

# Regional Intellectual Capital Formation: A Computational Approach

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**Abstract:** The purpose of this paper is to test empirically the potential of Intellectual Capital (IC) as a driver of formation of cross border coalitions in European Union (EU) regions. The question is important given that, at present, economic and social cohesion is a major factor of stability in the EU. We use a computational model based on different similarity matrices, for the cross-border cases of Portugal and Spain and for Hungary and Romania, respectively. We find that the results differ with the form of attraction we suppose between the regions, namely driven by diversity or conservative. At least the potential for attraction between such regions, based in IC, may be a useful approach for modeling. We believe that our model should be replicated in other EU regions, and thereby increased in depth. However, we regard our results as a promising step towards understanding some important organizing principles for the multi-regional economics of the 21<sup>st</sup> century.

**Keywords:** Metro-regions, cross-border regions, intellectual capital, innovation, complementarities and cooperation, cultural settings

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## 1. Literature review and theoretical model

Intellectual Capital (IC) is considered to be a relatively new concept (Edvinson and Malone 1997) intended solve the increasingly complex problem of the definition of the value of companies and organizations which have many knowledge-related activities, mainly within our so called Information Society. IC is also related to the Knowledge cycle in organizations (Nonaka and Takeuchi, 1995). A multitude of measurement methods for IC were presented (Sveiby, 2012), and the models were applied to countries (Bounfour and Edvinsson, 2005; World Bank, 2012) and cities (Rodrigues and Tomé, 2010) as well. Regional development pursued by regional policy, for instance with the creation of “poles of development” was put forwards already in the sixties (Hansen, 1967), and regional studies received increasingly more attention from scholars following the studies of Krugman (1991) on economic geography. The localization of successful businesses requires the local availability of IC assets, in its various forms. Positive, virtuous cycles of prosperity and vicious cycles of decay and poverty are generated by the existence or inexistence of IC in a given region.

Accordingly, in this paper we aim at bridging a “research gap” between common studies about IC in companies and countries (Bonfour and Edvinsson, 2005) and regional IC as a promoter of the region’s success – especially when focused on various cross-border regions. This is our goal and our research question. The problem is important because such regions are both abundant and widely scattered all over the European Union (EU). We believe that in the current phase of the evolution of the EU, the regional dynamics is decisive for balancing the Eurozone trend. Therefore, at the EU level, such and related studies are and will be highly relevant. Considering various NUTS-based (or otherwise elaborated) regionalization schemes for the EU one may observe that regions, including many adjacent regions, are indeed differing with respect to a series of important aspects and that they do so in more or less unexpected ways. Transforming a status quo into a more advantageous situation in terms of IC potential – for instance by reviving past (forgotten) industrial-intellectual traditions in some cross-border regions – would require bold approaches, which must be based on high acceptance levels of the region’s citizen.

In order to answer our research question we take several steps. In section 2 we review the literature on IC and regions and discuss a qualitative scheme for connecting cultural settings with the formation of IC via innovation and successful economic utilization allowing different functional and content-based points of view, which may also imply a critical role of regions in the process. Then in section 3 we summarize some known studies on the matter. In section 4 we define the computational model we used for assessing chances of cooperation between our regions. Section 5 presents the results of our analysis, which are further discussed in section 6. Section 7 ends the paper, with the presentation of its conclusions, limitations, implications and some ideas for future related research.

## 2. Literature review and theoretical model

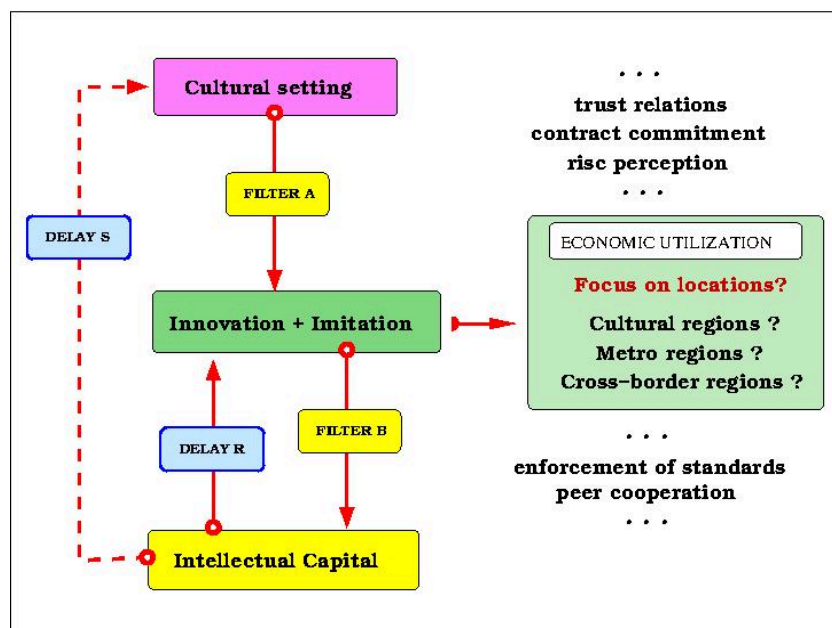
### 2.1 Regional IC as a promoter of long term success?

Historically, Europe has seen many regions (including metro- and cross-border ones) rise and fall. We do not expect this to be fundamentally different for the south and south-east European regions, especially owing to the fact that modern societal progress is to a lesser degree tied to Intellectual Capital which derives from extremely capital intensive and high-tradition, knowledge-oriented industries (big science, defense, etc.), but depends more readily on certain types of socio-technological flexibility and (learned, inherited) creativity within the local populations. In fact, this evolution comes very much to the advantage of hitherto less developed and sometimes “marginalized” European regions. One may observe, in addition, that south European cities enjoy features which are often much closer to what one may term “agreeable urbanism” than their north European cousins (both in aesthetic and in functional terms). Potential complementarities may be exploited, thus developing more and also new forms of regional IC. Such regional IC is in turn closely related to the influence of local entrepreneurship and local innovation capacity (Audrescht et al. 2005, Cook 2007, Chung et al. 2012 ).

Intellectual Capital (IC) may be formed with an accelerated rate in and around urban centers but also in other designated locations like cross-border regions. IC formation is very probable in high growth cities while the case of IC growth in cross-border regions remains less probable; it is uneven and it deserves more investigation. Within cross-border regions there is also a tendency for people to migrate towards important national urban agglomerations. The chances of effective IC formation in cross-border EU-regions must thus be weighed against the respective outward migration tendencies.

### 2.2 Theoretical model: Co-determination of IC formation by particularistic, systemic and cultural factors

We think of a dependency chain which starts with the cultural settings (mind-sets) in a population (Figure 1). These settings are themselves long term and therefore the least removable. They include many behavioral and valuation features in the (regional) population, depending ultimately on religious imprinting and deep rooted tradition, which influence the ease and the intensity of canalizing individual and group problem solving potential into effective innovation and, eventually, into lasting IC.



**Figure 1:** A qualitative scheme for linking cultural settings to innovation and to IC formation. Within these nested cycles the role of regions can be critical

Filter A, acting on the forwarding of new ideas and solutions is a result of the culturally conditioned trust relations prevailing between persons, their credible commitments and their risk perception, which tend to "control" what is

considered worthwhile to be pursued by innovation and imitation. Adopting new ideas, techniques, etc., by means of innovation and imitation then leads to - more or less successful - economic and social utilization. Being at this point part of a particular region can have catalytic or detrimental effects, depending on the region's characteristics. Filter B may be thought of as selecting those outstanding (i.e. remarkable, successful) innovations which may integrate more easily into an existing edifice of IC. With some delay (R) intellectual capital will feed back into the innovation and imitation block, possibly enhancing these further. The formation of IC itself is enhanced by *successfully building standards and cooperation*. Hence, it seems worthwhile to study condition under which cooperation may occur more frequently. This can be done by considering socio economic agents, like firms and consumers, but also by considering regions and certain *inter-regional flows* of information and innovation (see the examples in Varga 2007). Other factors and relations of interest are instances of *inter-regional co-innovation* (Chessa et al. 2013).

Finally, the notoriety and success of IC may find its way back into regional culture itself, albeit with a longer time delay (S), gradually changing some of the cultural settings. They in turn will influence the filters but also the delays. Cultures and regions may actually differ a lot by such entities, like *gestation delays*. For instance, countries like the USA may have relatively short delays  $S > R > 0$ , while others may have much more *restrictive filters* and longer delays, the latter spanning over many generations.

### 2.3 Theoretical model: Possible role of a multi-disciplinary recommender system: A test for regional IC

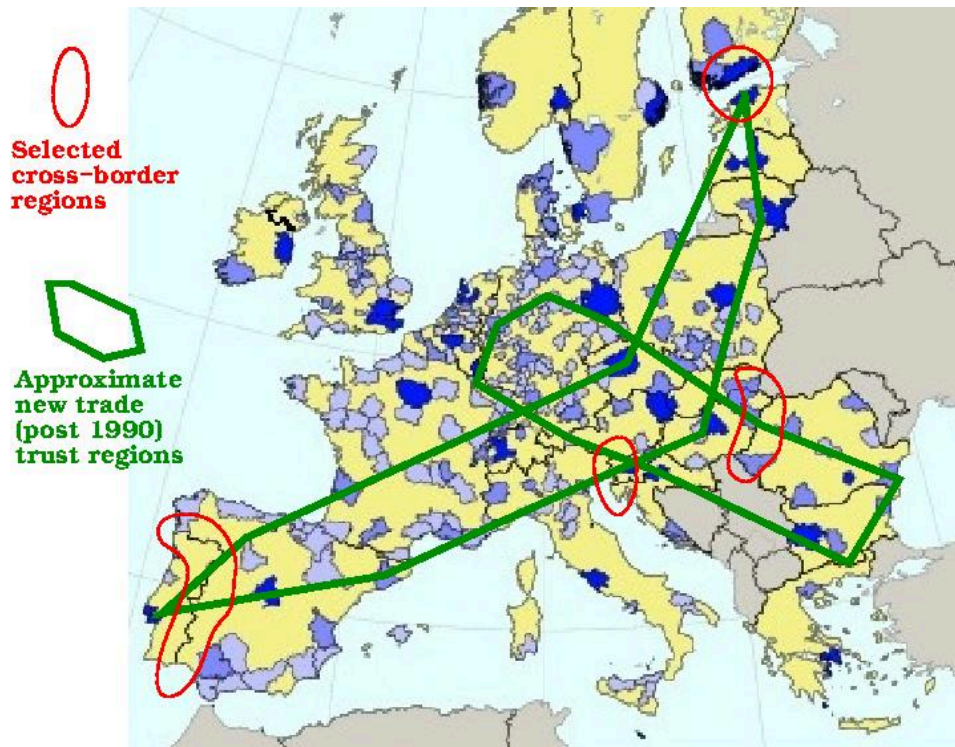
If we are thinking about using recommender systems in the wider context of regional IC formation, one would attempt to develop mechanisms by which recommendations may lead to a significant probability of influencing (i.e. "convincing") a critical mass of persons to adopt potentially useful new socio-technological procedures. In order to gain acceptances and to *increase trust* such recommendations cannot as aggressive as the usual commercial variants may be. They may find ways to *display complementarities*, which are, almost as a rule, multi-disciplinary by nature. By now there is considerable experience with purely commercial recommenders (Ricci et al. 2011) but also with other, more explorative variants like, for instance, educational recommender systems. Furthermore, the recommender must find adequate ways to address the specific interests of all those who can benefit from enhanced regional IC formation:

- ventures capitalists investing in innovative regional (e.g. cross-border) services and technologies;
- policy makers designing guidelines for metro-region & cross- border development policies;
- employers' federations and citizens' interest groups.

Finally, the recommender may integrate *innovation contests* (Malone et al. 2010) and *prediction markets* (Pennrock et al. 2001). Both are internet-based coordinated activities which try to interfere with often highly non-standardized complex socio-technological networks and processes. Massively data based recommenders may reach superior results in terms of anticipating (i.e. correctly forecasting) and influencing, especially when compared to the case of using a few domain experts.

### 3. Known studies: First steps towards mapping regional IC – different resolutions on accessible data

Each cross border region has its own historical (and hence also "path dependent") development trajectories, which may explain a larger part of its development success (or its relative backwardness) by means of specific patterns of political and economic interpersonal relations and random events. However, one should not completely exclude the action of systemic forces, a situation which may indeed be modeled by more or less formal approaches. For instance, successful generators of IC based on export-oriented, locally clustered industries are the regions containing the so called "Hidden Champions" (Simon 2009) of traditionally capitalist Western Europe. They form an interesting category of regionally clustered firms, having i) a strong "personalized" tradition, ii) a strong tendency towards exports, and iii) certain dominating, not marketing-centered, process and product quality concerns. Work on appropriate conditions for internationalization and regional innovation systems in Hungary is Lengyel and Leydersdorff (2011) and whether they guide IC formation within cross-border or other specific regions remains an interesting question. In the sequel we aim at determining some *less specific systemic factors* which may contribute to regional IC formation. To this end we use selected data from The Global Competitiveness Report 2012-2013 of the World Economic Forum (Schwab and Sala-i-Martin (2013)). From this rather extensive, world covering data base we first select 21 European countries which are contained within the trade corridors of figure 2 or which may be in general interesting cross-border and metro-region candidates.



Source: Metro-map from EUROSTAT 2010, region insets by the authors

**Figure 2:** The EU countries with their larger metro-regions

In figure 2, the varying shades of patches are: capital city metro-regions (dark) and other bigger city metro regions (lighter shades), respectively. Four selected cross-border regions and some rough “trade corridors” with increased and many new activities in the post-soviet period (after 1990) are included by dark contours.

#### 4. Methods

We perform two related studies, the first based on subsection 4.1 and presented in subsection 5.1, the second based on subsection 4.2 and presented in subsections 5.2, 5.3 and 5.4, respectively.

##### 4.1 First study

In order to compare EU countries with common borders and without, we select the data representation in terms of *global rankings* from the Global Competitiveness Report referred to in section 3. The rankings in these data from this report rankings of over a larger set of countries which contain all EU countries, hence the worst ranking happens to be 144 and the best one is 1. We compare the selected EU countries by computing linear correlations over all country pairs on 40 selected influence factors. We conjecture that these influence factors contribute to a significant degree to the eventual formation of regional IC. They are, respectively, 9, 7, 7, 8, and 9 different rank variables (variable blocks) from the following five major influence domains: (1) Business sophistication, (2) Technological readiness, (3) Innovation, (4) Higher education and training, and (5) Quality of infrastructure. The results of this analysis are shown in section 5.1.

##### 4.2 Second study

As described in Schebesch and Tomé (2013) we use tree matrices describing relations between the respective eight urban centers of each county (region) within the two cross-border regions (super-regions): A symmetric matrix  $D_0 \geq 0$  for the transport distances between the cities. A symmetric matrix  $D_1 \geq 0$  describing similarities between these cities in terms of several measures related to economic performance and quality of life (roughly a subset of measures from figure 3) and a symmetric block diagonal matrix  $D_2 \geq 0$  accounting for country specific performance. The final influence matrices, one for the PT-SP and one for the HU-RO case is then given by  $M(\alpha, \beta) = -D_0 + \alpha D_1 + \beta D_2$ , with parameters  $\alpha, \beta \geq 0$  for scaling the influence of the two last matrices. This

influence matrix will be used in two interpretable variants: A very optimistic view is “attraction by diversity” (see also subsection 4.1) and a more constrained view is “conservative attraction” (or asymmetric trust, see also subsection 4.2). Attraction by diversity simply assumes that two sub-regions will be attracted proportional to their distance  $d(i, j)$  in their measurements  $y_i$  and  $y_j$ , which are contained in  $D_1$ . This reflects the ability to exploit differences as useful complementarities within regional cooperation. The variant of conservative attraction is using  $D_{ij} = d(i, j)$  if the difference in associated measurements  $y_i$  and  $y_j$  is positive when the measurements are being normed, i.e. if we have  $\|y_i\| > \|y_j\|$ , and it is using  $D_{ij} = -d(i, j)$  otherwise, reflecting the proposition that those regions will be attracted towards cooperation, which have in the above sense superior performance measurements while their candidate partner (i.e. partner  $j$ ) will be restrained from seeking cooperation. These are obviously very crude assumptions, which underline just basic forces. There are more possibilities of defining propensity towards cooperation; however, they need more refined assumption about the role of culture and innovation as depicted in figure 1 (of section 2).

Equipped with these preliminary influence matrices and with the two views on regional cooperation formation we now specify a simple rule which evaluates inter-regional cooperation and which pre-selects only such coalitions (for cooperation between regions) which are stable against simple coalition switching. This mechanism was first used in Axelrod et al. (1995), and we outline it here for convenience: as both cross-border cases (HU-RO and PT\_SP) happen to have eight counties with their urban centre, a county  $i \in \{1, \dots, 8\}$  may or may not be in one of the coalitions  $x \in \{0, 1\}^8$ . It is part of a coalition if  $x_i = 1$ . In such a situation there is obviously a payoff (here a propensity for cooperation) of  $\sum_k M_{ik}(\alpha, \beta)x_k$ . Such a coalition  $x$  is said to be *stable* if no other county from coalition  $x$  can improve its payoff by switching to the counter-coalition  $1 - x$  (e.g. with  $x$  and  $1 - x$  being like [0011 0001] and [1100 1110], respectively).

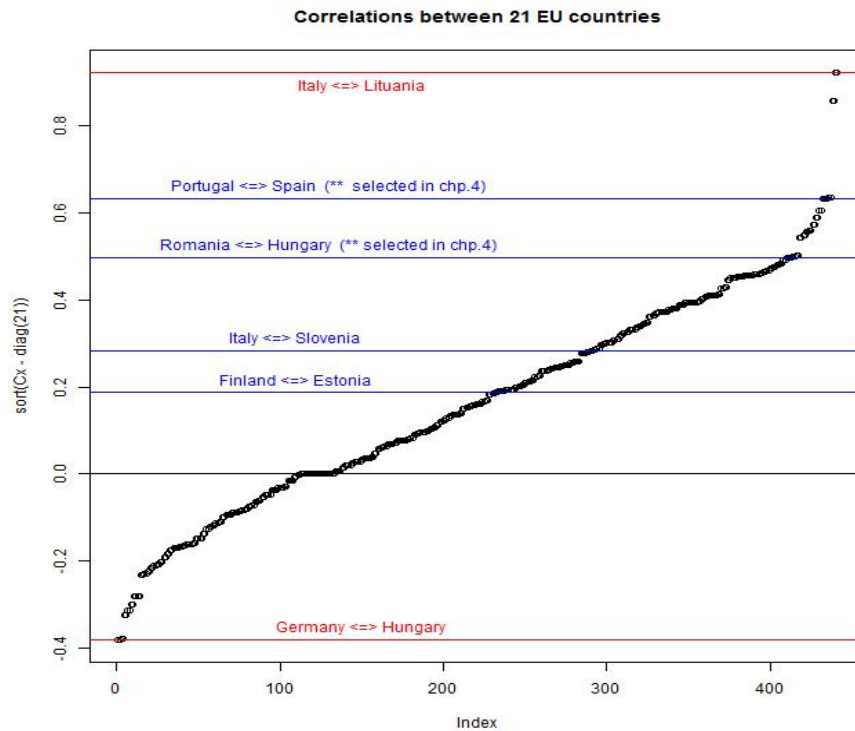
Data sources for computing the similarities in order to build the three matrices  $D_0, D_1$  and  $D_2$  for describing pairwise attraction (or repulsion) between the involved metro-regions or the counties' urban centers are UNDP (2012) country profiles, EU (2012) operational programs for cross-border cooperation (for the PT-SP and HU-RO cases respectively) as well as Corruption Index (2012). Details for building these matrices can be found in Schebesch and Tomé (2013). The results of the simulations based on this computational model are shown in sections 5.2, 5.3 and 5.4.

## 5. Results

### 5.1 First steps towards mapping regional IC – different resolutions on accessible data

As stated in subsection 4.1 we first compute the correlation structure between the IC-relevant variables between all the 21 selected EU countries (with and without common borders). Sorting the  $21^2$ -21 linear correlation coefficients obtained for all country pairs (see figure 3) one first observes that the (outstanding) extreme cases are furnished by non-cross border cases. Actually, the maximum positive correlation occurs between Italy and Lithuania, which from the point of view of regional IC seems to be a random event. The second largest point in figure 3 (above 0.8, not labeled) refers to the pair of Romania and Bulgaria. While certainly obeying a logic of structural similarity between the two countries, this case does not seem worthwhile to follow for now, owing to the possibility of merely describing a latent “underdevelopment trap”. At the other side of the correlation spectrum we have the somewhat surprising pair of Germany and Hungary (the value above -0.4 from figure 3). A certain logic may here still be found in this case by considering the chain of neighbors Germany – Austria – Hungary with decreasing pair-wise correlation, possibly indicating complementary relations within the east-west trade corridor (see figure 2). In the following two subsections (5.2 and 5.3) we choose to further investigate the structurally different cross-border cases, namely that of Portugal and Spain, being a pair with high positive correlation, as well as the moderately correlated pair of Hungary and Romania, a pair with many cultural differences. In figure 4 we also contrast these two selected pairs with two further, in other ways rather different cross-border country pairs, which are both weakly positively correlated and highly asymmetrical, namely Italy and Slovenia, and Finland – Estonia, respectively. As the figures 3 and 4 indicate, altogether these four cross-border cases describe rather different European cross-border situations. Hungary and Romania (Figure 4, upper left) are moderately correlated with Hungary outranking Romania in most variables, Portugal and Spain (Figure 4, lower left) are more correlated and enjoy much better rankings than HU-RO. These two countries are culturally more homogeneous and have both long colonial histories as well as deeply rooted traditions. Despite the visual impression one may get from inspecting figure 4, Slovenia and Italy (upper right) are weakly

correlated, and, finally, Finland is strongly outranking Estonia (Figure 4, lower right). This pair has the weakest correlation of all country pairs highlighted in Figure 4.



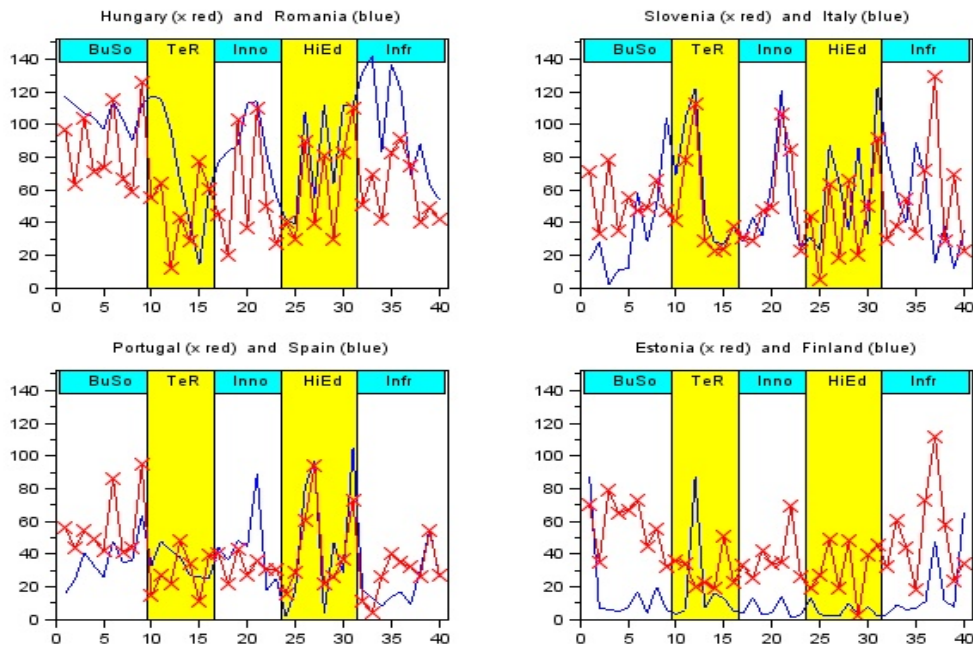
**Figure 3:** Correlation coefficients between the 21 selected EU countries computed by with selected features from WEP 2012/13 (see also figure 4) relation to competitiveness, flexibility, innovation, education and quality of infrastructure

The latter two country pairs (Italy-Slovenia and Finland-Estonia) present a simpler picture and they are certainly more attractive regions, to foreign investment, to immigrants and also to the local population. This may be attributed to the power (weight) and / or the absolute ranking of at least one of the countries and also partially to the relative vicinity of important modern metro regions.

The former country pairs (PT-SP and HU-RO) differ in less clear ways and they also seem to act more like repellers to foreign inflows and local populations. One might be tempted to ask whether this situation can be reversed, and at what cost. While the present paper cannot find definitive answers to this question it still attempts to identify factors which may influence this situation. Upon accepting innovation-imitation as a path to IC formation as sketched in figure 1, one is next lead into asking for factors which determine innovation success in a regional setting. According to McCann and Ortega-Argilés (2013) a list of “*broadly accepted evidence*” regarding innovation and innovation policy outcomes, containing factors which are sources of successful innovation, is the following:

- internationalization and foreign direct investment,
- collaboration between firms,
- public funding,
- combined product and process innovations as opposed to product or process innovation,
- innovation-related sales which lead to higher firm survival prospects,
- technology frontier firms which enjoy higher returns to innovation,
- size and innovation: the most innovative are small and large firms,

to name a few. All the above statements are based on the notion of *outperforming the counter-variant in probabilities*. Significant such performance increases in the range of 20% to 70% over the counter-variant are reported, largely being measured in OECD countries.



**Figure 4:** Difference of four cross-border country pairs in terms of 40 selected rankings from The Global Competitiveness Report 2012-2013 of the World Economic Forum. The five abbreviations for variable blocks (1) BuSo, (2) TeR, (3) Inno, (4) HiEd and (5) Infr are explained in the main text of subsection 4.1.

Furthermore, with the classification into (i) World-class performing regions, (ii) Industrial employment focus and (iii) Science and service regions, for our selected country pairs from figures 2 and 4, we find that none is in (i). Eastern Finland, Valencia and Catalonia are examples for regions in (ii) and Rome, Central Hungary, Lisbon are (as non-cross border) regions in (iii); However in (i) we find South East England, the Capital Region of Denmark and Upper Austria. They are not part of our selection but they are clearly (part of) cross-border and metro-regions.

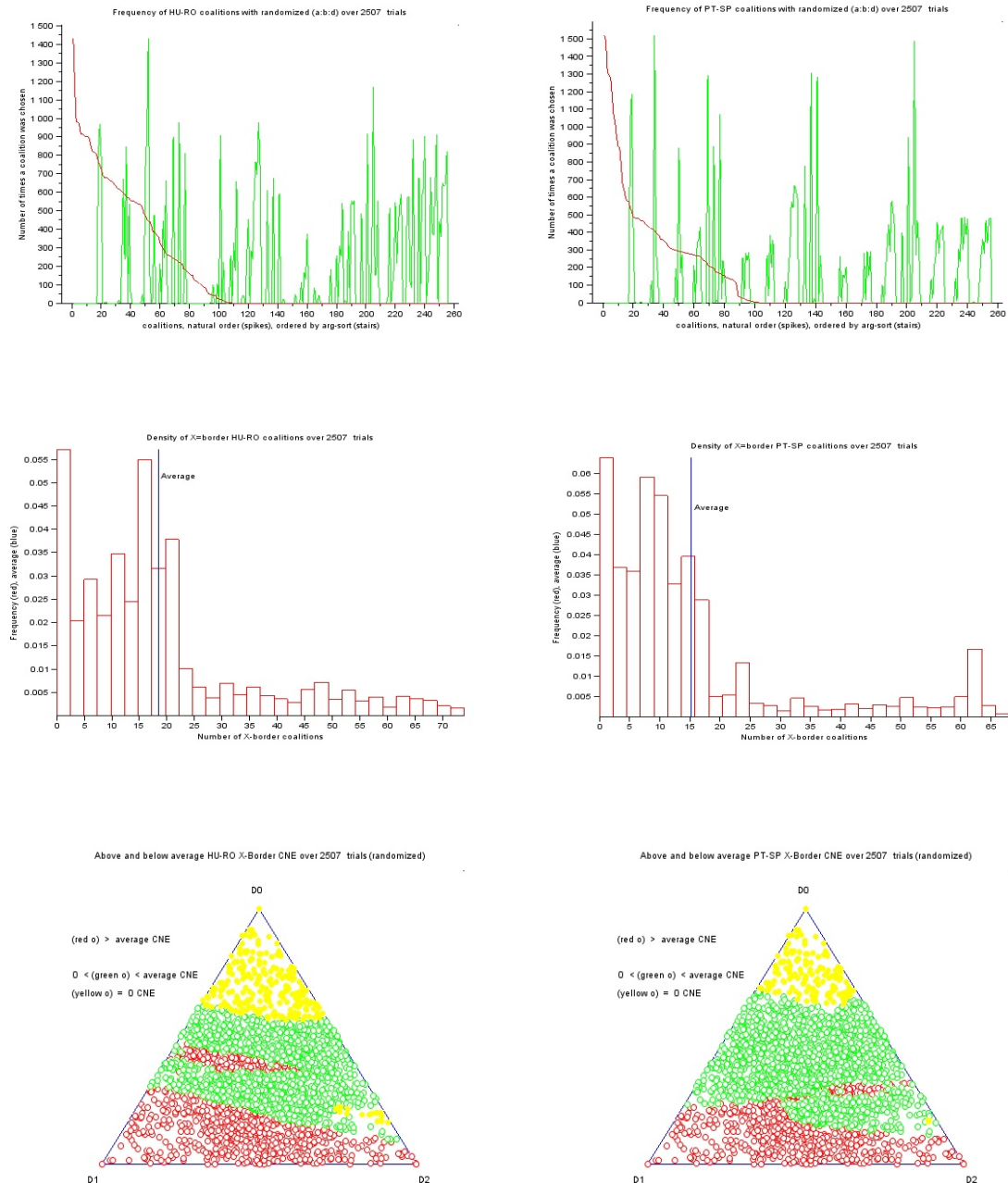
### 5.2 First steps towards creating a recommender: A mapping of possible region-coalitions

As stated in the introduction and in section 2 a practical tool for assessing regional IC would be to design a recommender for the different stakeholders (investor, agencies, the political public, etc.). In order to meet this end one would start by mapping possible region-coalitions, which may form a basis for evaluating the probability a region may tolerate, block or encourage IC formation. Obviously the approach presented here is stylized (although data oriented), meaning that it may be strongly refined and updated by including more concepts, data and filter rules (see section 2). The computations presented in the sequel are limited to two EU cross-border cases, namely Hungary-Romania (HU-RO) and Portugal-Spain (PT-SP), which happen to have four cross-border counties each with eight metro- or metro-like sub-regions respectively (for details see Schebesch and Tomé 2013). Otherwise these two cross-border cases differ quite a lot, as may be read off from the different rank variables of figure 4, which refer to aspects of business sophistication, technological readiness, innovation, higher education and training, and quality of infrastructure.

### 5.3 A simple form of attraction by diversity: Cross-border cases HU-RO and PT-SP

Figure 5 below shows the result of the simulations based on the model which is described in subsection 4.2. Each of the columns of plots in the figure represents a cross-border region (left column stands for the case of Portugal and Spain and the right column for Hungary and Romania). The upper row contains the 256 possible coalition in the natural binary ordering, for instance [0110 0000] contains no cross-border coalition and [0010 1000] contains a cross-border coalition between county 3 of country 1 (HU) and county 1 of country 2 (RO). In practice such coalitions may come about between the important urban centers and subsequently by drawing in their surrounding counties (i.e. a total of 2x4 such counties for HU-RO and PT-SP, respectively). The spikes are the payoffs of the stable cross-border coalitions in the sense described above and the dark line are those same payoffs sorted. The relatively large number of stable coalitions forms here due to the liberal “attraction by diversity” assembly rule for matrix  $M$ . Coalitions far to the right can contain few members, as e.g. [1100 1000] might illustrate. In any case one would “recommend” small cross-border coalitions with high payoffs which are associated with larger probabilities of realization. Using payoff

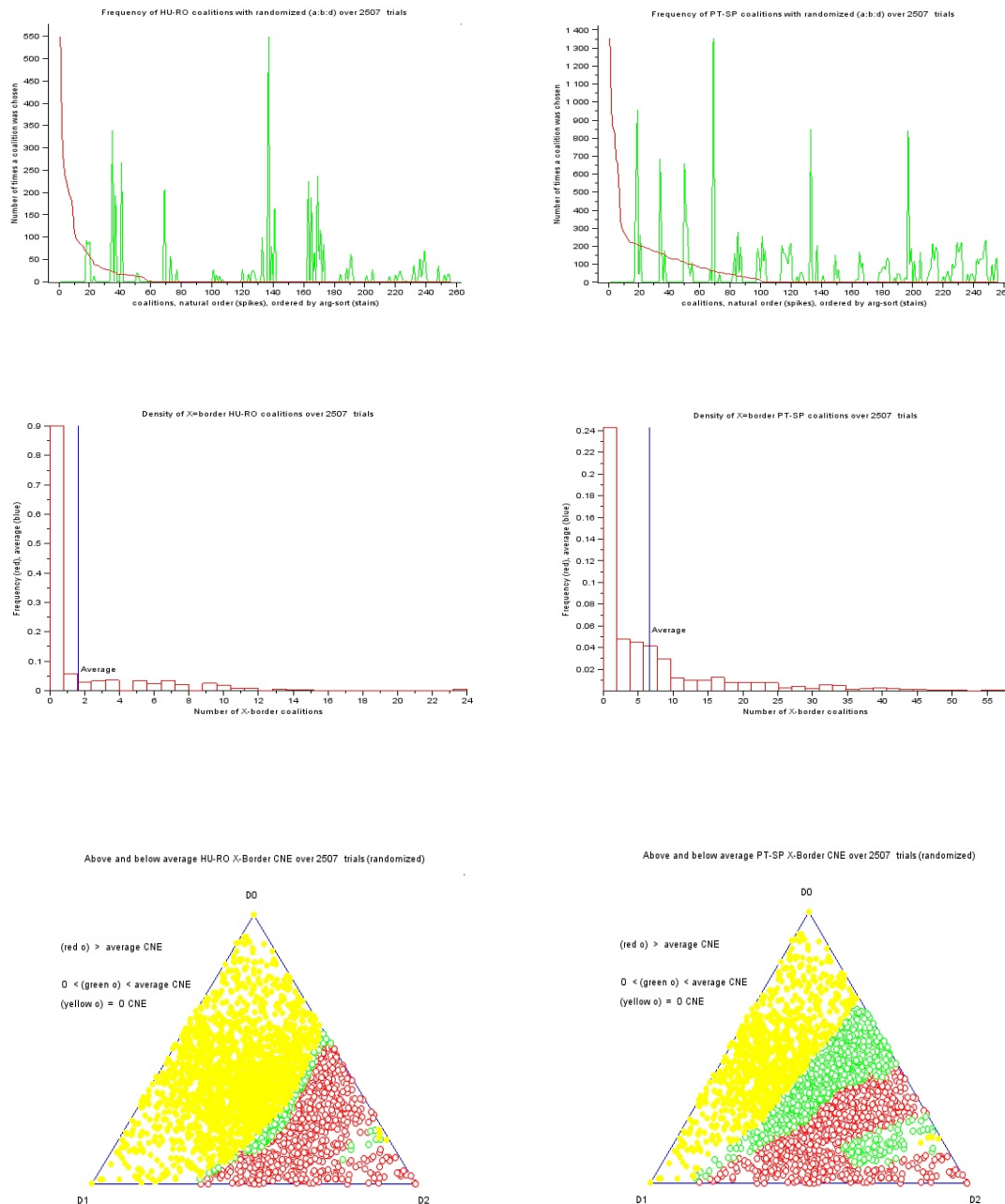
thresholds would suitably decimate the number of remaining coalitions. In this sense PT-SP shows a somewhat larger number of high payoff coalitions than HU-RO. The next two lines of plots from figure 5 refer to a sensitivity experiment which is done by varying the relative weight of the three influence matrices leading to  $M$ : Within the simplex of convex combinations between the three influence matrices, 2500 random draws were evaluated and the number of stable coalitions which formed in each situation was retained. The runs with matrix combination located at the barycenter  $(1/3,1/3,1/3)$  of this simplices (the lower plot) is exactly that depicted in the upper plots. As can be seen from the middle and the lower plots, respectively, each country pair attains a different number of coalitions according to relative importance given to the three matrices  $D_0, D_1$  and  $D_2$  (e.g. vertex  $D_2$  of the simplex means that  $(0,0,1)$  is used, etc.). Chances for finding a stable cross-border coalition are high in both cases.



**Figure 5:** The HU-RO case (left column) and the PT-SP case (right column). Upper plots: the number of times a coalition (out of 256) was chosen. Middle plots: frequency of a cross-border coalition (vertical lines denote averages). Lower plots: zero, below- and above-average coalition numbers for different matrix weights.

Points with dark color in a simplex of figure 5 (lower plots) mean that the number of cross-border coalitions is above average (dark or red) and below average (medium dark or green). Light shade (yellow) means no cross-border coalition is found. The differently colored points within each simplex represent different relative influences on potential coalition formation of the three respective similarity matrices described above.

### 5.4 A simple form of conservative attraction: Cross-border cases HU-RO and PT-SP



**Figure 6:** The HU-RO case (left column) and the PT-SP case (right column). The meaning of the single plots is the same as that from figure 5

Changing the mode of assembling matrix  $M$  from “attraction by diversity” to “conservative attraction” (depicted in figure 6) strongly reduces the number of the cross-border coalitions for both country pairs and it also partially affects the composition of the few coalitions with the largest payoffs. Most notably it reduces the chances of finding any coalition in the HU-RO cases. The coloring of the simplices also reveals that changing the composition of the single

matrices  $D_0, D_1$  and  $D_2$  has a nonlinear effect upon the number of cross-border coalitions produced. One may interpret the utility of such computations as follows: urban county centers which are part of more stable coalitions (over different attraction rules and different combinations of influence matrices) can be thought of as contributing more intensively to IC formation. Coalitions with high payoff (assuming that these are also contributing with a higher probability to eventual IC formation) can be siphoned out by more complex rules. However simply putting thresholds on the payoff in order to acts as filters, may also do well. As is the case with any strongly data dependent (commercial) recommender, the results of a recommender using information as provided in this section will also improve by continuously updating its data-base and by continuously re-computing any implied relations between the data, like, for instance, the stable cross-border coalitions discussed in the present section.

## 6. Discussion

While we are aware of the importance of highly specific and “path dependent” sequences of historical events which co-determine effective IC formation in a cross-border region, we also think that a list of more “systemic” features should be included, which, in a very wide sense, are more amenable to measurement and modeling.

The degree to which (regional) IC formation is co-determined by particularistic factors or by systemic factors may vary in practice from region to region and is a result of more or less hidden cultural factors. Indeed, IC formation in different cross-border regions like those exemplified, i.e. between Hungary and Romania and Portugal and Spain, respectively, faces very different systemic and cultural barriers. In order to address a wide spectrum of such particular differences (in other EU regions as well) we address a simpler but related problem: to find ways to express cooperation modes between urban centers of cross-border regions attainable with non-negligible probabilities. In order to process such situations one can by now rely on a series of high-quality IC-related data sources at the country level. However in searching for regional information, finding adequate data proves to be much more difficult and several proxies need to be constructed, partly in order to produce comparisons in analogy to those at the country level.

Our model succeeds in showing that mechanisms of “pure” market forces, like those preferred by liberal economists would generate much more (IC-induced) coalitions that a much more conservative way of looking at coalition formation. This indicates that policies might be developed in order to help transform the *conservative* solutions into the *liberal* solutions, because the liberal solutions may not be “naturally” achievable, owing to societal resistance to accept pure market forces or owing to market failures. Those policies would enable the cross border regions to reach the potential of growth they implicitly have, especially that owing to underutilized regional IC. Such policies could be more active – making interventionist efforts, or more passive – liberating hidden societal forces to foster efforts with similar results.

The next issue concerns the relation between policy recommendation the formation of regional IC and possibilities to effectively turn this relation into an instrumental research and assessment program involving effectively implementable information technology (IT) based recommenders. A faint analogy would be that of participative commercial (peer-2-peer) product recommenders used today in e-commerce (Ricci et al. 2011).

However, in our context, there is much more to the design of recommenders than that of using collaborative filtering as used by many clients for many products. An overview concerning a “non-cultural” viewpoint of extended recommenders, which emphasizes creativity, context awareness and explicit knowledge in the context of educational recommenders may be gained from the collection of works in Santos and Boticario (2012). From a conceptual point of view these edu-recommenders are an intermediate concept between the widely utilized commercial variety and our intended IC-related policy recommenders.

Here we like to highlight that IC-related recommenders should include a component which evaluates the culturally determined propensity for (cross-border) cooperation and eventually the shaping of the filters and the assessment of the delays in the regional IC formation process (see figures 1 and 7). Figure 7 is a regional cross-border re-formulation of figure 1. It includes links to items borrowed from collective learning, which are more instrumental at a much “smaller” organizational level (e.g. for firms, schools, cities, etc.).

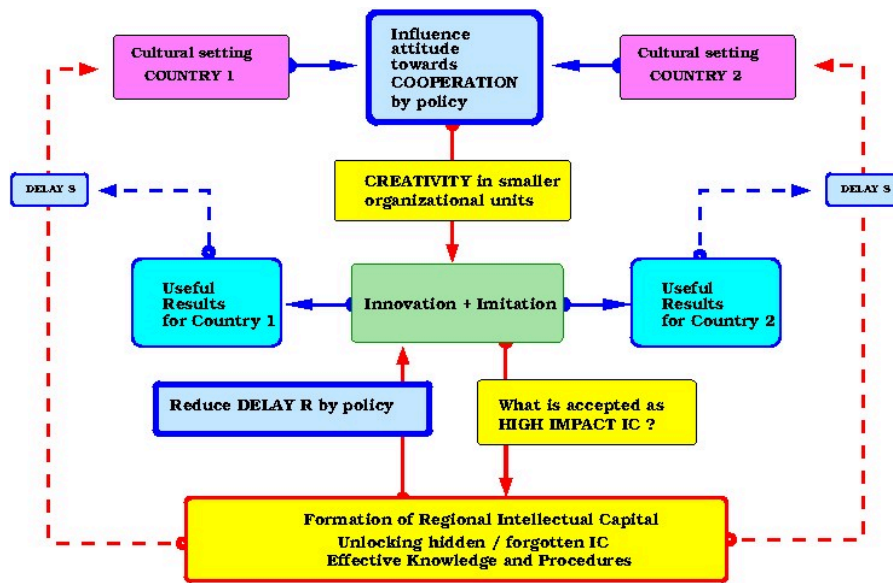


Figure 7: Two bordering countries (may) contribute the common IC formation

Finally, we think that a more stringent link to concrete socio-technological solutions with high regional impact should be fostered. For instance, in analogy to the recommendation of different strategic "energy solutions" described in Schebesch (2013), one may propose, say, common technological recipes for advanced housing and energy use, advanced educational or vocational activities, new types of "industrial" agriculture, etc., well adapted to the needs and the IC potential of a cross-borders region. Such solutions would involve a mix of new concepts and technologies which would have to be ordered and interconnected according to depth and breadth of regional IC. Hence an IC-based policy recommender should be able to integrate the aspect of regional (cross-border) IC formation as indicated in figure 7 with such socio-technological aspects. In order to achieve this based on empirical data and participative evaluation, one may rely on using some existing IT tools, as for instance innovation contests" or "prediction markets", which can all be organized as online solutions. Consequently, they would be largely based on appropriate variants of "crowd-sourcing" which are practically achievable by IT-means. Figure 8 depicts a dependency loop which would arise in such a situation of collecting data and evidence on one (o more) high impact technologies from two bordering countries and eventually transforming them into policy recommendations.

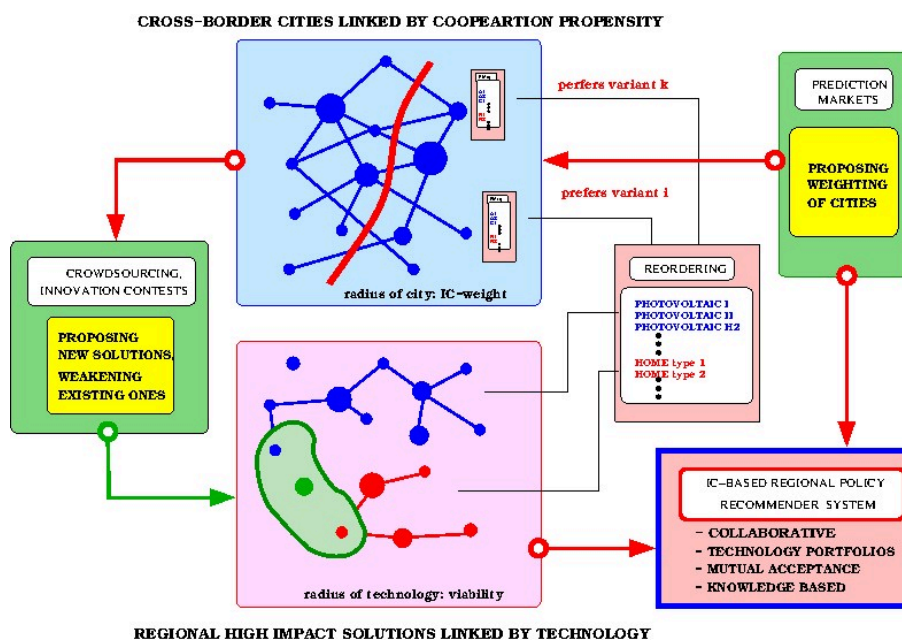


Figure 8: The link between country-level factors, technology preference, proposing new solutions and recommending policies for implementing most agreeable new technological solutions in a cross-border region

While the discussion of the integrative aspect of policy recommenders is mainly conceptual, each element contained can be effectively realized and adapted in terms of suitable IT technology. Henceforth, in principle, the decision of whether to use a more active or a more passive variant of policies in order to foster a regional development which is better reflecting the potential of regional IC would be now relegated to the outcome (e.g. the result of a majority vote) produced by such a participative recommender.

## 7. Concluding comments

We created a computational model to explain attraction between cross border regions due to IC-related factors, which is based on empirically constructed similarity matrices for the cases of two rather different sets of countries with cross-border regions – Portugal and Spain, and Hungary and Romania, respectively. We concluded that liberal coalitions are much easier to achieve than coalitions that form in other, more stringent context. However liberal coalitions are less plausible from a societal and cultural viewpoint. In policy matters this means that we may have to adopt active or passive policies in order to “lift” the economy at the level of market efficiency. The main limitation of the study is the small number of cases involved. To improve this study we hope to replicate it soon for other cross border regions like Finland and Estonia or Italy and Slovenia.

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