the Kaiser-Meyer-Olkin (KMO) statistic tests whether partial correlations among variables are small. The KMO thus measures sampling adequacy and should be greater than 0.5 for a satisfactory factor analysis to proceed (Hair, et. al., 2006). According to our results, University R&D Employment and Governmental R&D Employment should not be considered in our integrated model as composite dimensions (Table 6). Each of the dimensions that integrates the Input layer comprises a specific subgroup of original variables that must have an at least "acceptable" level of correlation between them in order to be suitable for further statistical analysis. The level of multicollinearity within the subgroup is defined as "internal consistency" and is obtained through Cronbach's Alpha coefficient. The majority of the factors show strong "internal consistency", with Alphas above 0.9. (The only exception is Knowledge Intensity (0.884), which shows only a "good" interrelation with other items). Although University R&D Employment and Governmental R&D Employment cohere with the theoretical background of the analysis, these factors do not show sufficient consistency to be suitable for further statistical analysis. However, given the importance of the information provided, and taking into account the RIS theoretical framework, it was decided to include them, replacing in the integrated model by the most representative items in their respective subgroups, namely, University R&D Employment (% of total employment) and Governmental R&D Employment (% of total employment). As shown in Table 5, these variables show greater preservation of their original variability within the retained factors, being more representative than the other variables, which have lower communalities.

According to Nunnally (1978), reliability and validity are essential to empirical assessments. The first step to assess these aspects was to use Confirmatory Factor Analysis (CFA) and Composite Reliability (CR) to test the reliability of the proposed constructs (Table 7). The typical threshold level is 0.7 for newly developed measures (Buesa, M., Heijs, J., Baumert, T., 2010; Nunnally, 1978). Values range from 0.861 to 0.972 in the case of CFA and from 0.870 to 0.975 in the case of CR (Table 7). In addition, all values for the Average Variance Extracted (AVE) are above the minimum of 0.5, ensuring the reliability of the constructs (Table 8). Therefore, these composite dimensions may be considered reliable (Garver and Mentzer 1999).

However, all AVE values are higher than the square of the correlation between the pairs of constructs (Table 8), indicating their discriminant validity (Bagozzi and Baumgartner 1994; Baumgartner and Homburg 1996). Therefore, we considered as modelling inputs (Table 4) the two remaining original variables (Table 5), labelled University R&D Employment (URE) and Governmental R&D Employment (GRE), and the 6 remaining dimensions shown by the Factor Analysis to have "excellent" or at least "good" internal consistency, namely, Corporate R&D (CRD), Market Potential (MKP), Demand Sophistication (DES), Governmental R&D Investment (GRI), Technological Capacity (TEC) and Knowledge Intensity (KIT). As output variables (Table 4), we considered Unemployment (UNE), Youth-Unemployment (YUN), Gross Value Added (GVA) and Gross Domestic Product (GDP).

Internal Consistency Analysis	Bartlett's Test	Kaiser-Meyer-Olkin (KMO)	Cronbach's Alpha (α)
Corporate R&D	0.000	0.766	0.922
Market Potential	0.000	0.757	0.908
Demand Sophistication	0.000	0.855	0.915
Governmental R&D Investment	0.000	0.706	0.977
Technological Capacity	0.000	0.742	0.939
Knowledge Intensity	0.000	0.763	0.884
University R&D Employment	0.000	0.497	0.286*
Governmental R&D Employment	0.000	0.506	0.460*

Table 6. Bartlett's Test, Kaiser-Meyer-Olkin (KMO) and Cronbach's Alpha (α). Source: Own Preparation. Asterisks* Indicate Cronbach's Alpha Scores that Indicate Variables are Not Suitable for Further Analysis.

Reliability Analysis	EFA	CFA	CR
Corporate R&D	0.922	0.922	0.922
Market Potential	0.908	0.908	0.908
Demand Sophistication	0.915	0.915	0.942
Governmental R&D Investment	0.977	0.972	0.975
Technological Capacity	0.939	0.939	0.960
Knowledge Intensity	0.884	0.861	0.870

Table 7. Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA) and Composite Reliability (CR).
Source: Own Preparation.

Validity Analysis	CRD	MKP	DES	GRI	TEC	KIT
Corporate R&D (CRD)	0.559	0.309	0.537	0.038	0.009	0.013
Market Potential (MKP)	0.309	0.584	0.433	0.071	0.012	0.000
Demand Sophistication (DES)	0.537	0.433	0.775	0.027	0.018	0.008
Governmental R&D Investment (GRI)	0.038	0.071	0.027	0.509	0.028	0.001
Technological Capacity (TEC)	0.009	0.012	0.018	0.028	0.512	0.017
Knowledge Intensity (KIT)	0.013	0.000	0.008	0.001	0.017	0.593

Table 8. Average Variance Extracted (AVE) and Squares of the Correlation Between Constructs. Source: Own Preparation. The Values in Bold Indicate the Correspondent AVE for Each Construct.

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5. Integrated Model of RIS

The first model (Table 9) suggests that Technological Capacity (-0.650) and University R&D Employment (-0.415) reduce Unemployment. However, other RIS components, namely, Knowledge Intensity (+0.436) and Market Potential (+0.424), appear to increase Unemployment. The overall RIS structure exerts a statistically significant effect (ρ-value of 0.038) and explains 20.2% of Unemployment variance (R2 of 0.202). The results from the second model suggest that the level of Demand Sophistication (-1.219), University R&D Employment (-1.195) and Governmental R&D Employment (-0.564) have an important role in reducing Youth-Unemployment. The regression model is significant (ρ-value of 0.000), and 38.7% of Youth-Unemployment variance is explained by the overall RIS (R2 of 0.387). It is important to note that the RIS configuration does not have any downside in terms of Youth-Unemployment. In the third regression model, it was found that Demand Sophistication (+1.039), Market Potential (+0.599), Governmental R&D Investment (+0.167), Technological Capacity (+0.132) and Corporate R&D (+0.095) have positive effects on Gross Value Added (GVA) but that Governmental R&D Employment (-0.101) has a negative influence on GVA. The regression model is statistically significant (ρ-value of 0.000), with the RIS model responsible for 87.8% of GVA variability (R^2 of 0.878).

The fourth model estimation shows that Demand Sophistication (+1.257), Market Potential (+0.601), Governmental R&D Investment (+0.145), Knowledge Intensity (+0.093) and Corporate R&D (+0.081) have positive effects on Gross Domestic Product (GDP), although the effort to increase Governmental R&D Employment appears to "consume" (-0.088) some of the wealth generated. The estimation is significant (ρ-value of 0.000) and explains 91.8% of GDP variance (R^2 of 0.918).

	Robust OLS			
	1. Unemployment	2. Youth Unemployment	3. Gross Value Added	4. Gross Domestic Product
Corporate R&D	0.200 (0.430)	-0.073 (0.829)	0.095 (0.013)***	0.081 (0.020)***
Market Potential	0.424 (0.094)*	0.293 (0.387)	0.599 (0.000)***	0.601 (0.000)***
Demand Sophistication	-0.136 (0.592)	-1.219 (0.000)***	1.039 (0.000)***	1.257 (0.000)***
Governmental R&D Investment	0.013 (0.960)	0.520 (0.125)	0.167 (0.000)***	0.145 (0.000)***
Technological Capacity	-0.650 (0.011)**	-0.367 (0.278)	0.132 (0.001)***	0.010 (0.767)
Knowledge Intensity	0.436 (0.046)**	0.414 (0.221)	-0.038 (0.308)	0.093 (0.007)***
University R&D Employment	-0.415 (0.043)**	-1.195 (0.001)***	0.011 (0.778)	-0.053 (0.128)
Governmental R&D Employment	-0.228 (0.367)	-0.564 (0.097)*	-0.101 (0.008)***	-0.088 (0.011)***
Constant	96.500 (0.000)***	98.607 (0.000)***	105.337 (0.000)***	105.430 (0.000)***
F test	2.115 (0.038)**	4.289 (0.000)***	134.382 (0.000)***	209.297 (0.000)***
R2	0.202	0.387	0.878	0.918

Table 9. Estimation Results. Dependent Variables: Unemployment (1), Youth-Unemployment (2), GVA (3) and GDP (4). Source: Own Preparation. In Brackets the p-value. In Italics are the Non-significant Coefficients to 90%. The Asterisks *, ** and *** Indicate Significance at the 10%, 5% and 1% Level, Respectively. The Data Includes 158 European Regions from OECD Regional Statistics Database.

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6. Discussion and Policy Implications

This study provides empirical evidence that innovation could be managed effectively at the regional level, due the localised nature of knowledge spillovers, absorptive capacity, technological transference, manufacturing set-up and new business formation. It is possible to identify the "subsystems" that shape the overall RIS and that could be generalised to all European regions, despite the differences and idiosyncrasies of the different regions. Surprisingly, the relationships between RIS core-dimensions and the attainment of measurable outcomes at the macroeconomic level show that Governmental R&D Investment does not have any statistically significant impact on Unemployment or Youth-Unemployment. Increasing Governmental R&D Investment contributes to a higher GVA and GDP but is far from being a "panacea" for stagnant growth, due to the relatively small weight of its effects. Although Governmental R&D Investment is a necessary condition for sustainable development (Ejermo, O., Kander, A., Henning, M., 2011; Nam, et. al., 2014), it is not the most important factor in seeking to stimulate economic growth, at least in the context of developed European economies. Governmental R&D Investment has less impact than Demand Sophistication or Market Potential either on GVA or GDP. This means that RIS effectiveness in translating R&D investment into economic growth depends on creation of the necessary conditions for maintaining or increasing the consumption of goods and services at the regional level. That is, regions should have the levels of income needed to absorb and leverage the growth and the technological development of local supply. Demand Sophistication affects the ability of a given region to grow or increase its Market Potential by attracting skilled, qualified, creative and productive human capital that can develop, design and produce more and better products or services at competitive prices. In this sense, the results are congruent with previous findings of Gilbert, B., McDougall, P., Audretsch, D. (2008), Norman (2002), Pe'er and Vertinsky (2008), Pires (2005) and Teixeira and Fortuna (2010), suggesting that Market Potential has a double-role: (1) Assuring demand: generating economies of scale that can assure the necessary levels of demand for the products and services produced, assembled, distributed or sold within regional boundaries to achieve attractive levels of remuneration for productive factors (i.e., capital and labour), stimulating FDI and formation of a medium-technology manufacturing base;

(2) Building "critical mass": increasing the availability of qualified human capital – embodied in Technological Capacity and Knowledge Intensity – tends to improve companies' absorptive capacity, productivity, rates of growth, technological sophistication and fit with market needs, leading to higher value-added and thus enhanced competitiveness.

Regional market size and income growth encourage firms to move away from centralised operations and adopt multi-location strategies, leading to increased FDI and the establishment of medium-technology manufacturing (Harhoff, 2000; Leydesdorff and Fritsch, 2006).

The critical importance of Market Potential and Demand Sophistication demonstrates the need to manage innovation in an integrated way rather than focusing narrowly on increasing R&D expenditures. For instance, factors that are value-drivers in terms of wealth-creation can at the same time reduce welfare, and vice versa. This is demonstrated by the particular cases of Knowledge Intensity and Governmental R&D Employment. A higher availability of knowledge-intensive services within a given region creates an incentive for companies to outsource in order to replace regular employment. Given the presence of economies of scale and the mobility of service providers within regional boundaries, firms tend to increase their outsourcing, generating additional Unemployment (Friedman, 2005). Knowledge-intensive services are also decoupled from the configuration of the regional economy, and headquarters locations of service providers are more strongly influenced by geographical and logistic factors than by specific RIS characteristics (Leydesdorff and Fritsch, 2006). However, replacing non-core regular employment by specialised service providers allows companies to reduce overall costs and to improve their competitiveness by converting structural costs into variable ones (Piore and Sabel, 1984). In this way, Knowledge Intensity contributes to price flexibility and to firms' abilities to cope with competitive market environments, generating more sales and leading to slightly higher GDP growth rates. On the other hand, Governmental R&D Employment can have the opposite effects. While it is important in reducing Youth-Unemployment, it also has a negative effect on competitiveness, as seen in GVA and GDP series. It is precisely these differential effects of specific RIS "subsystems" that make it difficult to operationalise for policy purposes, as noted by Uyarra (2010, p. 116).

Despite the negative side-effects of Governmental R&D Employment on both GVA and GDP, University R&D Employment appears to have a quite important role in reducing Unemployment, especially Youth-Unemployment, while it also does not have a downside in terms of economic growth. This means that replacing Governmental R&D Employment with University R&D Employment can, up to a point, be an effective way to promote both employment and youth-employment by strengthening innovation while avoiding inefficient consumption of public resources. R&D outlays of regional universities are typically measurable and competitive. In addition, they can be benchmarked internationally in terms of scientific outcomes, absorptive capacity enhancement, productivity incorporation and technological transference. Hence, such outlays have a tangible impact on value-added and on the competitiveness of the regional economic capacity. Although some subsystems (i.e., Knowledge Intensity and Market Potential) contribute to additional Unemployment, it is important to note that none of the RIS core-components has a downside in terms of Youth-Unemployment. If balanced with other policies and accounting for the specific trade-offs of each subsystem involved in improving overall RIS "quality," Knowledge Intensity and Market Potential appear to among several possible means of simulating additional youth-employment, despite the various ways in which they lead to increased Unemployment.

On the other hand, Governmental R&D Investment and Technological Capacity enhancing policies appear to positively affect GVA growth, showing that managing innovation at the regional level can be used to increase wealth in an effective and measurable way. The role of Technological Capacity in GVA growth is congruent with previous findings of Auerswald (2010) that the development of higher technology, embodied in more complex production and in less replicable technologies and products, whenever fitting market needs (Adner and Levinthal, 2001) and matching firms' absorptive capacity (Harhoff, 2000; Teixeira and Fortuna, 2010), allows for higher prices and thus higher profit margins without decreasing demand levels (Wersching, 2010). Technological Capacity enhancement is the most effective instrument for reducing Unemployment and is a policy without any downside regarding sustainable regional development. It was also found that Governmental R&D Investment and Knowledge Intensity have significant positive effects on GDP, and according to the insights of Friedman (2005), Norman (2002) and Piore and Sabel (1984), scale-up of knowledge intensive services generates competitiveness gains and business volume growth through:

(1) Increased flexibility: conversion of structural costs to variable costs, improving companies' abilities to cope with demand volatility;

(2) Improved competitiveness: production management and optimization supported by knowledge-intensive services allows companies to reduce prices without undermining profitability and improve strategies for coping with bullish markets and dynamic pricing competition.

Although Knowledge Intensity slightly enhances GDP growth, it also generates increased Unemployment because it incentivises outsourcing, inducing the replacement of regular employment by external service providers. In this case, the creation of additional Unemployment is much more pronounced than the contribution of Knowledge Intensity to GDP growth, highlighting the need to considerer the specific trade-offs of each policy.

Corporate R&D also contributes to creation of the necessary conditions for achieving increased economic growth (Eckhardt and Shane, 2011; Harhoff, 2000; Huynh and Petrunia, 2010), as appears to be reflected in both GVA and GDP growth rates. According to the literature, increased R&D intensity of firms improves their access to financial resources, regardless of the sizes of such firms (Audretsch and Weigand, 2005), improving the environment for growth within regional clusters (Gilbert, B., McDougall, P., Audretsch, D., 2008). However, despite its small positive effects on economic growth, Corporate R&D is not associated with additional employment or youth-employment gains.

The results suggest that the RIS core-dimensions can be used effectively, both for improving welfare and for achieving higher economic growth, if they are measured, planned and implemented in an integrated way. However, the RIS subsystems are not homogenous, and some of them have significant negative side-effects, such as generating Unemployment or slowing economic growth. Increasing Governmental R&D Investment could positively contribute to economic growth, but simply increasing R&D expenditures may be ineffective if not combined with Demand Sophistication and Market Potential policies. It is worth noting that Government R&D Investment does not have a statistically significant impact on employment, indicating the need to assess the trade-offs of policies that could lead to significant increases in government expenditure. Surprisingly, Governmental R&D Employment does not contribute to mass-market employment, despite its quite important role in reducing Youth-Unemployment. At the same time, Governmental R&D Employment appears to be a quite inefficient policy because it consumes excessive financial resources, thereby undermining economic growth, as seen in its negative effects on GVA and GDP.

Translating R&D outlays into employment and economic growth does not follow a simple "input-output" logic. Increasing the scale of R&D investment, either public or private, is a necessary condition for sustainable development, but it must be combined with other policy measures to be effective. The emergence of the so-called "European Paradox" shows that R&D investment is not maximally effective and that increasing the scale of public R&D expenditures is not sufficient to generate employment and sustained economic growth (Aldridge and Audretsch, 2011; Ejermo, O., Kander, A., Henning, M., 2011). That is, 'throwing money at the problem' policies are neither efficient nor effective solutions. The RIS approach may thus be a valid alternative, as it appears to improve regions' abilities to exploit their differential competitive advantages to overcome the effects of unfavourable input endowments, spatial locations or levels of knowledge base maturity.

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