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Sustainable Equilibrium Index (SEI): A Measure to Analyze the Systemic Dependences in Territorial Development

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Abstract

Regional prosperity not only depends on economic issues but also in social and environmental aspects. Achieving a sustainable growth path in the long term implies "coherence" in the advancement of these three dimensions (avoiding potential imbalances threatening that path). Here the notion of "sustainable" competitiveness arises. In this context, the objective of this paper is to demonstrate, through a quantitative methodology, that the coherence of economic, social and environmental dimensions is in fact at the core of regional prosperity and regional gap. To do so, the paper analyses the systemic interdependencies between these three fields using a quantitative methodological approach: the Sustainable Equilibrium Index (SEI). The results include the overall estimates for the SEI in each Spanish region as well as a detailed decomposition of the index by economic, social and environmental fields. Finally, recommendations are made to consider SEI as a metric for the upcoming RIS3 strategies.

Keywords

indicators, evaluation, competitiveness, regional development

1. Introduction

Measuring has always been a central issue in economic science. At the beginning of the XX century, Lionel Robbins defined economics as the science which studies human behavior as a relationship between ends and scarce means which have alternative uses. Here, the term "scarce" implies the importance of how to measure and monitor resources and available assets to optimize the wellbeing of society.

After the 50s, the progressive complexity of economic systems and the imperative of optimizing those resources and assets gave measurement techniques remarkable importance as tools for understanding how economies perform. Specifically, they had become part of the definition, implementation and

evaluation processes within economic activity for both public and private agents.

Nowadays, as globalization introduces pressures under competitiveness procedures and demographic growth challenges, the optimality in the use of natural resources and their social distribution (Canuto & Giugalev, 2010) and the monitoring and evaluating of overall performance become critical to ensure a continuous minimum level of welfare, not only for us but for future generations. This provides a sense of sustainability in line with the Brundtland report highlighting a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Here, not only economic, but also social and environmental dimensions, must be interrelated parts within the overall prosperity debate.

Although many measurement methodologies and techniques have been developed since the generalization of evaluation science in economic, social and environmental fields, not much progress has been achieved considering the systemic analysis of all these three dimensions. Besides, as our concept of sustainability also involves a "dynamic" approach, it must be said that this aspect lacks a widespread analysis in these three dimensions.

The objective of this paper is, therefore, twofold: First, introduce the notion of systemic interdependencies between the three dimensions we think compose a pattern of prosperity, and Second, to introduce the notion of time in the analysis as a component of the later pattern that links the heritage determinants to future prosperity possibility frontier.

Thus, the aim is not focused on discussing the identity of current measurement framework neither in economic nor in social and environmental fields, but propose a new preliminary debate on how to include their interrelationships and time aspects, in the research debate. The methodological approaches included here, as well as the preliminary results on their application, must be analyzed carefully, since their aim is not to be deterministic, but opened to further developments and improvement. The work carried out has been presented in this paper in the following sections:

In the first section ("a new sense of sustainability: towards a sustainable equilibrium") a brief introduction to conceptual insights on how the current world context determines the prosperity model and its implication to measurement has been included. In addition to this, there is also a brief review on previous measurement experiences on the three fields mentioned (economic, social and environmental) which has been included.

The second section ("new measurement methodologies") includes some considerations about difficulties and barriers when defining metric and measurement methodologies that must be taken into account (also in the case of current analysis). This section will also present the methodological approach of our "harmonic" modeling of competitiveness though the definition of the Sustainable Equilibrium Index—SEI.

The third section ("unveiling sustainable equilibrium patterns: a comparative analysis for Spanish regions") presents the previous methodological approach applied to the Spanish regions cases. This analysis includes the overall estimates for the SEI in each region as well as further work for four

specific case studies.

In the last section ("conclusions: smart vs sustainable"), a review of the main results, as well as the barriers and limitations encountered, is included. This section adds an additional assessment about the opportunity of the methodological approach proposed for a new economic development model, such as smart specialization, and policy insights, such as smart specialization strategies.

2. A New Sense of Sustainability: Towards a Sustainable Equilibrium

2.1 The Imperatives behind the New World Context

Competitiveness has become the main agenda for discussion on regional economic growth and prosperity. Given the unstable international economic and social situation, the challenges of globalization and its new related business models, and the threats of climate change and environmental risks, most academics, politicians and businessmen agree that competitiveness is key not only for understanding the new economy but for maintaining and increasing welfare and employment levels (Castillo & Paton, 2011).

Among these challenges, although those related to the economic dimension seem to be predominant, the social and environmental dimensions are also shaping the global debate (European Commission, 2010). In fact, these three elements must not be understood as isolated event but, rather, they are complex elements deeply interrelated. As Castillo and Paton (2012) state "sustainability is about how to ensure, in the medium and long term, a coherent growth in economic, social and environmental dimensions since they are elements of the same path to prosperity and actions taken in one of them have inevitably consequences in the others".

So, our conceptual framework will be focused on three main clear dimensions that configure our understanding of prosperity, as well as an additional driving factor—globalisation—that operates in all of them increasing the scale and scope of conjunctural and structural changes:

Table 1. New World Context Imperatives and Challenges

Dimensions	Issues	Effects
Globalisation	• Scope and scale of challenges and changes in the other three axes	• Globalisation acts as a multiplier element for the other axes making global the economic, social and environmental issues
Competitive patterns	• Knowledge and innovations as primary sources • Fast technological change • Cooperation and open models	• Competitive advantage focused on frontline knowledge and technology use and how economies combine their own resources with external ones.
Societal challenges	• Demographic growth • Ageing of developed societies • Immigration phenomenon • Unbalancing change in world order	• Societal challenges will determine many of the future economic trends. Those economies with sound governance mechanisms and social commitment will lead maintain their welfare.

Environmental challenges	• Scarce natural resources (depletion) • Climate change and environmental disasters • Health threats	• Environmental challenges will determine economic and social trends. They are becoming threats and opportunities in equal terms.

Competitiveness has evolved from a traditional cost-efficiency pattern to an added value one. This added value comes from differentiation and these characteristics rises from knowledge intensity and innovation. Schumpeter (1942), Romer (1986, 1990) and Lucas (2000) carried out important work understanding the effects of knowledge and technological change as a source of economic growth. But the increasing specialization and the scale of new markets make innovation difficult without "open" thinking. As Chesbrough (2003) highlights, "*organisations must use their own knowledge, but also make use of what the environment can offer to their advantage*". Therefore, as can be seen, the new competitiveness model based on knowledge and innovation, because of the nature of both elements, must be understood as a complex system where interrelationships determine the competitiveness levels, even if there is no clear measure of it (Rosenberg, 1982).

The social dimension here acquires a capital importance, since they serve as fostering elements of competitiveness and as enablers of territorial anchorage for innovation. Although difficult to measure, social networks and social capital have value and contribute to productivity (Putnam, 2002). They generate trust and this determines significantly competitiveness levels, wealth and Jobs generation (Fukuyama, 1996). Besides, and tied to the economic competitiveness dimension, if innovation is the basis for competitiveness, and the it is based on collective learning, interaction and collaboration (Morgan & Cooke, 1998), networks and social capital become critical elements of the prosperity conceptual approach.

The environmental dimension, along with economic and social dimensions, becomes a pillar of prosperity and without which it is impossible to refer to sustainability. The pressures on resources are increasing. If current trends continue, by 2050, the global population is expected to have grown by 30% and people in developing and emerging economies will legitimately aspire to the welfare and consumption levels of developed countries (Canuto & Giugalev, 2010). This fact is a threat and a challenge, but also an opportunity, since a new economic sector is emerging strongly: ecoindustries. The new regional debate will be focused on how to make business combine environmental friendly activities with a competitive advantage.

Finally, globalisation has changed the way the previous dimensions perform and interrelate, bringing with it both threats and opportunities. The main threat has appeared in the shape of increased levels of rivalry and new geographical scope of competition. But delocalisation, pressures on prices of final products and primary inputs, volatility of capital assets etc. have become only the tip of the iceberg. Social pressures and environmental problems have also become global problems that need systematic and coordinated responses (MITYC, 2011).

Here, the opportunity comes from the ability to take advantage of "global" resources available. But not all economies are positioned in the same stage to do so. It is necessary to strengthen most won assets and seek critical mass in order to be able to enter the global channels and play a certain role in the global context. This rebirth of "territorialisation" acquires remarkable importance as even the main determinants are exogenous, the capacity of become competitive remains endogenous and tied to a local context (Roudometof, 2005; Beck, 1998).

These four dimensions clearly corroborate our initial thoughts of a complex prosperity concept composed by several interrelated dimensions. As it can be seen from the previous arguments, economic, social and environmental issues are interrelated and so, the measurement model of prosperity must reflect this condition.

But still, apart from interrelationships, the sense of time must also be incorporated. These four dimensions implicitly tackle it. In the case of the economic dimension, following Porter (1990) "*competitiveness depends on the ability of firms to innovate and continually improve, and how firms acquire competitive advantage through innovative efforts*". The inclusion of "continually" here, besides supporting our sustainability concept based on time, also induces us to think about the historical determinants that lead to our current competitive position.

Heritage determines how the economic, social and environmental dimensions configure their interrelationships evolving through time.

Therefore, following both elements (interrelationships and the sense of time) in the following section, two measures will be defined: the Relationship sub-index and the Consistency sub-index.

2.2 Previous Experiences and Background

In the context of regional economy, metrics and measurements methodologies have long been developed with the aim of supporting policy definition, evaluation and monitoring. In 2007, an innovative project carried out in the Basque Country (Innobasque, 2007) made a complete benchmark study on the main measurement techniques, indicators and indexes covering regional competitiveness. This work continued afterwards by a group of experts. In it, some interesting insights appeared and led to some research in the field (Paton, 2010; Navarro et al., 2011).

Table 2. Remarkable Indexes Covering Economic Competitiveness, Social and Environmental Issues

Field	Author	Name
Economic Competitiveness dimension	• World Economic Forum (WEF) • OECD • UK Government BIS • University of Cambridge • US Bureau Economic Research • EC DG Enterprise • PROINNO • European Union	• Global Competitiveness Index (GCI) • OECD ST Industry Scoreboard • Regional Economic Performance Indicators • World Knowledge Competitiveness Index • National Competitiveness Capacity Index • Regional Innovation Monitor • Innovation Union Scoreboard-IUS • EU 2020 Indicators

Social dimension	• PNUD • World Bank • MERCER • European Union • New Economics Foundation	• Human Development Index (HDI) • COMPAS • Worldwide Quality of Living Survey • EU 2020 Indicators (inclusive growth) • Happy Planet Index
Environmental dimension	• Yale & Columbia, WEF, JRC of EC • Yale & Columbia, WEF, JRC of EC • Global Footprint Network • European Union • EC-DG Environment	• Environmental Performance Index (EPI) • Environmental Sustainability Index (ESI) • Ecological Footprint • EU 2020 Indicators (sustainable growth) • EU Environment Indicators

The benchmark found that, although quite widespread, international and with significant sophistication, the measurements frameworks available for whatever of the three dimensions mentioned lacked a focus on systemic approach. In other words, those metrics did not consider other dimensions and analysed economic, social and environmental issues as isolated elements. Even the most strategic frameworks obviate the complex and interrelated nature of each of them.

The same problem arises when trying to identify the notion of time and heritage determinants. In fact, because of the youth of many of these initiatives, the time series availability was usually reduced to five years, at best. On the other side, in terms of methodological designing, many of them were indexes built-up from simple or composed indicators around a certain conceptual model that explained the issue to be measured. In other cases, large scoreboards include several indicators without order and no aprioristic relationship. These benchmarks support the identification of a set of preliminary considerations before the definition of our methodological proposal.

3. New Measurement Methodologies for New Sustainable Approaches: The Sustainable Equilibrium Index

3.1 Some Preliminary Considerations

Although critical for a good evaluation and monitoring process when trying to improve public and private actions, measuring still presents sound limitations in whatever field we choose.

According to Paton (2010), most of these limitations can be grouped into three main fields, namely: (1) a poor design of indicators and metrics used to reflect quantitatively what it is that needs to be measured; (2) problems associated to difficulties in gathering information from the target population; and (3) difficulties in designing models that reflect, significantly, the trends and characteristics of the phenomena addressed.

Table 3. Limits and Barriers in Designing Indexes

Fields	Issues	Effects
Poor design of indicators & metrics	• Structural vs conjunctural • Units of measurement • The heritage barrier	• Not modeled disturbances • Low accuracy to targets • Restrictions in adding new measures
Problems in	• Geographical availability	• Lack of comparability

collection of data	• Lack of time series • Subjective responses	• Sort term foresight limitation (low significance) • Errors in what it is measured
Misunderstanding and errors in designing the models	• Weighting simple indicators • Correlations within groups & subareas • Uncontrolled confounding variable • Short term vision definition	• Subjectivity in model • Over importance of certain areas • Imperfect information (definition bias) • Inability to foresight

All the limitations referred in those three fields can lead to a range of suboptimal situations affecting the decision making process (Roberst, 1979; OCED, 2000). In fact, most of these issues can be found, to a certain extent, in the background experiences included in the second section. Our aim here is not to cover all these limitations regarding the traditional approach to measurements in economic, social and environmental fields but in terms of the two objectives stated in the introductory section: the interdependencies within those fields and the dynamic nature of the analysis.

Regarding the first objective, focused on a poor design of indicators and metrics, the most significant problems are related to indicators not able to reflect correctly the structural nature of the use to be tackled. This implies measures changing significantly when non-stochastic events occur and the impossibility to make any predictions. Secondly, the unit of measurement chosen is also a central issue in analysis such as ours where multiple dimensions are attempted to be combined. The most common approach here is to normalize them into one single unit of measurement. It must be highlighted, however, that this is not always possible due to the nature of what is it being measured.

Considering the second objective focused on problems in collecting quantitative data, geographical availability is probably one of the most severe ones. With no comparability, a good benchmark is not possible and individual results cannot be evaluated, only monitored. There is also a lack of achievable targets regarding leading references in each field of study. Some initiatives are facing this problem (e.g., European Cluster Observatory, Innovation Union Scoreboard and Regional Innovation Monitor) but still need improvements; basically because they limit their activities in gathering multiple sources of data and homogenizing them, with the problems this approach supposes.

In this second group of limitations there is a problem with the lack of long time series availability. This leads to difficulties in modeling the relationships between the variables and indicators chosen since the results (those with longest time series only accounts for 10-15 years) present low significance values.

Finally, regarding the problems of misunderstanding and errors in designing the models, they are mainly focused on typical econometric limitations linked to variables identification and choice decision. Subjective choices on weighting design and variables correlation usually lead to opportunistic model definitions (sometimes because of the limitations stated before and other times because of political preferences).

Some limitations must be considered when going through the following sections, as some of them are not faced or answered in the text. As mentioned in the introductory section, our aim is to consider them in order to improve the initial approach in the future. In this sense, some conclusions and

recommendations are included in the conclusion section.

3.2 An Initial Research: The Sustainable Equilibrium Index (SEI)

Following the "indexing" approach analysis in the second section of this paper, our methodological proposal lies on the use of a set of simple indicators covering a number of areas, namely demography, economy, employment, research and development and education (Note 1). These five areas comprise a total of 21 simple and composed indicators that give an overall socioeconomic picture of a territory.

All the indicators included in the analysis share the characteristic of enough time series availability and comparable at regional levels across Europe. The main source used was the European Cluster Observatory's indicators (http://www.clusterobservatory.eu) gathered mainly from Eurostat and the European National Statistics Institutes.

Table 4. Indicators Considered in the Analysis. Data from ECO

Area	No.	Indicator	Acronym
Demography	1	Population density (p/km^2)	Pd
	2	GDP per capita (EU ppp)	GDPp
Economy	3	Disp. income per capita (€ PPP)	Dincp
	4	Labour productivity (€ ppp)	Pr
	5	Business investment per employee	Binv
	6	Employment rate (%)	Emp
	7	Hightech manufacturing employment (%)	Htmanu
Employment	8	KIS employment (%)	HTServ
	9	Employment in business services (%)	Empadvse
	10	Long term unemployment rate (%)	Ltunemp
	11	Part time employment	Partemp
	12	Business R&D (%GDP)	BRDGDP
	13	Public R&D (%GDP)	PublicRD
	14	Business R&D personnel (%)	BRDp
R&D	15	Patents (million hab.)	Patm
	16	Patents Hightech (million hab.)	PatmHT
	17	Patents Biotech (million hab.)	PatmBIO
	18	Patents ICT (million hab.)	PatmICT
	19	Tertiary education (% 20-24)	TerEdu
Education	20	Vocational education (% 15-24)	VocEdu
	21	Lifelong learning (% 25-64)	Lifelear

These five areas are related (to a certain extent) as they are dimensions of what we defined as prosperity in the second section. According to our thesis, the coherence between all of them through time may be reflected accordingly to better prosperity level.

To reflect this coherence, we analyse the correlation between each indicator considering a period of 10 years. We calculate the Rho-Spearman correlation for each pair of indicators above:

$$\rho_{ij} = \frac{6\sum d_{ij}^2}{N(N^2-1)}$$

where "ρ_{ij}" is the Rho-spearman correlation between two set of variables "i" and "j", "d" is the difference between the orders of the two variables mentioned and "N" is the number of pairs.

As a result, a square correlation matrix for each given territory is obtained. This matrix has "n" rows and "n" columns where each element is the correlation value for each pair of indicators considering a 10 year' period. This matrix is symmetric with a value of 1 (total correlation) along the main diagonal and values in the rest of the matrix ranging from -1 (total negative correlation) to 1 (total positive correlation):

ρ matrix	I_1	I_2	I_3	...	I_n
I_1	ρ_{11}	ρ_{12}	ρ_{13}	...	ρ_{1n}
I_2	ρ_{21}	ρ_{22}	ρ_{23}	...	ρ_{2n}
I_3	ρ_{31}	ρ_{32}	ρ_{33}	...	ρ_{3n}
...	...	...	...	...	...
I_n	ρ_{n1}	ρ_{n2}	ρ_{n3}	...	ρ_{nn}
Total	$\boldsymbol{\Sigma\rho_{n1}}$	$\boldsymbol{\Sigma\rho_{n1}}$	$\boldsymbol{\Sigma\rho_{n1}}$	**...**	

Figure 1. Correlation Matrix for Each Given Territory

Using the information contained in the Rho-Spearman correlation matrix, two sub-indexes have been defined to analyse the interdependencies: the relatedness sub index and the consistency sub index. The first one (Relatedness Sub index—RI) is a relative measure of the degree of interrelationships between the components of the economic system for a given territory. It has been defined as follows:

$$RI = \frac{\sum \rho_{ij}}{Z}$$

where "ρ_{ij}" is the Rho-spearman correlation between two set of variables "i" and "j", and "Z" the total number of correlations.

Similarly, the information contained in the matrix has been used following the methodology proposed by Frenken et al. (2007) and Loss (2000) in the case of IO symmetric matrix, to mapping the relative position of each indicator for a given territory. We use here the MDS (Multi-Dimensional Scaling) method to put this information into a R^2 graph.

Form the coordinates identified in the R^2 graph, the second sub index (Consistency Sub-index—CI) is a relative measure of the degree of coherence between the components of the economic system for a given territory. It has been defined as follows:

$$CI = \sqrt{\frac{\sum_{i=1}^{N}(CoorX_i - \overline{CoorX})^2}{N}} + \sqrt{\frac{\sum_{i=1}^{N}(CoorY_i - \overline{CoorY})^2}{N}}$$

where "$CoorX_i$" is the coordinate for X axe and indicator "i", "$CoorY_i$" is the coordinate for Y axe and the same indicator, and N is the total number of indicators.

4. Unveiling Sustainable Equilibrium Patterns: A Comparative Analysis for Spanish Regions

4.1 Main Results at Spanish Level

The Relatedness Sub index (RI) and the Consistency Sub index (CI) have been calculated for each Spanish region using the information contained in the European Cluster Observatory. The results have been included in the table below:

Table 5. The Sustainable Equilibrium Index for Spain (RI and CI Sub-Indexes)

Rank	Region	RI	CI
1	Basque Country	,537	1,815
2	Navarra	,520	1,889
3	Catalonia	,511	1,819
4	Madrid	,493	1,827
5	Aragón	,483	1,741
6	Valencia	,468	1,790
7	Andalucía	,448	1,860
8	Castilla y León	,434	1,854
9	La Rioja	,431	1,921
10	Baleares	,429	1,928
11	Cantabria	,412	1,813
12	Murcia	,408	1,897
13	Castilla La-Mancha	,370	1,916
14	Galicia	,364	1,769
15	Canarias	,356	1,849
16	Asturias	,348	1,868
17	Extremadura	,321	1,886

As can be seen, both RI and CI values for the Spanish regions seem to show some kind of regional development level classification. In the case of the RI sub index, higher values are clearly linked to regions with higher economic and social performance. Therefore, considering the results, it may be understood that the degree of interrelationships between different dimensions within an economic system can be considered as a good measure of good systemic performance. This superior performance is supposed to determine, accordingly, the prosperity level of a territory, or, in other words, the future prosperity possibility frontier.

Therefore, if a region has big asymmetries in the performance of individual indicators (or entire areas), the value of RI will be low. Even if high values in some of them are shown (or precisely because of that), if the rest of the system performs below those figures, a long term disconnection is generated. This disconnection is probably related to severe structural problem.

In the table above, three separate groups can be made. The first one contains those regions with higher RI value, or in other words, those regions that seem to have a more balanced performance between the

different areas considered in the analysis. It seems that this classification is somehow related to the widespread thought of their relative position in terms of social and economic development.

A second large group is composed by those regions with a heterogeneous social and economic profile. According to their profiles, this group seems to include regions that perform quite well in some indicators (and areas) but not so well in others, resulting in a "threatening" inconsistency that is limiting their capacity to reach a sustainable growth patterns.

Finally, one last group presents regions with quite a low value that show a sound structural problem. The profile of these regions is characterized for being low in term of national average and very low in terms of the European ones. The low values regarding the CI sub index for these regions is quite likely a consequence of a complete asymmetric performance of every indicator (no one field contributes to the targets of the other fields) and an inexistence of a regional system on its own.

Table 6. Regional Patterns Regarding the Relatedness and Consistency Measures RI and CI

PATTERNS	CHARACTERISTICS	RI*	CI*
Pattern A	Regions with an outstanding coherence between the different determinants of the prosperity model. The development of one does not limit the development of the others, but foster it. Economic growth generates wealth that contributes to improve social and environmental conditions. In turn, social and environmental conditions contribute to maintain good economic basis.	(1.00;5.80)	1.73 +0.06 -0.09
Pattern B	Regions with good coherence between the different determinants of the prosperity model but with certain fields where linkages must still be fostered. The development of one does not limit the development of the others in most cases but some could contribute more. This regional pattern is characterized for not being among the top regions but among well performing ones towards a sustainable competitiveness.	(5.80;4.80)	1.80 +0.08 -0.12
Pattern C	Regions with medium coherence between the different determinants of the prosperity model. Some determinants still lack coherence within the regional system. Sometimes, the development of one does not contribute to the overall performance. In fact, it can suppose a limitation in the medium term. Some structural changes may occur before start considering it as towards a good sustainable competitiveness path.	(4.80;3.80)	1.86 +0.06 -0.07
Pattern D	Regions with low or very low coherence between the different determinants of the prosperity model. There is no a systemic approach on regional development understanding. Economic, social and environmental issues do not share a common approach and this leads to a sound threat in the medium and long term. Basic measures must to be developed in order to start considering a preliminary sustainable competitiveness strategy.	(3.80;0.00)	1.86 +0.05 -0.08

* Indicative ranges.

In the case of the CI sub index, the relationship between CI's values and economic and social performance is not very clear. The main reason for this is that consistence pattern may differ within a given classification regarding RI relative position. Higher CI refers to relative higher distances deviation between indicators. Therefore, considering the results, it may be understood that the degree of consistency between different dimensions within an economic system can be considered a good measure of the sustainability of good systemic performance. This superior performance is supposed to determine, accordingly, the prosperity level of a territory in the medium and long term, or, in other words, the availability to achieve the future prosperity possibility frontier.

So, although not so directly related to economic and social performance than RI, CI show lower figures to better positioned regions. In every group (A, B, C or D) regions can coexist with different CI values as this measure refers more to future possibilities than the present situation. Thus, those regions with lower CI (in whatever group) seem to have more chances to maintain and improve their already balanced performance.

On the other side, regions with higher CI values reflect larger distance deviation between indicators and a potential problem in the medium and long term due to a probable disconnection (leading to an interrelationship problem in the future).

To further contrast these results and the significance level of the RI and CI, the same exercise has been done for a set of European hubs of reference (Table 7) used as control groups. These hubs are thought to be some of the leading regions in terms of economic, social and environmental performance at European and international level.

Not surprisingly, all these hubs (apart from Berlin region) are above the Spanish regions in term of both RI and CI. These results seem to corroborate the thesis contrasted before for the Spanish case.

Table 7. The Sustainable Equilibrium Index for Main European Hubs (RI and CI Sub-Indexes)

Rank	Region	Country	RI	CI
1	Etela Suomi	Finland	,629	1,736
2	Île France	France	,619	1,793
3	Bayern	Germany	,592	1,734
4	DK	Denmark	,586	1,767
5	Baden-Württemberg	Germany	,583	1,647
6	Rhône-Alpes	France	,558	1,820
7	Brussels	Belgium	,543	1,859
8	Wallonia	Netherlands	,537	1,680
9	Basque Country	Spain	,537	1,815
10	Navarra	Spain	,520	1,889
11	Catalonia	Spain	,511	1,819
12	Berlin	Germany	,496	1,828
13	Madrid	Spain	,493	1,827

4.2 Detailed Results for 4 Spanish Regions

The analysis included in the previous subsection give us an overall vision of the interest in considering RI and CI as good measures for present and future analysis of systemic performances. However, this information can be used to further understand the phenomena identified and support strategic actions. In line with the contents before, the research in this subsection does not aim to analyse the possibilities under CI and CI exhaustively, but opens the debate to do so in the future.

Here we are going to analysis further the RI sub index. The question focuses on how each subcomponent (simple and composed indicator relationships) contributes to the overall figure of RI in each region. From all regions included in the analysis before, four have been chosen: Etela Suomi (used here as a control group), the Basque Country, Catalonia and Madrid.

Supposedly, those regions better positioned in the RI sub index have more balanced figures in most of the indicators (Etela Suomi and Basque Country) than the worse positions (Catalonia and Madrid). Even these differences are not very high in the case of the three Spanish regions.

In the case of Etela Suomi, the only indicators adding a significant disturbance are those related to R&D (business R&D and personnel). In this case, even considering the important level of other indicators, R&D figures can be considered as "too" high regarding the rest. This does not mean, however, that R&D efforts must be lowered, since the analysis is more complex than that (Note 2).

Table 8. The Sustainable Equilibrium Subcomponents

	Basque Country		Madrid		Catalonia		Etela Suomi	
	RI	%	RI	%	RI	%	RI	%
Population density (p/km^2)	0,035	6,49%	0,034	6,91%	0,033	6,49%	0,038	6,11%
GDP per capita (EU ppp)	0,034	6,29%	0,034	6,83%	0,035	6,92%	0,037	5,83%
Disp. income per capita (€ PPP)	0,034	6,29%	0,032	6,49%	0,035	6,92%	0,038	6,11%
Long term unemployment rate (%)	0,029	5,46%	0,010	2,10%	0,007	1,36%	0,032	5,15%
Employment rate (%)	0,033	6,22%	0,031	6,25%	0,033	6,44%	0,031	4,88%
High-tech manuf. employment (%)	0,002	0,42%	0,027	5,55%	0,018	3,59%	0,015	2,41%
KIS employment (%)	0,032	6,01%	0,025	5,01%	0,033	6,40%	0,036	5,72%
Labour productivity (€ ppp)	0,034	6,29%	0,032	6,44%	0,033	6,56%	0,037	5,83%
Patents (million hab.)	0,011	1,96%	0,008	1,64%	0,004	0,79%	0,025	4,04%
Patents High-tech (million hab.)	0,002	0,42%	0,008	1,53%	0,018	3,58%	0,037	5,93%
Patents Biotech (million hab.)	0,006	1,05%	0,009	1,86%	0,006	1,10%	0,032	5,06%
Patents ICT (million hab.)	0,028	5,18%	0,008	1,59%	0,030	5,80%	0,036	5,76%
Business R&D (% GDP)	0,034	6,25%	0,022	4,53%	0,027	5,38%	0,002	0,36%
Business R&D personnel (%)	0,033	6,13%	0,032	6,58%	0,029	5,58%	0,007	1,18%
Business investment per employee	0,035	6,61%	0,027	5,42%	0,029	5,67%	0,034	5,34%

Employment in business services (%)	0,029	5,37%	0,024	4,83%	0,022	4,28%	0,032	5,09%
Tertiary education (% 20-24)	0,032	5,94%	0,032	6,53%	0,026	5,02%	0,037	5,85%
Vocational education (% 15-24)	0,002	0,42%	0,018	3,66%	0,014	2,81%	0,032	5,13%
Lifelong learning (% 25-64)	0,033	6,14%	0,024	4,88%	0,019	3,64%	0,033	5,26%
Public R&D (% GDP)	0,028	5,13%	0,029	5,96%	0,030	5,96%	0,032	5,05%
Part time employment	0,032	5,92%	0,027	5,42%	0,029	5,72%	0,025	3,91%
Total	0,537	100%	0,493	100%	0,511	100%	0,629	100%

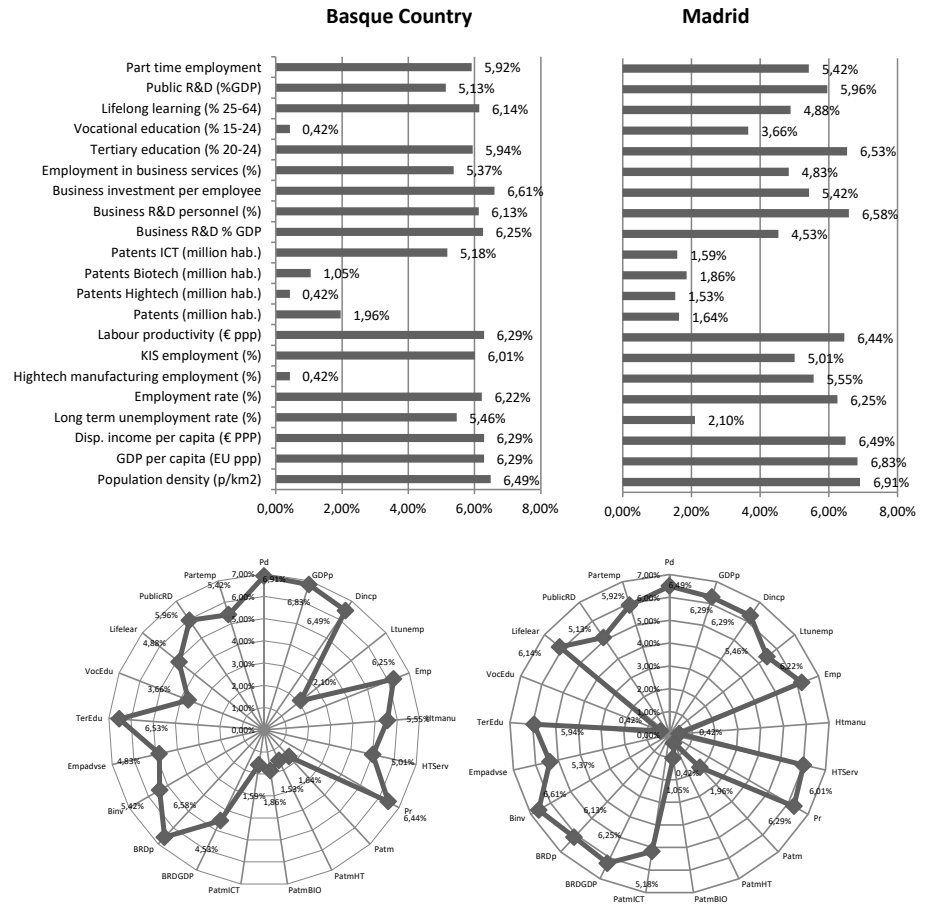

Figure 2. The Sustainable Equilibrium Subcomponents (I): Basque Country and Madrid

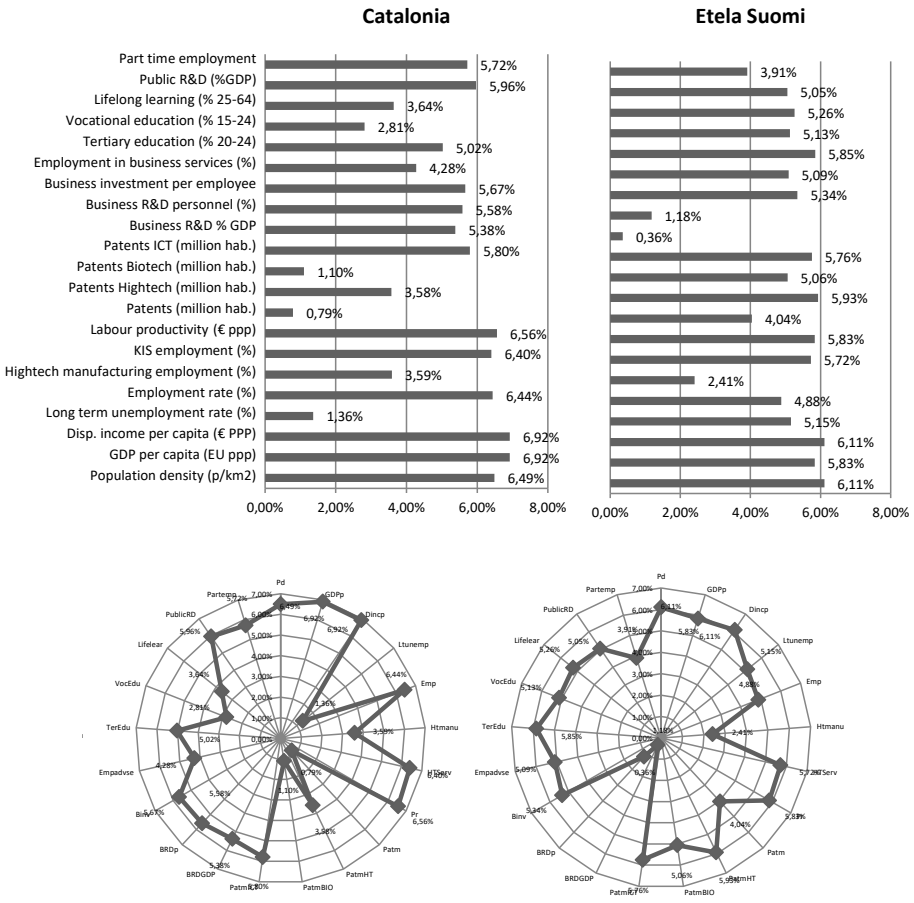

Figure 3. The Sustainable Equilibrium Subcomponents (II): Catalonia and Etela Suomi

Although not much higher than the finish control group, the Spanish regions chosen show quite balanced systems. The main disturbance is found in the patenting indicators, vocational education and long term unemployment.

In addition to that, the Basque Country shows potential interrelationship breaks due to low figures in high-tech manufacturing and vocational education. The reality seems to corroborate these results, as the Basque Country is highly specialized in medium tech industries and there is a lack of business needs orientation from the education sector (Orkestra, 2011).

Madrid presents low figures, basically, in the patenting indicators (all of them) and long term unemployment, though vocational education is not badly positioned. Again, these figures seem to corroborate the reality, since Madrid, even with the bulk of Spanish R&D resources (nearly to1/3 of total Spanish R&D), demonstrates a severe gap between research and commercialization. In fact, the Regional Competitiveness Strategy 2008-2011 focuses regional priorities on strengthening regional interdependencies between businesses and academia through clusters, science and technology parks and other intermediate infrastructures.

Finally, Catalonia also presents lower figures in some patenting indicators, long unemployment rates, high-tech manufacturing employment, vocational education and lifelong learning.

All three Spanish regions must focus their efforts not only in improving the figures of those indicators but, especially, on improving the value of the CI sub index and the measure of the availability to reach a sustainable competitiveness frontier in the medium and long term. For that, further analysis of distances deviation under the CI value is necessary.

Those regions with lower CI values have the indicators located much nearer one another than those regions with higher CI values. In any case, as can be inferred from the graphs, the Spanish regions share quite similar distances deviation patterns (represented in a trapezoidal shape), in contrast to the Finnish case (represented in a circular shape). The CI values associated to these figures vary from 1.81-1.82 in the case of Spanish regions and 1.73 in the case of Etela Suomi. First, Spanish regions show a more imbalanced distribution regarding the 4 areas (quadrants):

- The Basque Country locates most of its indicators in the upper right quadrant while those with lower contribution to RI are located far away from the main group (bottom left quadrant) and upper left (quadrant).
- Catalonia locates most of its indicators over the frontier between the upper and bottom right quadrants while those with lower contribution to RI are located quite far away from this group (bottom left quadrant mainly).
- Similar to the latter, the Madrid Region located most of its indicators over the upper and bottom right quadrants while those with lower contribution to RI (patenting indicators mainly) are located in the bottom right corner of the graph.
- However, Etela Suomi shows a deviation pattern where distances are not so imbalanced with an equal distribution across quadrants. That makes that the deviations associated decrease.

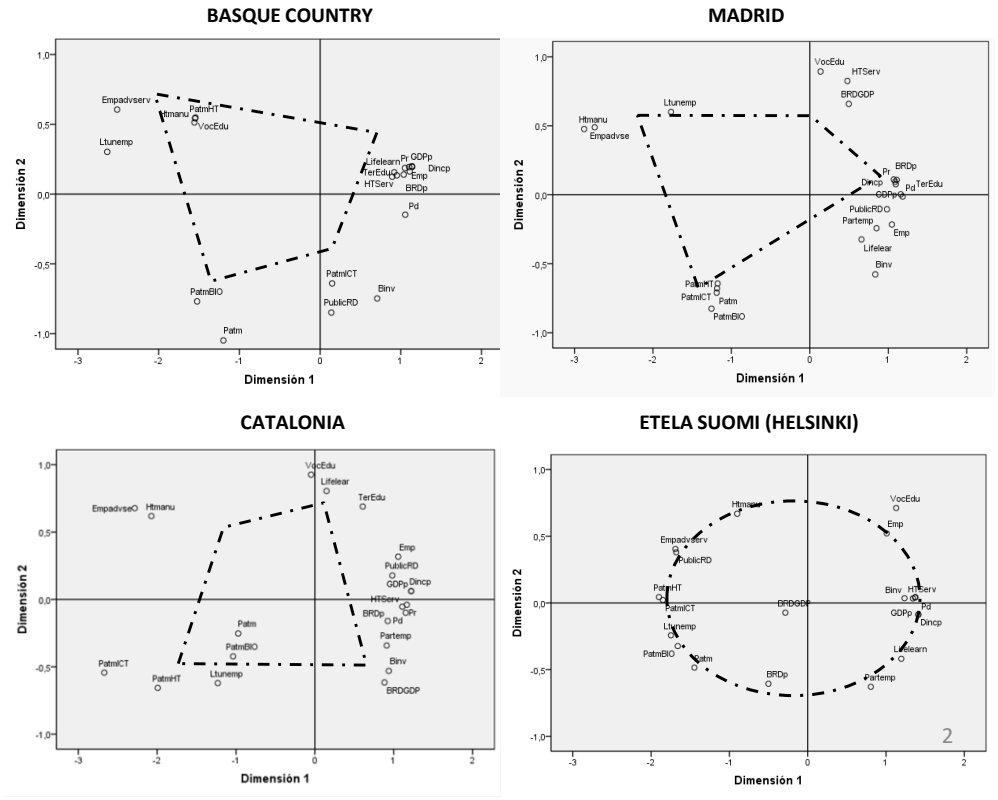

Figure 4. The Sustainable Equilibrium Patterns: Mapping Harmonic Consistency

At this point, Spanish regions must first reduce the overall distance between their indicators (they are 1.0 point in the X axis and 0.8 in the Y axis higher than the Finnish region) as well as moving to a "circle" pattern. To achieve this, target structural changes considering the interrelationship between them is necessary (going back to RI sub-index analysis).

5. Conclusions: Smart vs. Sustainable

Since the very first stages of regional development theories the notion of "systemic performance" was at the core basis of regional analysis. However, although well incorporated into academic debate, interrelationships and time determinants were scarcely put into practice.

Some remarkable limitations regarding the design of indicators, the collection of data and errors in the design of models have complicated demonstrating the systemic performance of regional development.

In this paper, we have proposed a quantitative methodology based on a new index that incorporates both interrelationships and time as variables that seem to explain the overall prosperity levels across regions.

According to the preliminary results, the higher the interrelationships are between the dimensions within a system, the higher the (perceived) prosperity level. Besides, since the index proposed is defined under a time series basis, the results also seems to demonstrate that path dependency determines, to a certain extent, the overall prosperity levels across time. Nevertheless, these

preliminary results must be considered with caution and from a critical perspective. Since the limitations mentioned have not been solved in this paper, further research would be needed in order to demonstrate our hypothesis with higher robustness. The challenge of future work will be focused on incorporating additional indicators regarding social and environmental dimensions that cover both geography and time availability. It is crucial to support, with statistical significance, the preliminary results presented here. In any case, the methodology proposed in this paper, and those instruments to be developed from it in the future, would undoubtedly be of interest for current regional policies focused on smart specialisation approaches.

Smart specialisation (and its related strategies) is a concept that has gained visibility due to its focus on efficiency, prioritization and critical mass of regional resources from a systemic basis. Besides, smart specialisation adds the notion of "sustainability" to ensure a regional development model across time.

Therefore, SEI, as well as the proposed methodology, would be a valuable instrument for those first stages of regional competitive analysis within a regional strategy. On the one hand, the index would add an additional measure to incorporate the "connectivity" issue into the analysis. On the other hand, the decomposition by individual indicators (from the global RI and CI) will also favor the identification of specific areas to focus prioritization. Finally, the SEI would also be a good instrument to complement the metrics of Europe 2020 and those proposed by the RIS3 Guide for evaluation and monitoring systems. More specifically, the proposed metrics will allow policymakers to identify the areas where the prioritization of regional resources is more advisable in terms of a "sustainable competitiveness model", and monitor it across time in the search for the optimum of the prosperity possibility frontier of any given region.

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Notes

Note 1. The reader must notice that, contrary to the insights stated in the second section, not all the three dimensions have been reflected here equally. This leads to consider some problems stated in the third category of limitations (misunderstanding an error in designing models). The main reason to continue with this ad-hoc risk is the unavailability of comparable data with enough time series. In any case, it will not affect totally to the demonstration of interrelationships and dynamics theories here proposed.

Note 2. RI and its subcomponents are relative measures of imbalances between indicators both when the values are too high or too low. The model here states that according to the hypothesis the investment could be over the optimum considering the other regional figures.