STATISTICAL VISIONS FROM THE STeMA APPLICATION: A JOINT TRIAL

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1. Problem definition and objectives

Economists, researchers and policy makers have long debated around the issue of territorial cohesion. As many authors (Evers *et al.* 2009; Böhme and Gloersen 2011 and Nosek 2017) point out, territorial cohesion is not easily definable, and its meanings and conceptions remain somewhat ambiguous. While some researchers perceive this ambiguity as a disadvantage, others have found it to be an advantage resulting in an opportunity (Colomb and Santinha 2014; Davoudi 2005).

Among the different conceptualizations provided in the literature around the topic, territorial cohesion ought to be unequivocally considered both a political concept (confirmed by the its increasing relevance at the centre of the cohesion policy of the European Union), and a question of policy planning, so that policies are increasingly cut off from the different territorial levels. From an operational standpoint, territorial cohesion is commonly conceived as a multidimensional concept, complex and sometimes contested (Collier, 2006; Hy Dao, 2017), composed of multiple dimensions, which are interconnected in intricate ways.

By definition, a dimension refers to an aspect of a given concept to be described (Alkire, 2002) and this requires the need to search broad consensus about the major dimensions of territorial cohesion. The literature developed in the last twenty years presents different dimensions and storylines chosen to explain and measure territorial cohesion (ESPON 2006; ESPON 2008, ESPON 2011a and b; Medeiros 2013, 2016 and 2019; Farrugia and Gallina; Waterhout, 2007; Prezioso, 2006 and 2008).

If conceptually these two approaches to the meaning and extent of territorial cohesion are attributable to two different models, the OECD tree model on the one hand (OECD 2008), and the Haier approach for policy analytics method on the other (Haier 1989 and 1993) and lead the first to a single meaning of territorial cohesion and different meanings the second, as Abramhs (2014, p. 2140) highlights

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"they both show an underpinning trust in essences, i.e. they both believe that a concept has an inherent set of components that can be identified and modelled into a coherent definition".

A renowned approach and adequate tool to measure multidimensional and complex concepts is the STeMA approach (Prezioso 2006, 2011a and 2018; Carbonaro, 2006 and 2011); the concept of territorial cohesion is indirectly represented, grounded also on Europe 2020's guidelines, comprising four core dimensions or determinants: 1) *Smart Growth*; 2) *Sustainable Growth*; 3) *Inclusive Growth*; 4) *Resources and Funds*. The method in PRIN has been developed with reference to Italian regions and provinces.

This paper attempts to evaluate some of the results obtained through the STeMA approach. One can evaluate the solution of the STeMA approach in a more streamlined manner, as a composite index [1], one for each dimension, able to rank the regions and provinces based on the key territorial cohesions' four dimensions. Below this analysis provides details about these results and the analysis indications and policy therefrom derived.

2. Materials and methods

The STeMA method specifies territorial cohesion by four core dimensions or determinants: 1) *Smart Growth*; 2) *Sustainable Growth*; 3) *Inclusive Growth*; 4) *Resources and Funds*.

The determinants also are complex phenomena with their specific characteristics identified by elementary indicators; the aggregation of the elementary indicators provides the categories; from these they are passed, again by synthesis, to the sectors and from these to the typologies; finally aggregating the typologies the determinants are obtained. The concept of territorial cohesion is articulated, therefore, in five levels, placed between one another in hierarchy: the indicators constitute the lower level and of maximum detail of the information available; categories, sectors and typologies represent intermediate levels and all contribute to the explanation of determinants (last stage of aggregation).

Each dimension may have a different number of indicators able to characterize it: 9 indicators for the determinant of *Smart Growth*, 28 for *Sustainable Growth*, 27 for *Inclusive Growth* and 10 for *Resources and Funds*.

For example and for space requirements with reference to *Smart Growth* dimension only, the indicators are nine (in brackets the acronym): 1) *Internet users* (UI); 2) *Ultra wide band access* (BUL); 3) *Internet in the Public body* (PAI); 4) *Structure education to the creation of knowledge* (PL); 5) *Index of innovative dependency* (IDI); 6) *Population with three years degree* (PET); 7) *Population in lifelong learning* (PLL); 8) *R&D Infrastructures* (RDI); 9) *Telecommunication development level* (RL).

The STeMA method works by means of a matrix 21 x 9 at regional level and 110 x 9 at provincial level. The rows represent regions or provinces, while the columns show the values of each of the 9 elementary indicators. The matrix is the initial basis for the system data: regional, or provincial, ex ante data. The values of the indicators are then subdivided into four groups, to which the ranks A to D are associated on the basis of the observed maximum and minimum values for each indicator and the three quartiles (for example, in decreasing order, the first group of values (rank A) is obtained from the maximum value and from that of the third quartile and includes the last 25% of the values, the second group (rank B), is characterized by the second and third quartile, the third (rank C) from the second and first quartiles and finally the last group from the minimum value and from the first quartile (rank D).

3. Results and discussion

As previously stated, the value of the applied methodology resides indeed in its capacity to create a circular process which can be implemented on the basis of the necessary policy actions to achieve set objectives in view of the effects they may have on each indicator and ultimately on each determinant. By comparing ex ante and ex post values of indicators first and then composite indices, evaluation is obtained of the effectiveness of policy actions, an indication of the need to redefine their scope and indication of the needs of specific actions.

Consider policies for the Europe 2020 strategy in relation only to the goal of smart growth and use the simplest possible symbolism.

These policies, denoted with Aj (j = 1,2,...m) in total 40 for all three objectives of Europe 2020, are 13 only for the goal of Smart Growth and are related to 12 effects Ci (1,2,...,n) that are intended to be realized by them. Each policy is considered a binary variable that takes value 0 or 1 respectively if the policy in not chosen/you choose to carry it out Table B.1.

Then we have the B matrix 12*13, policy effects, policy action Aj (j = 1,2,...h), the latter relating solely to the determinant (strategy) Smart Growth. The cells within the matrix indicate effectiveness – high, medium, low, and zero respectively – of each policy intervention in generating the effect, starting from the decision to implement a specific policy (Aj = 1). STeMA denoted them by bij (B matrix of the weights) and with the numbers 3,2,1,0 the weight of each intervention in terms of the ability to generate a given effect. These values are prefixed and different in each row, in relation to the different effects.

One may start with possible policy choices. In total, there are m (13) policy interventions related to the smart growth objective. However, since some interventions do not generate effects (capacity = 0), the eligible choices are reduced to k, 8 for example in relation to the first effect (Population increase 'surfing in the digitalisation') still at 8 for the second (Process/product innovation), at 5 for the third effect (Increase the access to the universitary education) and so on until the last one (Sustainable tecnological change in supporting CC adaptation), the twelfth effect for which the actionable interventions are reduced to 7.

Denote with Bi. the sum of all the capacities that policy choices have to generate a certain effect relative to all three objectives of Europe 2020 (smart growth, sustainable growth and inclusive growth) and you get for example 44, 49 and 23 for the first 3 effects and so on until the last effect in relation to which the ability to generate it through the 40 possible policy choices is 43. These row sums can be read as the potential capacity of policy actions to generate a certain effect when implemented as a whole. Denote with B'i. (i = 1,2,...12) the sums of the capacity of the policies with

Tab. B.1 - Policy choices and policy effects with reference to Smart Growth matrix.

				Education and Human Capital		Digital society					Innovation and R&D			Transnport/Network		
				supply of education	Human capital internationalisation	Brinding digital divided and digital transition	Technologica/innovatiove dissemination for the enterprises and institutions	Support tp transnational cooperative projects	Use/development of environmental friendly technologies	Quality certification and assessment tools	R&D infrastructures	Support to BAT	Development of recycling tecnologies and products (circular economy)	Development of comunication networks	Development of energy networks	Increase of Phisical accessibility
Effects	**Ci**	**Bj'**	**Bj**	0	0	0	0	0	0	0	0	0	0	0	0	0
population increase 'surfing in the digitalisation'	0,00	0	44	3	2	3	2		1		3	2		1		
process/product innovation	0,00	0	49		3	2	3	1	2	1	2		1			
increase the access to the universitary education (magistrale)	0,00	0	23	3	2	1		1				2				
increase the access to the tertiary education level (triennale)	0,00	0	23	3	2	1		1				2				
increase of life-long learning	0,00	0	12	1	2											
reduce of social-exclusion risk (poverty) and increase of societal well-being	0,00	0	28	2	2											
increase of relation infrastructures and network	0,00	0	49			3		2					2	3	3	3
increase level of aid to innovative and sustainable business creation	0,00	0	56		3	2	1	2	2	3	2	2	2	2		
increase of coehesion between firms, institutions, population	0,00	0	34	2	3				2				2	3		
increase of productivity	0,00	0	46		2	2	1	2		3	2	2	2	1		
Internazionalizzazione	0,00	0	19	3	3	2	1	2						2		
sustainable tecnological change in supporting CC adaptation	0,00	0	43				3	3	3	2	3	1	3			

Source: Author's interpretation

regard to the single objective of Smart Growth. If the real capacity of the polity actions shall be considered as percentage shares of potential capacity Bi. (that is B'i./Bi.*100) you get the result of the effectiveness of the policy actions related to the goal of Smart Growth on each of the 12 desired effects, the vector C, (for example 39% for the effect of Population increase 'surfing in the digitalisation', and the two highest values 68% and 42% related to the effectiveness of these policies on internationalization and sustainable technological change in supporting CC adaptation).

The values ci (i = 1,2,...n = 12 effects) are then attributes to each of the 9 elementary indicators previously introduced, based on the weight matrix D of policy impacts on each indicator in determining that effect and you get the matrix D'(modified policy impacts). Again, the weights of the policy impacts are 3, 2, 1, 0 for the greatest impact up to zero, respectively. The column sums in matrix D show the total potential impact of all policy effects on each indicator; the column sums of matrix D' the weighted average impact on the single indicator, that is the impact which each indicator actually receives in relation to each effect, taking into account the weight of the impact on the indicator.

Tab. B.2 - Effectiveness of the policy actions related to the goal of Smart Growth on each of the 12 desired effects and weight matrix D of policy impacts on each indicator.

Effect	Matrix D (weights)									Ci
1	3	2	3	1	3	2	1	1	3	0,386363636
2	2	3	2	2	2		1	2	3	0,306122449
3	2			3	3	2	2	1	2	0,391304348
4	1			3	3	3	2		2	0,391304348
5	2	1	1	3	3	2	3		2	0,25
6	2		2	1	1	2	1		2	0,142857143
7	2	2	1	2	2			3	3	0,326530612
8		2	1	3	3			2	1	0,375
9	1	1	2						3	0,352941176
10	1	2	2	2	2	2	2	2	2	0,369565217
11	3	3	1	1					2	0,684210526
12			1						1	0,418604651
	19	16	16	21	22	13	12	11	26	

Source: Author's simulation

Matrix D and vector C give the matrix D' (modified policy impacts).

Then the values of matrix D' shall be divided into four groups on the basis of maximum and minimum values and three-quartiles. Finally by comparing the normalized column sums with the values of the three quartiles (and maximum and minimum) are assigned to the same gamma values as 0, 1, 2 or 3. This will serve to change the values of the indicators and to evaluate the gains of the policies (Carbonaro, 2006).

Now we want to think about a previous step, namely the effectiveness of policies and consequently the effectiveness of policy impacts on indicators to draw some useful considerations for policy decisions. Start with a simple reading of the D and D's matrices about the ability of Smart Growth policies to generate the twelve effects concerned and consider reading per line and column of the D or D' matrix.

Being the weighting matrix D policy impacts assigned, each row in the D' matrix shows the capacity distribution of policies for each effect based on the relative weight assigned to each indicator for that effect (policy impacts modified).

For example, for the first effect, Population increase surfing in the digitalisation, capacity equal to 0,3863 is allocated for (3/19) to the first indicator, where 19 is the row sum of weights, 2/19 to the second indicator and so on. Similarly, the capacity of policies to generate the second effect (0,3061) is attributed with a weight of 2/17 to the first indicator, 3/17 to the second and so on.

Saying the same thing differently, capacity for example 0,3863, being a constant relative to the distribution on the 9 indicators determines an impact of the policies (now for the first effect) which potentially ranks, between 27 (maximum impact or all 3 on the same row, and so 27 is the sum of weights) and 1 (minimum impact, excluding a sum of weights equal to zero because it does not make sense) on all indicators.

Tab. B.3 - Matrix D': capacity distribution of policies for each effect (policy impacts modified).

1	0,0610	0,0407	0,0610	0,0203	0,0610	0,0407	0,0203	0,0203	0,0610	0,3864
2	0,0360	0,0540	0,0360	0,0360	0,0360	0,0000	0,0180	0,0360	0,0540	0,3061
3	0,0522	0,0000	0,0000	0,0783	0,0783	0,0522	0,0522	0,0261	0,0522	0,3913
4	0,0280	0,0000	0,0000	0,0839	0,0839	0,0839	0,0559	0,0000	0,0559	0,3913
5	0,0294	0,0147	0,0147	0,0441	0,0441	0,0294	0,0441	0,0000	0,0294	0,2500
6	0,0260	0,0000	0,0260	0,0130	0,0130	0,0260	0,0130	0,0000	0,0260	0,1429
7	0,0435	0,0435	0,0218	0,0435	0,0435	0,0000	0,0000	0,0653	0,0653	0,3265
8	0,0000	0,0625	0,0313	0,0938	0,0938	0,0000	0,0000	0,0625	0,0313	0,3750
9	0,0504	0,0504	0,1008	0,0000	0,0000	0,0000	0,0000	0,0000	0,1513	0,3529
10	0,0217	0,0435	0,0435	0,0435	0,0435	0,0435	0,0435	0,0435	0,0435	0,3696
11	0,2053	0,2053	0,0684	0,0684	0,0000	0,0000	0,0000	0,0000	0,1368	0,6842
12	0,0000	0,0000	0,2093	0,0000	0,0000	0,0000	0,0000	0,0000	0,2093	0,4186

Source: Author's simulation

As a result, weights for each effect on the nine indicators can be considered, for example, 19, the total weight for the first effect, 17 for the second, 15 for the third effect and so on. From the structure of the weights can be obtained useful indications about the situations (in the present application, the effects of the policy) that determine particularly unsatisfactory (or, vice versa, satisfactory) impacts of the policies when each effect is attributed to the 9 Smart Growth size indicators. Subsequently, the following simple methodology is proposed. It is an initial exploratory analysis of policy impacts on all 9 indicators for each effect.

Three-quartile are considered for each effect in relation to the real values of weights (maximum value 19 and minimum value 2). In the literature the calculation of quartiles is done taking into account the number of the collective, multiple of 4, and otherwise, the rest that is obtained by dividing the number of the collective by 4 (e.g. 1, 2 or 3). In the present case, since there are 12 effects, the four partial distributions each containing 25% of the units are formed by the sums of weights 2,7,10 (first distribution); 11,12,14 (second distribution); 15, 15, 17 (third distribution) and finally 17,17 and 19 (fourth distribution).

The quartiles are therefore: Q1 = 10,5; Q2 (median) = 14,5; Q3 = 17.

Only the problem remains that the value 17 is the last mode of the third partial distribution, as well as the first mode of the fourth partial distribution. This will be solved by considering the variability of the three distributions whose sum of weights is 17.

It is therefore defined:

- low impact of the policies is that attributed to the effects when the weights on indicators are below the first quartile (10,5);
- medium-low impact of the policies is that attributed to the effects when the weights on indicators are between the first and the second quartile (10,5 and 14,5);
- average impact of the policies is that attributed to the effects when the weights on indicators are between the median and the third quartile (14,5 and 17).
- high impact of the policies is that attributed to the effects when the weights on indicators are equal or greater than 17.

Table B.4 shows the results obtained. It should be noted with the same weight of 17, the tenth effect is classified in the average impact category because its weight distribution is less variable (measured by the Pearson coefficient of variation, CV) than the weight variability of the other two effects. The three coefficients of variation are, as a percentage of the average, respectively 28,211 (second effect), 36,735 (fifth effect) and finally 16,638 for the tenth. Thus, there are four groups of equal number.

Even more interesting is the column reading of the matrix D. By column you have the sums of weights attributed to each indicator or, considering the matrix D' the weighted average of the effects on each indicator considered individually. By reasoning as before and taking into account that the maximum possible impact on each indicator is 36 and the minimum 1, and really 11 and 26, considering more simply to divide the values of the weights in three groups it is possible to identify the indicators that receive an impact low, medium and high by all twelve the effects of policies (Table B.5).

Finally, it should be noted that the results obtained according to the D matrix of weights correspond to those obtained on the D matrix. (modified policy impacts).

4. Conclusion and further research

As already stated, the value of the STeMA methodology applied in fact resides in its capacity to create a circular process which can be implemented on the basis of the necessary policy actions to achieve set objectives in view of the effects they may have on each indicator and ultimately on each determinant. By comparing ex ante and ex post values of indicators first and then composite indices, evaluation is obtained of the effectiveness of policy actions, an indication of the need to redefine their scope and indication of the needs of specific actions.

In the STeMA methodology, two weight matrices are crucial. Matrix B enables political actions to be transformed into the desired effects (vector C), while matrix D distributes, on the one hand, each effect on the indicators of the determinant in question and, on the other hand, the totality of the effects on each indicator considered individually.

Tables B.4 and B.5 correspond to the reading of the matrix D in two ways.

Horizontally, Table B.4 documents the effects of policies that provide unsatisfactory results on the different indicators, in the case examined on all 9 smart growth indicators. This suggests a circular use of information, and therefore a return from the aggregate measure provided by the vector C lines and, therefore, on the results of the effectiveness of the policy actions related to the goal of smart growth on each of the 12 desired effects. For example, the low impact of the policies related to twelfth effect, (Sustainable technological change in supporting CC adaptation); the Ninth effect (Creation of cohesion between firms, institutions, population) and the eleventh effect (Internationalization) each effect on the nine indicators of Smart Growth suggest that, despite a high effectiveness of the policy actions, one could imagine a different choice of indicators.

It's the case of the effect of Internationalization that although strongly determined by policy interventions (it's the highest value of 0.6842, as stated in Tab. B.3) ends up having an impact on only two of the nine indicators of smart growth.

Vertically, the reading of matrix D and Tab. B.5 informs on the impacts of all twelve effects on each indicator. The consideration here is for the three indicators, the Eighth indicator *R&D Infrastructures* (RDI); the Seventh indicator *Population in lifelong learning* (PLL); the Sixth indicator *Population with three years degree* (PET) for which there is a low impact of all the effect of the policies, the structure of the weights is such that more results would be obtained with a uniform distribution of the same (in the case of the sum equal to 11) or the same result (12) or a result only slightly greater (13).

Tab. B.4 - Impact of the policies related to each effect on the nine indicators of Smart Growth matrix.

Impact	Weight	Effect
Low	2 7 10	Twelfth effect, (Sustainable technological change in supporting CC adaptation); Ninth effect (Increase of cohesion between firms, institutions, population); Eleventh effect (Internationalization).
Medium-low	11 12 14	Sixth effect (Reduce of social-exclusion risk – poverty and increase of societal well-being); Eighth effect (Increase level of aid to innovative and sustainable business creation; Fourth effects (Increase the access to the tertiary education level).
Average	15 15 17 (CV = 16,638)	Third effect (Increase the access to the universitary education); Seventh effect (Increase level of aid to innovative and sustainable business creation); Tenth effect (Increase of productivity).
High	17 (CV = 28,211) 17 (CV = 36,736 19	Second effect (Process/product innovation); Fifth effect (Increase of life-long learning); First effect (Population increase 'surfing in the digitalisation').

Source: Author's simulation

Tab. B.5 - Impact of all the effect of the policies on each indicator within Smart Growth matrix.

Impact	Weight	Indicator
Low	11 12 13	Eighth indicator R&D Infrastructures (RDI); Seventh indicator Population in lifelong learning (PLL); Sixth indicator Population with three year degree (PET).
Average	16 16 19	Second indicator Ultra wide band access (BUL); Third indicator Internet in the Public body (PAI); First indicator Internet users (UI).
High	21 22 26	Fourth indicator Structure education to the creation if knowledge (PL); Fifth indicator Index of innovative dependency (IDI); Ninth indicator Telecommunication development level (RL).

Source: Author' simulation

Saying otherwise the same thing, and referring now to the matrix D', the use of the average simple compared to the weighted one would lead to negative gains, null or not very positive.

This has an important effect since the reading of the column results of the matrix D' develops the comparison between regional (or provincial) ex ante data and regional ex post data and finally between the latter and those territorialized.

A simple application of this kind, which shows the potential of double clustering (compared to rows and columns), is to be placed, finally, in the continuous updating of the STeMA method, aimed at filling, in the matrices of weights B and D, the white cells.

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