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How cluster, firm, and regional business environment influence different types of innovative activities in European Union

Evidence from Community Innovation Survey

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Abstract: As widely accepted, innovations are of great importance for regional and national economic growth and competitiveness. Innovation Union is one of flagship targets of European Union Horizon 2020 initiative. However, to understand innovation is still challenging, give its complicated nature; moreover, among factors within policy influence, which variable could help facilitate innovation is also inconclusive. This paper will carry out Regional Competitive Framework to understand how cluster, firm behavior, and business environment impact on innovations performance in a both static and dynamic way, and further provide policy implications for promoting innovations. In this paper, Innovation would be perceived as innovative activities from firms' subjective views, measured from Community Innovation Survey (CIS). Consequently, six aspects of innovation activities would be discussed, with EPO patents as objective innovation measurement for reference.

Key words: **Innovations, Community Innovation Survey, competitiveness, cluster, firm behavior, business environment.**

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Acronyms and Abbreviations

CIS	Community Innovation Survey
ECO	European Cluster Observatory
EPO	European Patent Office
GCI	Global Competitiveness Report
NUTS	Nomenclature of Territorial Unit for Statistics
PCA	Principle Component Analysis
RCF	Regional Competitiveness Framework
RIS	Regional Innovation System
SME	Small and Medium Enterprise

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1. Introductions

Innovation has long been regarded as impetus for competitiveness and economic growth. In relation to European Union, to be an Innovation Union is a deliberate strategy, as one of seven flagship initiatives of Europe 2020 (European Commission, 2011). In this ten-year framework of Europe 2020, there will be coordinated policy and funds targeted to shape and maintain European's superior innovative position in the globalization era. Within this flagship initiatives, European Commission intend to carry out a set of policies, including adjust and reform R&D and innovation system, foster regional smart specialization, maintain European's prominent role in science and technology, and assist young people into startup and innovations. Moreover, connections between education, training, and business are also emphasized to be enhanced. Commission also determines to improve the business environment in this 2020 framework, especially for SMEs, by reducing transactions cost of doing business and promotions of clusters, as well as active national and local government to facilitate indispensible network and provide essential service.(European Commission, 2011)

In one hand, though consensus has reached about importance of innovations, complicated features of innovation makes it very hard to identify and measure which certain aspects of innovations. In another hand, there is still gap in identifying which factors are important for which different aspects of innovations, especially for the factors could be directly influenced within policy ranges. This paper tries to carry out Regional Competitiveness Framework to study how cluster (specialization), firm behaviors (R&D), and business environment impact innovations. In this framework, innovation abilities are treated as one perspective of competitiveness. RCF is chosen as study method for these three competitive drivers for innovations are policy-relevant. In this paper, Innovation is treated as innovative activities from firms' subjective views, data from Community Innovation Survey (CIS) 2012. From this Survey, six aspects and measurements of innovation activities are presented. How cluster, firm behavior, and business environment will influenced on these six innovation measurements will be studied and compared, also with European Patent Office patents applications as an objective innovation measurement for benchmark reference.

This paper will try to find out relationship between the competitive drivers (cluster, firm, business environment) and innovation performance (from Community Innovation Survey), and their relatively importance in explaining the disparities of innovation in European context. Six innovation variables will be discussed in this paper, each one catch one perspectives of innovations activities (4 channel and 2 types). From this paper, we could know how competitive drivers impact on multi-dimensions of innovations.

2. Theoretic background

2.1 Competitive Framework

2.1.1 Former competitive framework

The competitiveness is still a highly controversial and arguable concept. In the academia, the competitiveness indicators are far from reaching consensus, and many studies highlight certain influenced while neglect the others.

In the national level, Global Competitiveness Report (World Economic Forum, 2009) and World Competitiveness Yearbook (International Institute for Management Development, 2009) are both targeting national holistic competitive capabilities and performance. Global Competitiveness Index introduced by World Economic Forum in 2004. The corresponding report defines competitiveness as "the set of instituions, policies, and factors that determine the level of productivity of a country". To be specific, 110 distinct indicators are categorized into twelve Pillars to address. These indicator, and also its pillars will be aggregated into competitiveness index which weights will follow the stage of development of the country (World Economic Forum, 2009) Not as broad countries-covering as Global competitiveness report, World Competitiveness yearbook aim to rank mostly developed countries by their ability to generate and sustain an environment maintaining the competitiveness of enterprises. It was calculated from 246 variables, with nearly half from the secondary sources, while the others from executive opinions survey (Aranguren et al, 2010b). The strengths of these two indexes are their offer of comprehensive information of specific country, especially the subjective executive opinion surveys, which could reveal further understanding of countries comparisons. However, there are two big drawbacks in these two global ranking, firstly, these large amount of indicators into pillars is not effective for providing policy advice, considering too many indicators and mix of indicators of enablers, intermediate targets, and results. Secondly, the underlying conceptual models used to calculate these indicators into an index did not have strong predictive power (Porter et al., 2008)

In regional level, European commission had adopted the framework of GCI, but abandoned the executive opinion survey to avoid criticism of representativeness and robustness. Moreover, European regional competitiveness index was carried out in NUT1 and NUT2 level, based on data availability.

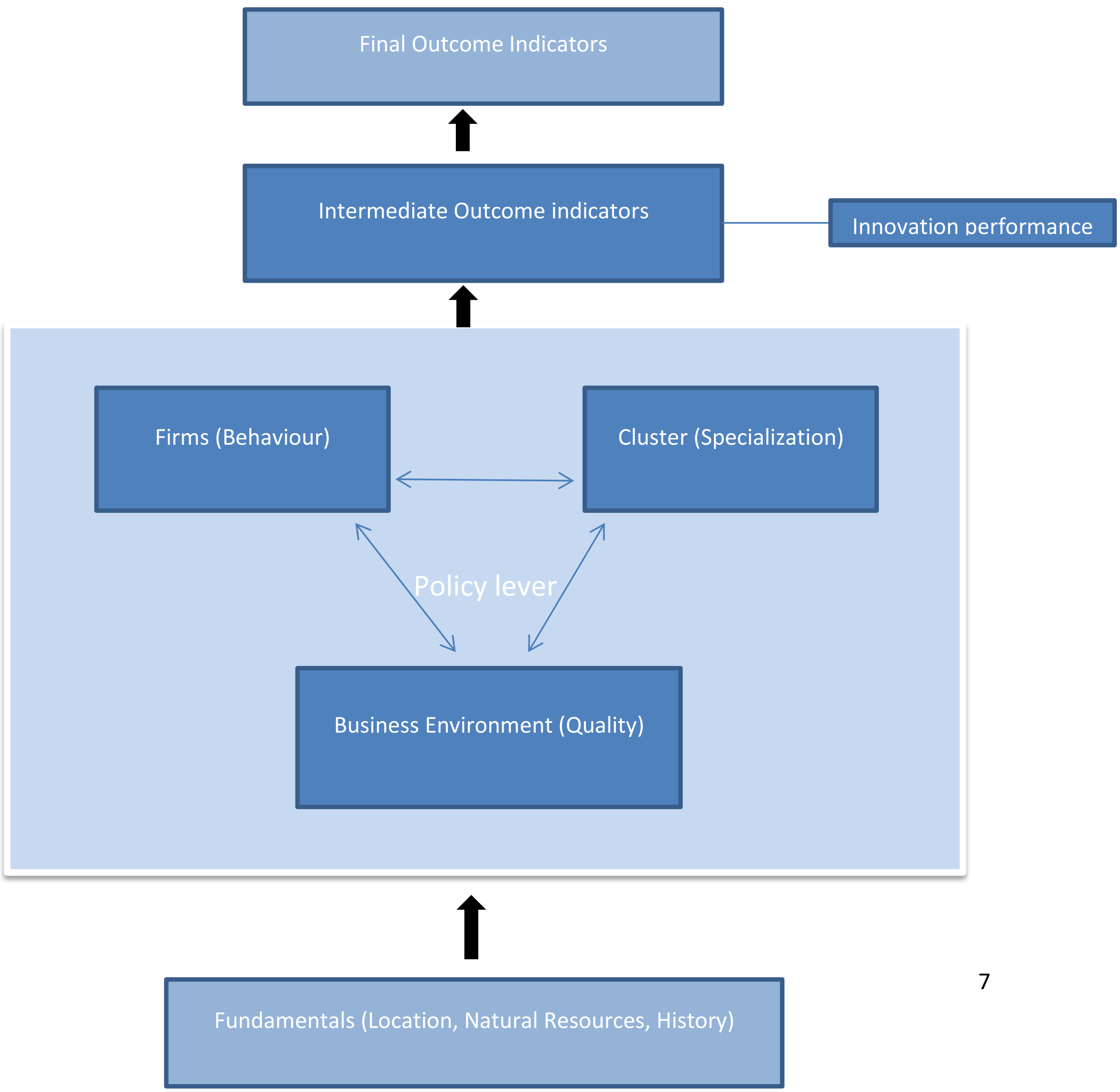
These frameworks are good, but have some major weakness, 1) variables are very broad and comprehensive, and framework is also undermined by data quality and arbitrary selection of data because of availability. 2) Variables are organized mixing different aspects, and are not beneficial to offering policy guidance.

2.1.2 Regional Competitiveness framework

Europe Cluster Observatory (ECO) team came with this Regional Competitiveness Framework (RCF). This framework aims to providing a solid basis to evaluate and benchmark the drivers of competitiveness of regional economies. This framework is important since it is clear for policy-relevant guidance. In the third layer, the competitive drivers, yet inter-related to each other, will be used as variables to explain the intermediate outcome-innovations in this paper. All these three drivers are within policy influences. As a result, RCF is useful for regional policy makers to base on, and improve corresponding fields.

This framework outlines in figure 1 and explain in the following paragraphs

Figure 1: Regional Competitiveness Framework



The top layer is outcome indicators, which represent the ultimate goal of economic policy, the living standard of the citizens in the particular territory. This layer could be measured by variables like GDP per capita, growth of GDP per capita, disposable income per capital, life satisfaction rate, Happy life years. This layer is highly important for policy-makers, but cannot influenced by policy directly, more like a final result of a series of policies and other factors contributing together.

Below living standards layer, there are intermediate performance indicators, within some extent of policy influence. To much emphasize these targets might bring dangers, since they are relevant, but not necessary to the living standard, especially the short run. For example, subsidies on scientific works and tax exemption might encourage more patents applications and FDI, but the long-term economic growth will only achieved if technological innovation abilities really improved from the scientific work, and the regional attractiveness is improved. "These intermediate indicators are in effect output of the underlying interaction between the firms in a region and their business environment" the three competitive drivers, could as diagnostic instruments to analyze the process transforming fundamental drivers of competitiveness to final target- higher standard of living. To sum up, intermediate performance would be as analytical tool, not as direct policy target.

The third layers are the three competitive drivers, namely cluster, firms behavior, business environment. "Firms" contains indicators which reflect firm's decisions make in investments, R&D expenditure, etc, all which would have impacts on their productivity and competitiveness. "Cluster" captures the industrial structure and agglomerations of regions. Cluster strengths are collected and calculated by ECO project. "Business environment" captures the quality of environment where companies need to operate. They could be understood as regional innovative system, and embedded territorial features. In this framework, Porter's diamond model will be used to identify these elements, including "factors", "demand", "context for strategy and rivalry", and "Related and Supporting industries" (Porter, 1990) To sum up, government policy can seek to influence towards all these three competitive drivers, which are important for policy makers. (Aranguren et al, 2010b)

"Fundamentals" are at the bottom of the framework, these elements could be considered to be fixed or difficult to change in the medium term, such as geographical location, endowment of natural resources, size of economy, etc. Above them stand the competitiveness drivers, which contain factors that are more likely to be affected by economic policy in the short and medium run.

Because of competitiveness drivers, this framework could help us better understand the relative importance and their interrelationship of clusters, firm behavior, and regional business environment in determining regional competitiveness outcomes. It is very useful for regional policy makers. As discussed, many other competitiveness frameworks mix intermediate indicators with the competitive drivers. In this sense, this RCF approach is more suitable.

Above all, advantages of RCF mainly lay in the following merits: 1)Clear layers structure, with different extent policy can impact 2) it facilitates analysis of three competiveness drivers'relative role in explaining different outcome 3) it also clear to analyze three drivers' inter-relationships.

2.2 Innovations (Intermediate outcome)

2.2.1 Innovations in Regional Competitiveness Framework

In the first phase of ECO project, only patent relevant indicators were introduced as innovative performance in the layer of intermediate outcomes (Franco et al 2011). In the second phase, ECO team include Community Innovation Survey (CIS) into the intermediate performance indicators with other patent relevant measurements (Franco et al 2014).

In one direction, Innovations dramatically shape economic growth. From endogenous growth theories, innovation is not just the important source for progress, but also itself is treated as knowledge accumulation for further development (Grossman and Helpman, 1991). Differences in innovation capacity are one of the basic reasons for persistent variance in prosperities.

In another direction, all three competitive drivers have considerable impact on innovations. Firm's performance is easy to understand, as a linear innovative approach. Their respective function mechanism on innovations and further growth will be discussed in later part of this section.

2.2.2 Innovations' measurements

Basically innovations measurement could be divided into two parts: indirect measurement and direct measurement. In the first part, R&D and patent are two most famous used methods. The strengths of these two methods are easy to get access to and also measuring objects are clear. However, their drawbacks cannot be ignored. R&D is just input instead innovative output, the intermediate process within company is a black box. Additionally, this measure neglects the meanings of acquired machinery and patents from outside, as well as neglect non-technological innovations, like marketing and organizational innovations. In terms of Patent, the apparent shortcoming is it is inventions instead of innovations, which defined by Schumpeter (1934) as "commercialized invention with new combinations". As a result, patent has quite different scope from innovations. Moreover, the different implementing of patent law between countries, the reluctance of applying process innovations into patent, and use patent only to prevent potential competitors all undermine the effectiveness of patents.

In the second part, the directly output measurements also have two very popular examples, one is Community Innovation Survey (CIS) by European Commission, another one is Literature based

Innovation output (LBIO). For the first one, CIS carried out by directly asking CEO or CTO of firms, whether or not firms had product, process, organizational, and marketing innovative activities within last three years. Consequently, this survey is measured subjectively towards the opinions of executives of sampling companies. It might be biased by the respondent's perceptions of the questions and culture difference. However, from another point, the executives, better than outside experts, have much better understanding of the firms. The advantage of CIS is it includes both significant innovation, and small-scale and incremental change, which neglect by many other methods. LBIO, on another hand, is to collect innovations within this region by scanning relevant journals which publicize companies' innovations. Supporters of LBIO mainly emphasize it is objective to measure and easy to compare. The opponents would claim LBIO method only focus on innovation which are new to the industry, but neglect routine, incremental innovation, which is very usual and important part as normal competitive activity. Moreover, these methods are mainly applied o technological innovations and ignore other innovations (Smith 2005).

This paper will use Community Innovation Survey 2012 results as measurement of innovations. The rationalities and target of every variable to capture will be discussed in Section 4.3.1

2.3 Cluster (Competitive driver)

2.3.1 Cluster for innovation and growth

Cluster, is defined as the agglomerations of similar firms, and relative organization, and institutional agents, locate within geographical proximity. This physical proximity would facilitate the inside firms to interact in the system of cooperation, competition, knowledge exchange and diffusion. Cluster becomes the genesis for innovations and subsequently economic growth (Rodriguez-Pose & Comptour 2012).

Malmberg and Power (2006), review the effects of Clusters theories and why and through which channel Clusters create knowledge empirically in relevant studies. There are three channels in theories indicate why cluster is important to facilitate generating of knowledge, namely inter-organization collaboration, intense competition from local rivalry, and spillovers from local personnel mobility. He found out from a series of empirical studies, there was no clear support for the first mechanism, and not enough empirical for the second, while spillover is an important effects. Moreover, Ron Boschma (2005) also indicates the importance of geographic proximity for innovation. However, granted its importance, Boschma also believes geographic proximity is not necessary, as long as other proximities, like institutional, social, organizational could be close enough to take place of geographic proximity, while cognitive proximity is the most important factor for generate innovations.

Tacit and codified knowledge would also be used as understanding why cluster, the physical proximity is important. Innovation travels with difficulty and suffers from distance decay effects (STORPER and VENABLES 2004).

In one way, innovation benefit more from the proximity of important varying actors, which together contributing to generation and diffusion of knowledge and in turn promote the clusters. In another way, economic actors clustered with physical proximity incline to be more innovative and benefit from each other comparing to the remote distance gap. Moreover, Cluster will also give actors advantages in time for quickly adapt to new technology and find partner to initiate economic opportunities (Moore and Mckenna 1999)

Cluster is more effective with a good social background. This is also legitimacy to put business environment into studies, combing with cluster. Clusterization would be more effective combining with actors beyond firm, in generating innovations. That is, when universities, R&D research institutions, and other agents create dense socioeconomic network in the environment, the actors within the region would benefit from exchanging and assimilating knowledge going through these channels. Further, innovation and growth would generate in this region. Above all, clusters would have greatest impact when they are not just merely collocations or agglomerations of firms from similar sectors, but when they form regional systems of innovation. (Doloreux and Parto 2005)

However, on the contrary, regional specialization also brings risks, as vulnerable to external shock, and easier to encounter lock-in. Nevertheless, larger amount of clusters open to outside, and dynamic clusters with linkage and overlap between each other, would largely decrease these potential risks (Solvell et al 2009).

2.3.2 Cluster measurement in ECO

Cheshir and Malecki (2004) has a review of how cluster contribute to the innovation, and further economic growth, which demonstrate there are numerous literature into this. However, most are qualitative case studies, and most illustrate the good performance of clusters, while the less superior region is lack of attentions.

Not many systematic approach have been done. However, Europe Cluster Observatory approach, the first time in Europe, could help address this issue, covering the European regions. Clusters are measured by industries employment data, not only detect the cluster winner, but also could find out the existence of inferior clusters.

In this work, we will follow cluster measurement done by European Cluster Observatory[1]. ECO group propose the following methodology of measuring clusters. Across the whole European

[1] Calculations of Size, Specialization, Focus and observatory stars present in Appendix B

Union NUTS 2 levels, fifty-one industries were categorized in ECO phase-I work. Based on the number of employment, each industry will get a star if could meet each requirement, but only clusters with more than 1000 employees will be considered to prevent insignificant small clusters. Then observatory stars will be added to "observatory stars". The maximum observatory stars are three and the minimum is zero. Theses star observatories are calculated from NUT2 level, then all industries stars will be added together also for NUTS2 level. For NUTS1 level, the stars will be aggregated using weighted average by industries employment number.

2.4 Firm behavior (Competitive driver)

Linear innovation model is generally how innovation happens by mainstream economies. In this understanding, research and development will firstly lead to inventions, then combined with designs, engineering, manufacturing, and marketing skills, these inventions will turn into innovations, further sales for the individual company level. One step further, in a macro level, research and development of this region, and this country. This approach is especially associated with patents, which trigger the economic growth. (Fagerberg 2005)

Endogenous growth model, input of Research and Development, and corresponding innovation capacity is the basic explanations for persistent disparities in economic performance and productivity. This linear model put localized R&D investment at the core position to impulse technological progress, and then turns to economic outcomes. Even this method is over simple and overlook many other key factors, like regional business environment and neighboring spillovers, this model is still popular over academic and policy makers, because it is fairly good explaining powers: nations and regions with higher R&D input percentage, tend to be more innovative, and grow faster.

However, without considering the innovative environment of specific region, linear model is more like a static process. There are many work indicates how firm's R&D input interact with other economic actors (Fagerberg 2005). Consequently, to add more local environment and systematic interactions into consideration is essential, as we will discuss in business envirnment.

2.5 Business environment (Competitive driver)

Business environment in this framework is inspired by evolutionary economics, like the regional innovation system and territorial embeddedness, and social filters (Aranguren et al, 2010b). Basically this strand regard innovation as event takes place not by unitary actor, but facilitated by a set of interplaying agents within innovation-prone environment and institutions.

Regional systems of innovations, by evolutionary theorists, the regional economic performance is not merely dominated by the internal performance of individual firms, but also by quite broad factors outside the firms, jointly creating the environment. The innovative capacities of certain regions are highly influenced by the endowment of the regional innovation systems. Innovation system, is neither solitary nor linear perspective, but more interactive, and regard innovation as carried out through a network of actors within an institutional framework. The existence of these agencies does not necessarily generate innovative performance; however, it is their functions and complex interactions that contribute. Moreover, based on a more evolutionary perspective, historic and geographic, path dependence also play important and more underlying role in shaping the innovation and development path (Asheim&Gertler 2005).

It has been widely agreed that innovation process is territorial embedded. Innovations cannot be understood without considering social and institutional conditions of the regional space (Lundvall, 1992). From this perspective, innovation is interactive process, instead of stylized patterns. It is implemented by a network of various organizations within institutional framework. All these actors, network, and institutional setting are embedded in certain level of regions, and can only work out effective at this level. The interplay between these components results in the development, diffusion and use of innovations. Cooke (2006) further maintains that true territorial embeddedness is only feasible in regional level. Indeed, the regional dimension allows different actors interact with each other, create and share knowledge, and develop mutual trust. All these proximity together make regional level good scale for an innovation-based learning economy. Consequently, regional level business environment is introduced in RCF framework.

Moreover, Rodriguez-Pose (2008, 2012) introduce social filter concept. This concept thinks social background is like substrata for innovation to happen. Social filters approach try to distinguish among diversified socioeconomic settings and enablers, of which are innovation prone, while others are innovation-averse or insignificant. From his studies, social filters could be a good explaining for economic growth in European Unions, both in a positive and negative way. Business environment in RCF also intend to identify different indicators impacts.

3. Previous research

Firm R&D behavior’s importance to innovations output have been suggested by many studies(Cheshire& Magrini 2000, Capello&Lenzi 2013, Colino et al 2014, Rodriguez-Pose 2012). Likewise, there are many paper about how socioeconomic background, and regional embedded innovative environment will largely influence innovative abilities from different strands (Lundvall 1992, Morgan 2004, Rodriguez-Pose 2008), the similarities of the theories are to generate innovative activities is a systematic work, with many agents interact and contribute sophisticatedly, and these innovative enablers and favorable institutional arrangement are grounded in this region. Besides, ECO Background paper 4 (Navarro et al, 2010) discuss the reference regions to compare in this framework, and find out the similar social and economic background regions have also similar innovative index, both measured in terms of innovation input and output. It is a clue that social and economic background is a good explaining for innovations. That is why RCF will independently isolate business environment as a competitive driver.

Cluster's positive role on economic growth of regions has been presented in many studies, and Porter (2003) had an overview of this discussions. ECO project has found out a relatively strong relationship between innovations performances, patent-based and cluster stars with coefficient of determination 0.357 (Solvell et al 2009, p13). Moreover, there is also positive relationship between cluster strength and economic prosperity from this report. Except for clusters in all industries, ECO's further report (Franco et al, 2014) found out the positive correlation between emerging industries' cluster level in Europe, and regional innovation performance from CIS. Crescenzi et al (2007) has a comprehensive review about relationship between regions and innovative performance, from the empirical studies in both Europe and US. US leading innovation could be largely attributed to the higher mobility of knowledge and capital promoting the cluster of research activities. In another word, the successful of cluster is one of essential reasons for leading innovations skills.

However, in term of ECO's cluster measurement, some research find out cluster's impact is not as significant as theories expect. Rodríguez-Pose and Comptour (2012) has done a pioneer study to understand how cluster, regional socioeconomic environment, and firm's R&D would impact economic growth over 152 regions of Europe from 1995 to 2006. ECO project clustering measurement was used in this paper. Quite surprising, this study revealed inconclusive results about cluster impact. Cluster per se is not necessary for economic growth, but when it combine with certain innovative-enhancing socioeconomic factors, it could have impact on economies. Moreover, generally cluster's impact is relatively weak and insignificant for growth comparing to socioeconomic environment and firm's R&D input.

In terms of Community Innovation Survey, there are many paper uses CIS to understand innovations' determinants and output. Besides CIS results have a positive relationship with productivity in Europe (Hashi&Stojcic,2013), most of them emphasize the knowledge source and channel innovation draw from revealed from CIS results. Franze and Ietto-Gilles (2009) uses CIS data in UK find out different channel of knowledge innovation draw from will highly influenced on innovative output (innovative sales per employees). For instance from their work, own-generating knowledge, and bought-in knowledge are associated with innovative performance, while collaborating seems not very relevant. Another study using fourth CIS of 15 countries, found out firms' internal R&D input and external search of knowledge both could explain differences in cooperating innovating strategies. Moreover, firms' ability of absorbing science-based knowledge from public source is favoring firm's innovative cooperation (Gallego et al, 2013). Battisti and Stoneman (2010) has discussed the correlation of CIS's each innovation activities to the others, and also the importance of categorizing innovation into "technological" and "non-technological", which are complement but not substitute to each other. Bach el al (2014) found out both internal R&D activities and external R&D activities would need to draw knowledge from a set of actors in operating environment, including firm, suppliers, customers, universities, governmental institutions, etc. However, though most of these actor could explain both internal and external innovative activities, their relatively importance vary country to country based on CIS findings.

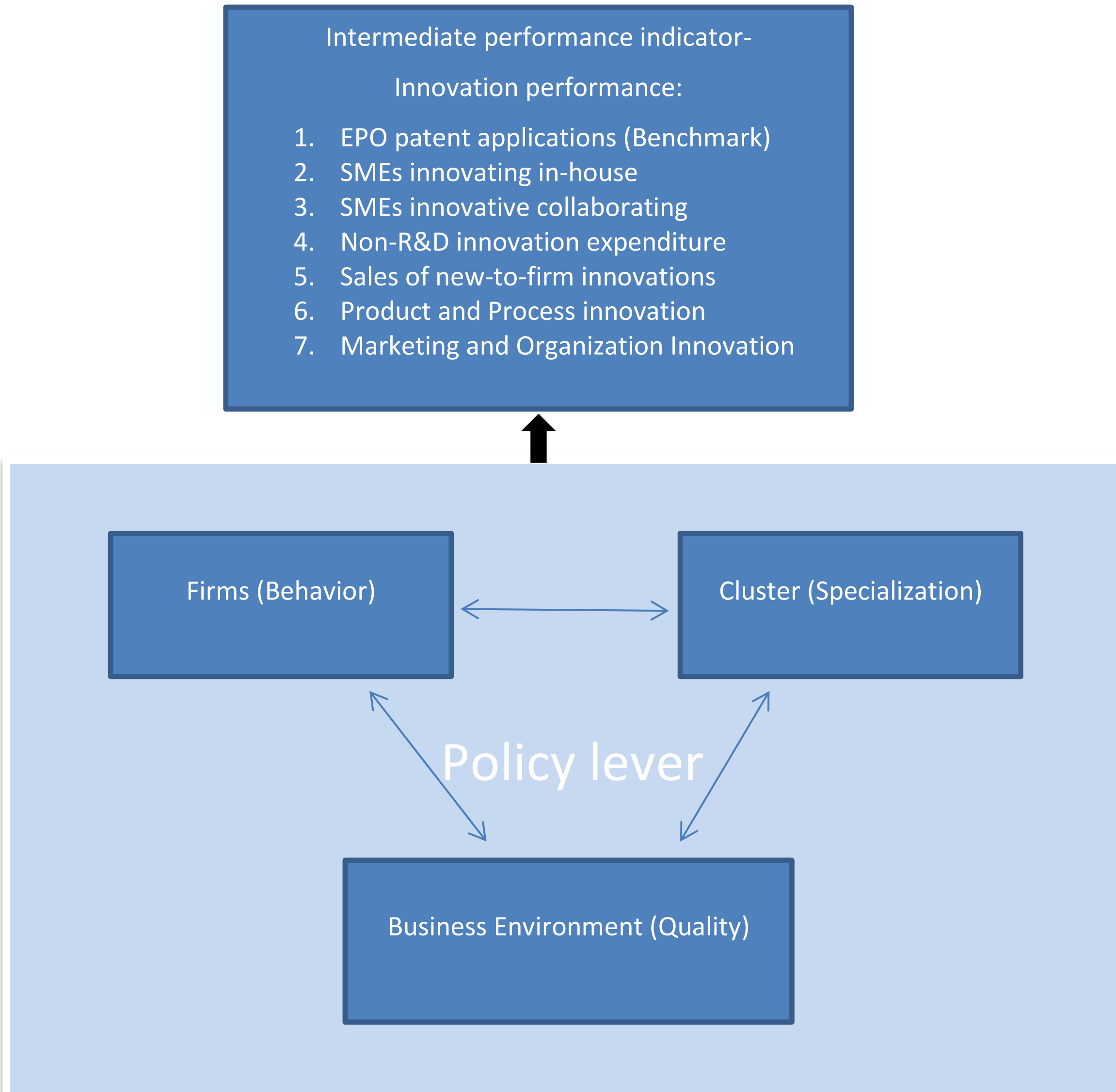
From the above literatures we do understand innovations activities can generate or acquire knowledge from different sources and channel. These different sources and channel do matter to further innovation performance. Consequently, there are the rationalities behind we should study how competitive drivers influence different knowledge channels and types of innovations.

4. Construction model, Methodology, Data

4.1 Motivation

Based on the literature review in section three, ECO project only have correlation studies of the three competitive drivers to innovation and economic growth. However, as far as author knows, ECO does not provide any systematic studies about how RCF's three competitive drivers (cluster, firm, environment) influence and their relatively importance on innovation performances, especially subject-view innovative activities from CIS, which could reveal more perspectives of innovations and knowledge channels. This paper tries to use Regional Competitiveness Framework to understand the above unexplored questions as showed in Figure 2.

Figure 2: research proposal of this paper by RCF



4.2 Methodology

4.2.1 Regressions

Ordinary Least Squares regression would be used to understand the research question we intend to study. The analysis would be carried out in cross-section regressions covering 156 in eighteen European countries. NUTS1 or NUTS2 regions are mixed used in this study, for reasons both the data availability, and also the similar decentralized tier of government and policy-making power. The 156 regions studied will be provided in the Appendix D.

For the time period, because of the CIS data we could get access is max-min standardized data from regional innovation scoreboard report (European Commission, 2014). Unfortunately, panel regression cannot been carried out. This would be discussed in limitation part. This paper will use <Regional Innovation Scoreboard 2014>. In this report, the data of innovation is from community innovation survey 2012 covering years from 2010 to 2012 three years average innovation survey results. As a result, year 2011 will be perceived as the year from CIS 2012. Both static and dynamic studies will be carried. In static part, the same year of independent variables will be used. In dynamic part, explaining variables in two years advance will be used to understand their influenced on innovation activities two years later.

Following the regional competitiveness framework, the independent variables will be divided in to three parts: Cluster, Firm behaviors, and Business Environment. Each of part will have several indicators to represent, and one index will be consolidated in each part by PCA, namely cluster index, firm behaviors index, and business environment index.

$$\begin{aligned}\text{Innovation variable} \\ &= \alpha + \beta_1 Cluster\ Index + \beta_2 Firm\ behavior\ index \\ &+ \beta_3 Business\ Enviroment\ index + \varepsilon \qquad (1)\end{aligned}$$

Innovation variables include the following indicators:

EPO patent applications

SMEs innovating in-house percentage

SMEs innovative collaborating percentage

Non-R&D innovation expenditure over turnover

Product and Process innovation percentage (Technological)

Marketing and Organization Innovation percentage (Non-technological)

Sales of new-to-firm innovations over turnover

Besides the regressions with three indexes will be carried, every disaggregated variable will also run regression with other two remaining indexes. These regressions are also very important, in one hand, it still follow the RCF setting, in another hand, they could reveal the effects of every individual variable on innovations, while PCA aggregated index might mix up different effects, and conceal individual’s impact.

4.2.2 Principal Component Analysis

Principal component analysis (PCA) method will be used to consolidate individual variables into index, in this paper, namely cluster index, firm behavior index, and business environment index. The advantages of PCA is that this method could identify internal patterns of data, including respective indicator's weight and sign, and simultaneously the final consolidated index maintain largest variations of the initial information (Hardle & Simar 2007). At the same time, fewer correlated variables in regressions can help reduce the issues of multicollinearity. Results of amalgamating variables into index by PCA are demonstrated in Appendix A. It is interesting to find out the signs of all proposed variables in next part have the same sign as theories expected.

4.3 Identify variables

In this studies, both explaining and dependents variables deserve analytical attentions, since explaining variables will reveal which one is important for generating innovations, while dependent variables will show different sources and channels of innovations activities.

4.3.1 Innovation

This paper will use six variables as dependent variables, from Community Innovation Survey. Each of them will be presented in Table 1 along with its target to capture. It is notable that only SMEs data are applied to these six variables, instead of all sizes of enterprises. The reason of this, besides data availability, is large size firm has all sorts of innovation performances, regardless of regions (European Commission, 2014) Therefore, it would be expected that, if all size of firms, CIS variables will be favorable to regions with larger proportions of large firms.

As discussed in the theoretical part, patent applications, though quite controversial, is still the most widely used proxy for the capacity of regions to generate and assimilate knowledge. Hence, as a traditional objective innovative indicator, patent application number would be a benchmark reference for other six subjective indicators.

Six innovation indicators could be classified as two categories. The first group measure the extent of innovations from specific knowledge sources and channels, while another are measured the frequency of two types of innovations firm implement, technological or non-technological. They will be assigned to Channel 1 to 4, and Type 1 and Type 2 in the following studies.

SMEs innovating in-house use the percentage of in-house innovating activities to capture the extent of knowledge and innovation by own generating (Channel 1). Likewise, Innovative SMEs collaboration with others could serve as proxy to capture the extent of knowledge and innovation produced from collaborating (Channel 2). Furthermore, Non-R&D expenditure measures the input to innovation, but not traditional R&D, but the purchasing of equipment and machinery, as well as acquisition of existing patents and licenses. This indicator is not measured by the percentage of positive respondents as channel 1 and 2, but by ratio of non-R&D expenditures to all turnovers. This indicator could target to represent the extent of knowledge and innovation acquired by purchasing from outside (Channel 3). The last indicator in this category is new-to-firm innovations for SME, which measures the turnover of new or significant improved products to firms, but not new to market (European Commission, 2014). This indicator serve as a suitable proxy for the extent of diffusion of state-of-the-art technologies, in other words, the extend of innovation acquired by learning from outside (Channel 4).

Another category is based on different innovative type technological or non-technological. The first one could use the percentage of SMEs introducing product or process innovations (Type 1), while the latter counterpart could be captured by the percentage of SMEs introducing marketing and organization innovations (Type 2).

Table 1: Innovative indicator from CIS

Indicators	Explanations	Proxy/Targets	Unit
SMEs innovating in-house	This indicator measures the degree that SMEs have introduced any new or significantly improved products or processes in-house.	Capture extent of innovation acquired by own generation (Channel 1)	% of all respondents
Innovative SMEs collaborating with others	This indicator measures the degree to which SMEs are involved in cooperation of innovation. Complex innovations need knowledge from diversified sources. This indicators measure collaborating sources both from public institution and private firms.	Capture extent of innovation/knowledge acquired by collaboration (Channel 2)	% of all respondents
Non-R&D innovation expenditure	This indicator measures non-R&D innovation expenditure over turnovers, including acquiring equipment, machinery, patent and license.	Capture extent of innovation/knowledge acquired by purchasing (Channel 3)	/turnover
Sales of new-to-firm innovations for SME	This indicator measures sales of new or significantly improved products to firm as a percentage of total turnovers. However, the product is not new to market.	Capture extent of innovation/knowledge acquired by learning (Channel 4)	/turnover
SMEs introducing product or process innovation (Technological)	This indicator measures SMEs participating rate of introducing new products (goods or services) and processes. Higher shares of technological innovations would indicate a higher level of innovation activities, especially for manufacturing.	Capture percentage of SMEs implement technological innovation (Type 1)	% of all respondents
SMEs introducing marketing	This indicator measures SMEs participating rate of introducing marketing and organizational	Capture percentage of SMEs implement non-	% of all respond

or organization innovation (Non-technological)	innovations. Firms, particularly services sectors, innovate through non-technological forms of innovation	technological innovation (Type 2)	ers

4.3.2 Cluster index

As discussed in the theoretical part, rational of including this index is the importance of physical proximity for generation of innovation. These variables try to measure the tendency of similar firm and sectors cluster together geographically. Three variables will be introduced for cluster and specialization. Two variables are from Europe Cluster Observatory (ECO). As introduced in the theoretic background, ECO used three dimensions to assess clusters-Size, Specialization, Focus, then added as observatory stars. There are two variables we will use, the first one is observatory stars, as introduced above, and NUTS1 and NUTS2 level depends on different regions. Another indicator is observatory stars in only technology and knowledge-intensive clusters[2]. As defined, this observatory star is to measure the strength of regional technological and knowledge-intensive clusters. Eventually, besides high tech cluster, another variable also will be complement to observatory stars, RCF recommends to use employment in high and medium high-technology manufacturing and knowledge-intensive services employment. It is noteworthy to know this variable is still different from the high-tech observatory stars, since observatory stars measure existent and degree of clusters, while employment in high-tech and knowledge-intensive measures the aggregated employing numbers of different high tech industries in this region, regardless each of them form a cluster or not. A higher employment in high-tech does not necessarily mean this regional has many high-tech clusters, maybe it has many diversified high-tech industries, but none of them is big or significant enough to be a cluster. However, despite of its biasness, it is still a good proxy for the technological strength of regions to complement solely clusters observatory stars.

4.3.3 Firm behaviors

Firm behavior also contains three variables. The first one is basic input, all R&D expenditures in the business sector as percentage of regional GDP (BER&D), the most widely used indicator as proxy for physical innovation input. The second variable is business R&D personnel over total employment, as a proxy for human resource input for innovation. The third variable is business investment, ratio of gross fixed capital formation over total number of employee. We expect the higher level of investment formation, including better facilities, will promote more innovations.

4.3.4 Business environment

The aim of this index is to simulate the business environment where firms are acting and operating. As discussed in the theoretic part, it is very hard to implement this, since many influencing factors cannot be quantified, let alone path dependence, and historic and geographic reasons, etc. Nevertheless, we still could use several indicators to reflect the socioeconomic

[2] Technology and knowledge-intense clusters are defined in Appendix C by ECO team.

conditions which make certain region more innovative than others. Business environment should catch the territorially embedded character of regions, by regional innovation system perspective.

We will follow Porter's diamond to discuss the regional factors (Franco el al, 2011). 1) Factors conditions. 2) Demands 3) Context for firm strategy and rivalry 4) Cluster (In this framework, cluster will be put separately in one competitive driver)

(1) Factors:

Public R&D expenditure is primary variable for the business environment, since public R&D indicate input to innovation infrastructure of this region, from a linear view, both private and public research input, will lead to patent innovation, though the commercialized path will be different from private patent, public input will contribute more indirectly through spillovers, collaboration, and franchise (Cheshire & Malecki 2004). Public R&D is expected to be one of most important mechanisms for generating innovations. Likewise, public R&D personnel percentage is also a good complement for physical input; however, given lack too many data from Eurostat, public R&D personnel will not be included.

Human resources in science and technology as percentage employed would be second It reflects the human resources working directly to create scientific knowledge and innovation. It is believed the presence of stronger scientific background will be more competitive for innovation and economic growth (Rodriguez-Pose 2012).

Indicator of students in per-vocational and vocational program will capture new generation of vocational skills among the youth. This would a proxy to catch the flows of vocational talents preparedness for market. Vocational training is essential for manufacturing skills, both for product or process innovations, especially in engineering knowledge-base. On the contrary, the more youth get into vocation program is also the signal from labor market. It could manifest labor market needs more skillful graduates from vocational trainings, and these vocational skills could fulfill firms' requirements and help promote innovations.

Likewise, indicator of students in tertiary program with academic orientation (% of 20-24 years old) also plays the same role for potential supply of academic knowledge input. This is a proxy to capture the flows of academic talents preparedness for market. Academic knowledge will be beneficial for the effectiveness and efficiency of R&D, especially in analytical knowledge industries. Similar to vocational studies, the higher attendance rate could also reveal the needs of labor market.

Unlike the above two flow of human resource preparedness, population with upper-secondary or tertiary education would be used to capture the stock of educative talents in this market, or in another word, the high-skill labor endowment in this region, which is widely regarded as a key innovative enabler.

(2) Demand

The sophisticated domestic market will bring pressure to firm to innovate earlier that its international competitors (Porter, 1990). The ECO team provide several variables to catch this complexity of demand needs, like Household Broadband access, internet trade, young population from 15-35, etc. However, these variables' proxy for complicated demand is controversial, and also ECO project do not find their much influence on intermediate and final outcome variables (Navarro et al, 2010). Hence, given lack of good proxy and available variables, this paper decide not choose variable from this part.

(3) Context of firm strategy and rivalry

Measured by percentage of adults aged 25-64 participating in education and training, lifelong learning can help assess the sophistication of firms' human resources. It is proxy for extent of continuous knowledge flow and creation. We expect innovative firm needs to operate in an environment where the employees are continually updating their knowledge stock.

Public sector employment could measures the weight and extent of public sector influencing the regional business context. However, this impact is intricate. In one way, more public sector indicate better public service for firms to operate more efficient; In another way, it also indicate higher tax burden of private sector, inhibiting innovations. Moreover, higher weight of public sector also might be result of inefficient governing system, not opposite way. Its influence on regional innovation performance is hard to predict theoretically.

Long term unemployment of all unemployment is proxy for rigidity of the local labor market, the degree of difficulties of companies adjust to their workforce (OECD,2013). Long-term unemployment is different mainly because of institutional arrangements (OECD, 2013) Higher rates of long-term unemployment are generally associated with relatively more generous unemployment benefits. Moreover, long-term unemployment also indicates the degree of rigidity of the local market. Stricter labor regulations and protection legislations would also bring higher cost for firm and then further prevent it to hire potential qualified unemployed persons (OECD 2004). Here we try to use this indicator to scale the efficiency of labor market and its degree of flexibility. As a result, we expect long-term unemployment will have a negative relationship with innovation performance.

The last variable we will use in business environment is agriculture percentage, used as a proxy to assess regional hidden unemployment and general productivity skills. More importantly, it serves as a regional proxy for economic development phase. We expect a negative sign of this variable in PCA index.

The followings are description and summarize of dependent and independent variables.

Table 2: Descriptions of the variables used for regressions

Variables	***Definition***	***Sources***	***Sign Expectation***
Dependent variables			
EPO patent applications	Applications per million inhabitants	Eurostat	
SMEs innovating in-house	Positive response of all responses	Community innovation Survey	
SMEs innovative collaborating	Positive response of all responses	Community innovation Survey	
Non-R&D innovation expenditure	Non-R&D Expenditure as percentage of turnover	Community innovation Survey	
Sales of new-to-firm innovations	Sales of new-to firm	Community innovation Survey	
Product and Process innovation	Positive response of all responses	Community innovation Survey	
Marketing and Organization Innovation	Positive response of all responses	Community innovation Survey	
Independent variables			
Cluster Index	PCA calculation		Positive
Observatory stars	See Appendix B	Europe Cluster Observatory	Positive
Observatory stars high-tech	See Appendix C	Europe Cluster Observatory	Positive
Employment in knowledge- ntensive jobs	Employment in medium-high/high-tech manufacturing and knowledge -intensive services of all employment (%)	Eurostat	Positive
Firm Behavior Index	PCA calculation		Positive
Firm R&D spending	Share of regional GDP (%)	Eurostat	Positive
Firm R&D personnel	Of total firm employment (%)	Eurostat	Positive
Firm investment	Ratio of gross fixed capital formation over total number of employees	Eurostat	Positive
Business environment index	PCA calculation		Positive
Public R&D spending	Share of regional GDP (%)	Eurostat	Positive
HR in science and technology	Human resources in science and technology Percentage of employment (%)	Eurostat	Positive
Potential vocational skills (flow)	Students in pre-vocational and vocational program (% of 15-24 years old)	Eurostat	Positive
Potential academic skills (flow)	Students in tertiary program with academic orientation (% of 20-24 years old)	Eurostat	Positive
Education skills level (stock)	Population with upper-secondary or tertiary education (%)	Eurostat	Positive
lifelong learning	Percentage of adults(25-64) participating in education and training	Eurostat	Positive
Public sector employment	Public sector, education and health employment (%)	Eurostat	N/A
Labor rigidity	Long-term unemployment of total unemployment	Eurostat	Negative

	(%)		
Agriculture (%)	Agriculture employment of total employment	Eurostat	Negative

Table 3: Summary statistics of the variables used for regressions

Variables	Obs	Mean	Std. Dev.	Min	Max
Dependent variables					
EPO patent applications	156	0.238026	0.156676	0.009	0.779
SMEs innovating in-house	156	0.344263	0.118666	0.055	0.814
SMEs innovative collaborating	156	0.384949	0.223613	0	0.991
Non-R&D innovation expenditure	156	0.330474	0.219646	0.013	0.868
Product and Process innovation	156	0.414859	0.247367	0	1
Marketing and Organization Innovation	156	0.355571	0.192975	0.034	0.778
Sales of new-to-firm innovations	156	0.447718	0.147627	0.071	0.926
Cluster					
Observatory star	156	12.7359	7.841327	2.58	47
Observatory star high tech	156	4.298077	4.117416	0	19
Employ in high and medium-high technological manufacturing and knowledge intensive service	156	0.495135	0.176592	0.09	1
Firm Behavior					
Firm R&D share of GDP (%)	156	0.730769	0.748557	0	3.8
Firm R&D personnel (% of total)	156	0.428782	0.384681	0.01	1.85
Firm investment (thousand EUR/employee)	156	12.65295	6.080946	2.61	33.51
Business environment					
Public sector R&D Expenditures	156	0.360186	0.190471	0.012	1
Employment in science and technology %	156	18.14295	5.986578	9.1	35.7
Students in pre-vocational and vocational program (% of 15-24 years old)	156	21.53974	8.454143	7.07	63
Students in tertiary program with academic orientation (% of 20-24 years old)	156	53.57397	27.7385	1.34	241.83
Population with upper-secondary or tertiary education	156	75.62603	14.38345	27.63	97.08
Lifelong	156	9.485161	6.119978	0.6	27.7
Public sector, education and health employment	156	24.78212	6.214189	10.41	44.1
Long term unemployment	156	40.15714	11.10146	16.2	71.1
Agriculture populations%	156	6.344936	8.492506	0.1	54.72

5. Results

The three competitive drivers are important for this study. Principal component analysis result is demonstrated in appendix A. To sum up, all three indexes have good representativeness of the individual variables' deviations. Cluster principal component accounts for 68.90 percent of the total variance. The sign of individual variables has the expected sign: Observatory stars, Observatory star high tech, and Employment in high tech-manufacturing and knowledge intensive service are all positive. Firm behavior index account for 70.53 percent of the total variance, and all three variables have positive sign. Business environment index accounts for 39.35% of total variance. The sign of public R&D, employment in science and technology, students participations in vocational training, in academic studies, population with upper-secondary or tertiary education, lifelong learning, and public sector are positive as expected. Furthermore, long term unemployment and agriculture percentage' signs are negative.

Before regressions results, we carry out the correlation analysis to have a general overlook of relationship between seven CIS innovative variables and GDP pc, the current level of economic level, especially to understand the innovative distribution in developed West Europe and transition East Europe.

Table 4: Correlation of CIS innovative variable with GDP per capita

Correlation r	EPO patent	In house	Collaborating	Non R&D	New-to-firm sales	product process	marketing organization
GDP pc 2011	0.568	0.550	0.400	0.102	0.347	0.557	0.436

It is interesting to find out EPO patent has a highest correlation level with 0.568, followed by technological innovation, and in-house innovations, this indicate patent- oriented, and in house generating are still biased to rich and west Europe regions. On the contrary, Non-R&D has very low positive correlation with GDP pc. This indicates purchasing knowledge and innovation from outside is not relevant to economic level of regions. It is very reasonable since we expect lag behind regions would purchase and exploit potentials of existing knowledge. However, other innovative activities have modest positive correlation with economic level.

Regression results are presented from Table 5 to Table 11 in Appendix E.

5.1 EPO patent application

Comments on Table5:

Firstly, the high adjust R2 coefficient of determinant manifest that these proposed independent variables from RCF could explain most of the variance of patent application in EPO.

For all the regressions, both firm behaviors and business environment, two consolidated index are significant, both with 1% confidence level, indicating robust relationship between firm level's input and innovation, and regional business environment's important contribution to innovations. Former index represent the linear model is still a powerful explaining factor, and the latter indicate embedded socioeconomic enablers could largely support to explain patent based innovations.

In terms of Cluster, effect is not as overwhelmingly significant as other two, but still considerably strong. Among thirteen regressions with composite cluster index, seven of them are significant. For disaggregated variables, high technology observatory stars has a clear positive impact, while the other two variables are insignificant. Observatory stars itself include all kinds of clusters, regardless of their productivity and performance; it might reveal not all agglomerations are good for patents. However, high-tech clusters stars is a good compensation for this limit. Employment in knowledge-intensive jobs is also insignificant; the reasonable explanation is that information might already be represented by firm activities and business environment. More R&D input suggest higher possibilities of more employment in high-tech industries, and vice versa. Moreover, cluster effect are also significantly positive with interplaying variables, including firms R&D input, potential academic skills (negative), lifelong learning, and public sectors (regression 5, 11, 13, 14). This implies that the effectiveness of clusters will be combined with regional firm input, as well as regional socioeconomic conditions. The interplaying relationship between firms, business environment and clusters is two directions (Aranguren et al 2010a). In one hand, companies cluster in one region will help facilitate knowledge and intellectual exchange and mobility between educated people. Cluster will have great impacts on agents to innovate more. On the other hand, certain characteristics of the regions, the secret recipe of regional innovation system, make certain clusters crucial for innovations, while others irrelevant to innovations.

For the individual indicators of firm behaviors, firm R&D input and R&D personnel still play a dominating role in generating patents (regression 5, 6), while business investment is irrelevant. Given patents are still driven mainly by R&D work, the result is not surprising.

For separate indicators of Business environment, It is surprising to find out public sector R&D's impact is not significant (regression 8). There are similar result from other papers, as discussed by Cook (2001), public investment in R&D is relatively not associated with innovation and further economic performance in the regions without strong socioeconomic conditions and absent of efficient jointing networks and systems to absorb knowledge in this region. Moreover, Tripple et al (2015) has provided a theoretic framework to study weakness of regions. Most of the cases are attributed to organizational or institutional thinness of regional innovation system. Because of these reasons, regions could not convert public knowledge supply into innovations and further commercial activities.

All other variables, except tertiary academic students, all have the positive or negative impact on innovation as expect. To be specific, employment in science and technology, student in vocational school, population with tertiary education, and lifelong learning, and public sectors have positive sign, while long term unemployment and agriculture have negative influences (regression 9-16). This suggests a strong scientific environment and high-skilled labor force could equip this region with innovation-enhancing abilities. In the theories of regional innovation system (Asheim&Gertler,2005), a set of highly educated skill labor with diversified knowledge, with positive public incentives and flexible labor mobility, would be helpful to develop an innovative community where knowledge and innovation are generated, diffused, interacted within different actors.

About the weakness of clusters in most of the regression will deliberately discuss in conclusion part.

5.2 SME innovating in-house

Comments on Table 6

SME innovating in-house is used to capture the extent of innovation generating from firm itself (Channel 1).

Firstly, Coefficient of determination indicate large proportion of variance in innovating in-house between regions could be explained by RCF drivers (most R2>0.4)

Most of clusters indicators is not significant, except the significant one with firm investment (regression 7). Generally, the existence of clusters, and high-tech strength of clusters cannot add values to explain the innovating in house. On the contrary, firm behaviors are very strong and consistent in every regression, including the separate indicators (regression 1-16). The result is not surprising, considering innovating in house mean generates knowledge and inventions by themselves, the internal efforts of firms should be predominating.

For the business environment, the results are more complicated and inconclusive. We could find out public sector R&D, scientific employment, potential vocational skills, lifelong learning, and public sector has a significant influence (regression 8, 9,10, 13,14). This result again indicates an innovative-prone socioeconomic background is essential for promoting firm internal innovations abilities, by providing enough public knowledge, and labor skills and good service. Nevertheless, students in tertiary academic education and population with higher education are negative significant. The first one of students in academic is consistent with EPO patent. The reason might be academic skills of youth cannot transfer these skills into innovations immediately, and also too many students still in full-time training, might have negative impact for current labor market. In terms of innovation in house, rigidity of labor market seems irrelevant, but agriculture percentage is significantly negative; This indicate a more advanced economic phase, a higher productivity is naturally explaining this innovation activity.

5.3 SMEs collaborating in innovation activities

Comments on Table 7

SMEs collaborating in innovation activities is used to capture the extent of knowledge and innovations acquired by collaborating (Channel 2).

Firstly, Coefficient of determinant manifest three competitive drivers could have a fairly good explaining for SMEs collaborating.

Surprisingly, in most of regressions, cluster is significantly negative. This result does not support against existing theories and also the benchmark results of EPO. This will be further discussed.

Again, we could find very strong support of firm behaviors' efforts contributing to innovations from collaborating with others, except the firm investment has a negative impact (regression 5,6,7). This is an important finding. It could be interpreted as, collaborations between firms happen more in regions where firms themselves are more research oriented and innovative at first place.

In term of environment, public sector R&D is not that important as we thought for SMEs participating into collaborations. As discussed, the reasons might be lack of appropriate organization to connect different agents, or institutional thinness, like distorted regulations and laws discourage cooperation between firms, and even worse SMEs are among of the most easily impacted agents. For other environment indicators, except potential academic skills with negative impact (regression 11) all other variables play significant roles with expected sign. This manifest a good business background is very beneficial for innovation, and acquiring innovations from collaborating will depend on good environment.

5.4 SMEs Non-R&D innovation expenditures

Comments on Table 8,

Non-R&D tries to catch the extent of knowledge and innovations acquired from outside by purchasing (Channel 3).

Firstly, coefficient of determinant is very low, and some even lower than 10%. This suggests there are more other variables would explain differences of Non-R&D expenditures. Cluster, firm, business environment proposed in this paper by RCF have limit understanding why some regions' SMEs choose to spend a lot, while others do not.
Also in some of the regressions, cluster index is significantly negative. It is against the existing theories and benchmark result of EPO patents with positive impact. Cluster result is not

significant in most regressions. This abnormal will discuss more in Final part. Despite the weak explaining powers, we still could find out the predominant factors of business environment here. Business environment have a consistent and strong explaining for non R&D expenditures (regressions 1-7)

In terms of individual variables, all variables from clusters and firm behaviors are insignificant, not good enough to catch the deviations among regions.
However, for business environment, Education level of active population has a significant impact (10% confident level) on purchasing technologies (regression 12), while to a larger extent, employment in scientific and technological positions, participation into lifelong learning, and existent of public sector, have a significant influence on firms' acquiring knowledge behaviors (1% confident level, regression 9, 13, 14). It supports the existing theories higher scientific background, complicated knowledge stock, and effective government will promote more technologies generation and facilitate exchange within agents, and one of the mechanisms is acquiring from each other. Moreover, this regression also indicates flexibly of labor market is also quite significant in explaining differences of non-R&D among regions (Regression 15). Labor flexibility could bring out more mobility between firms, as a good channel to exchange information and knowledge, including purchasing knowledge.

5.5 SMEs sales of new-to-firm over turnover

Comments on Table 9

SMEs new-to-firm sales of percentage of turnover is used to capture the extent of knowledge and innovations acquired by learning (Channel 4)

Firstly, Coefficient of determination is extremely low (less than 10%), indicating that competitive three drivers proposed in this study is very limited to explain the distribution of new-to-firm sales within EU, and many more missing variables are not included in this quantitative model. The variance in extent of state-of-art technologies acquired by learning is hard to understand from this study.

For cluster index and separate variables, there are not even one regression has significant result.

For firm behaviors, we could find out except one regression with firm R&D share of GDP (regression 5), all regressions are significant for firm behaviors index and variables. It could be understood that firm behavior has a prevalent influence on SMEs new to firm sales of turnover. It is interesting to find out regions, in which more firms tend to put into more innovative input, are also the regions where firms could more easily learn from others by introducing similar but new to firm products.

For business environment, it is desperate to find out no variable is significant and with the expected sign(Regressions 8-16). However, given the extremely low coefficient of determinations, too many more factors need to take into considerations, so it is highly likely that business environment does not perform effectively because of lacking other indispensible factors.

Above, generally this proposal RCF is very weak in explaining the difference of SMEs new-to-firm sales over turnover. Despite the overall weakness, among the three competitive drivers, firm behaviors play a leading role in understanding their differences.

5.6 SMEs product and process innovation

Comments on Table 10

SMEs product and process innovation is used to capture the extent of SMEs participate into technological innovations (Type 1).

Firstly, Coefficient of determinant shows that three competitive drivers could have a modest explaining for SMEs product and process innovations.

For cluster index, similar to its effects for four channels discussed above, only one regression indicates cluster index is significant (regression 7), for individual indicators, no variable is significant. To sum up, cluster effect in explaining product and process innovation of SMEs is very weak.

Firm behaviors are dominating in this regression, including individual variables of firm behaviors (regressions 1-16)

For Business environment's result are inconclusive, the environment index is very significant with individual firm behavior variable, the significance decrease to 10% confident level when firm behavior index included. For disaggregated variable, first three variables are significant, namely public R&D, employed in science and technology, and potential vocational skills, while others socioeconomic variables are not significant. For SMEs product and process innovations, we could expect the region with the higher percentage of the above three variables is easier to innovate, as this regional business background could facilitate more knowledge and technique generations, and further more product and process innovation activities in SMEs of these regions.

However, it is interesting and inspiring to find out students with academic education, population with higher education, lifelong learning, and public sector larger present are not necessarily to promote more product and process innovations for SMEs. It might be these variables do help facilitate innovations, but mechanisms vary from places to places, moreover, these variables can only play a role with specific organizational and institutional support, which cannot be measured easily in this quantitative model.

5.7 SMEs marketing and organization innovations

Comments on table 11,

SMEs market and organizational innovation is used to capture the extent of SMEs participate into non-technological innovations (Type 2).

Firstly, Coefficient of determinant indicates that RCF drivers could have a relatively plain explaining for variance between regions for SMEs marketing and organization innovations.

For cluster index, there are three regressions identify cluster index as significant (regressions 5,7,12), while all three separate three variables are insignificant (regression 2,3,4)

For firm behavior, it is extremely strong support of positive impact of firm behaviors index, including three separate variables, to SMEs' marketing and organizational innovation activities (regression 1-16). This result is a little surprising and suspicious, Since firms' R&D expenditures and personnel are more scientific driven, they are supposed to influence more on product and process innovation, but not necessarily non-technological innovations. These innovations are concerned about how firm adjusts itself internal business organization or apply new marketing strategies to be more competitive and target niche market. However, their relationship might be correlation but not causation. The regions with higher R&D expenditures and personnel, most in developed countries, might also share other innovation-prone characteristics. They might be in the missing variables or even cannot be easily quantitative. These features make this region more innovative in organizations and marketing than others.

For Business environment, it is also find out public R&D, similar to private R&D, has noticeable impact on Type 2 innovative activities. The other variables are either insignificant, or significant but against theoretic expectations (regression 12, 15). To sum up, generally Business environment is very weak in explaining organizational and marketing innovations.

5.8 Summary report and policy implications

Table 12: Static regressions (joint table of tables 5-11)

Number of regressions with significant and positive index coefficient (total number of regressions)	EPO patent (Benchmark)	In house (Channel 1)	Collaborating (Channel 2)	Non R&D (Channel 3)	New-to-firm sales (Channel 4)	product process (Type 1)	marketing organization(Type 2)
Cluster index (13)	7	1	0	0	0	1	3
Firm Behavior Index (13)	13	13	13	6	13	13	13
Business Environment Index (7)	7	7	7	7	0	7	0
Coefficient of Individual variable regress with other two index							
Cluster Index							
Observatory star	.002 .001	.000 .002	-.006*** .002	-.001 .001	.000 .002	.001 .002	.001 .002
Observatory star high tech	.006*** .001	.000 .004	-.006*** .002	-.003 .002	-.002 .003	.003 .004	.006 .004
Employment in knowledge-Intensive jobs	.026 .054	-.094 .098	-.114 .099	-.086 .064	.022 .083	.005 .120	.097 .098
Firm Behaviors Index							
Firm R&D share of GDP (%)	.115*** .012	.111*** .024	.100*** .023	.014 .015	.020 .020	.081*** .030	.068*** .024
Firm R&D personnel (% of total)	.225*** .029	.229*** .053	.156*** .052	-.008 .034	.103** .045	.202*** .065	.158*** .053
Firm investment (thousand EUR/employee)	.002 .001	.007*** .002	-.004* .002	-.001 .002	.012*** .002	.012*** .003	.009*** .003
Business environment Index							
Public R&D spending	.046 .046	.157* .083	.093 .091	.022 .056	.066 .069	.341*** .098	.271*** .080
HR in science and technology	.006*** .001	.010*** .003	.018*** .003	.007*** .002	-.002 .002	.011*** .003	.004 .003
Potential vocational skills (flow)	.0015* .0009	.004*** .002	-.001 .002	.001 .001	.001 .001	.006*** .001	.002 .002
Potential academic skills (flow)	-.001*** .0002	-.001* .0005	-.002*** .001	-.001 .0003	-.000 .000	-.001 .001	-.000 .001
Education skills level (stock)	.001** .0005	-.002* .001	.003*** .001	.001* .0006	-.003*** .000	-.002 .001	-.002** .001
lifelong learning	.003** .001	.011*** .002	.016*** .003	.006*** .002	-.002 .002	.004 .004	-.003 .003
Public sector employment	.006*** .001	.008*** .002	.016*** .002	.007*** .001	-.002 .002	.004 .003	.001 .003
Labor rigidity	-.001 .0007	.001 .001	-.003** .002	-.002** .001	.005*** .001	.005*** .001	.005*** .001
Agriculture (%)	-.002** .001	-.005*** .001	-.006*** .001	-.002 .001	-.002 .002	-.005*** .002	-.002 .002

Blue indicates coefficient is significant and sign is as expected.
Red indicates coefficient is significant but sign is not as expected.
Black indicates coefficient is not significant for 10% confident level

Table 12 presented above is a joint table for table 5-11, including all regressions in statics way. For three competitive driver indexes, their coefficient will not be showed, but how many regressions contain significant and positive coefficient of the index will be displayed. More regressions, means this index have a strong explaining powers for this innovative activities. For separate indicator, their coefficient and standard deviation are presented.

Based on former seven regression tables, below discussion will draw conclusions about how each independent variable impact different channels and types of innovations. Consequently, the corresponding policy implications have also be implied. If we carry out policy to enhance this factor, this factor will impact which Channels and Types of innovations. Or another way around, if we want to support certain channel or type of innovations, which factor we could impact on to facilitate or intensify this innovation. For example, we could know from Table 11, if we implement policy targeting to promote public R&D, we could expect it has positive impact on Channel 1 (in-house), Type 1(technological), and Type2 (non-technological) innovations, while insignificant on channel 2 (collaborating), channel 3(non-R&D),channel 4(new to firm sales) innovations. Thus, the influences from variable to innovative activities, discussed below, also reveal corresponding policy implications.

(1) Cluster

Generally, Cluster index only significant in first benchmark regressions, the EPO patent applications, and for individual variable, only observatory stars of high tech is significant and positive for EPO patent regression, but not in any others. From this study, at least from ECO's measurement of cluster, we have very weak evidence to support cluster as an important factor for innovations, except for patent based output. This result is very shocking, since many theories have suggested the importance of clusters for innovations and growth. There are three possibilities for this result. Firstly, cluster is as important as we think, as Martin and Sunley (2003) suggest that studies about efforts of cluster is biased to successful instead of failures and average examples. Furthermore, Rodríguez (2012) also found out cluster cannot function well with certain socioeconomic enablers, which are more essential than clusters for innovation and growth.

Secondly, besides there are many types of clusters (Aranguren et al, 2010a), Cluster methodology is biased to employment-intensive clusters. More variables, like productivity, value-added, cluster life cycle should be added, catch more strength and dynamics of clusters, and also shift the balance to knowledge-intensive Cluster. Besides, three stars methodology is suitable to identify clusters. However, to add them together as observatory stars, and to further aggregate all industry'stars is very arbitrary, which made the observatory stars unsuitable for quantitative regressions. Interesting, ECO team also recognize this defects, and introduce new method, would be discussed in limitation and future studies part.

Thirdly, important variables might miss in regressions. Even though we could rule out the possibilities of multicollinearity by VIF, the missing other important variables might account for this. Low value of coefficient of determinations could support this possibility, especially Channel 3, Channel 4, and Type 2 Innovations. With other relevant variables, which could largely increase the explaining power, the cluster coefficient might change dramatically as well.

(2) Firm Behaviors

Firm Behaviors index is prevalent significant and strong for all innovation performance except Channel 3, Non-R&D expenditures (still has 6 significant and positive coefficients over 13 regressions). This could prove that this region's firm behaviors of R&D input and R&D personnel employment are highly associated with different kinds of innovative activities. For separate variable, firm RD input could be helpful for patent, Channel 1, Channel 2, Type 1, Type 2, but not for Channel 3 and 4 innovations. Firm RD personnel input could be beneficial for all innovative activities except Channel 3. Ultimately, firm investment is also very relevant (significant for Channel 1 and 4, and Type 1 and 2), but more from an indirectly way, since investment cover every aspect of assets accumulations, could provide a good internal environment for innovations.

(3) Business environment

For business environment index, the index is significant in explaining five out of seven innovation activities, namely EPO patent, Channel 1, 2, 3 and Type 1 innovations. However, the index has very weak explaining power to Channel 4 new-to-firm sales, and Type 2 organizational and marketing innovations.

For business environment indicators, the results are varying and inconclusive, which are very reasonable, considering the complicated nature of innovations, imperfect measurements.

Public R&D is not significant in every innovative activity as expect Channel 2, and both types of innovations.

By contrast, employment in science and technology has a strong power in explaining five innovation performance except, new-to-firm sales (Channel 4), and marketing and organizational (Type 2). It is within expectation, a good scientific and technological industrials structure is important for different innovations.

Two variables of potential labor intellectual preparedness have quite different explaining. Vocational student's percentage has a positive impact on three of seven innovation performances, while academic student's participation does not have any positive impact on any innovation aspect; Even, this academic preparedness has three significant negative influenced on three innovation performance (patent, Channel 1, Channel 2). It is quite different from the theoretic expectations. It could be caused by time lag, since this preparedness of talents will go into labor market in a few years, and in dynamic studies it seems the negative effect is decreasing. Or it is possible this variable is not suitable to catch the regional innovative endowment, and innovative-prone business environment.

As a complement to the former vocational and academic skills flow, population with upper-secondly or tertiary education is the stock of existing skillful endowment. The result is also very inconclusive, for three innovative activities it has positive affect (patent, Channel 2 and 3), and there are equal number of negative impacts (Channel 1, 4, and Type 2).

In terms of context for firm strategy, lifelong learning and public sector play the same positive roles for four innovation activities (patent, Channel 1, 2, 3), but both insignificant other three innovative performance (Channel 4, Type 1, 2) It is interesting to find out these two variables have a non-negative impact on all kinds of innovation activities, while they both have positive impact on four kinds of innovations.

Long term unemployment, is a proxy to catch flexibility of labor market. For Channel 2 and 3, the sign of coefficient is negative as expected, which indicate the rigidity of labor market will prevent innovations. Nevertheless, for Channel 4, and Type 1, 2, the impact is positive. The reason might be rigidity is just one part of labor market efficiency, there are others missing variables for measuring efficiency of labor motilities.

The last but not the least, agriculture percentage as a proxy for hidden unemployment, productivity level, and economic growth phase for regions. The result is consistent, for all EPO, channel 1,2 and Type 1, the impact is negative. This suggests that more advanced economic structure, in which more employment in manufacturing and tertiary industries, and higher productivity, tend to be more innovative than their less advanced counterparts.

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5.9 Dynamic studies

In this part, the independent variables from 2009 will be used to explain the same seven dependent variables of 2011. Cluster data before 2009 have not yet been collected and calculated by ECO. Thus, Year 2009 is chosen for dynamic analyze. However, the result might turns out be quite interesting if longer lagged period could be studied.

Table 12: Dynamic regressions joint table

Number of regressions with significant and positive index coefficient (total number of regressions)	EPO patent (Benchmark)	In house (Channel 1)	Collaborating (Channel 2)	Non R&D (Channel 3)	New-to-firm sales (Channel 4)	product process (Type 1)	marketing organization(Type 2)
Cluster index (13)	6	1	0	0	0	1	3
Firm Behavior Index (13)	13	13	13	6	13	13	13
Business Environment Index (7)	7	7	7	7	0	6	0
Coefficient of Individual variable regress with other two index							
Cluster Index							
Observatory star	.001 .001	.000 .002	-.007*** .002	-.002 .001	.001 .001	.001 .002	.001 .001
Observatory star high tech	.007*** .002	.001 .004	-.001 .003	-.003 .002	-.002 .003	.004 .005	.006 .003
Employment in knowledge-Intensive jobs	.029 .054	-.089 .097	-.103 .098	-.076 .065	.002 .082	.006 .119	.097 .097
Firm Behaviors Index							
Firm R&D share of GDP (%)	.115*** .012	.112*** .024	.103*** .022	.023 .016	.013 .020	.085*** .029	.069*** .024
Firm R&D personnel (% of total)	.222*** .029	.221*** .054	.157*** .052	.011 .034	.078* .044	.202*** .065	.156*** .053
Firm investment (thousand EUR/employee)	.000 .002	.006** .003	-.006*** .002	-.001 .002	.012*** .002	.012*** .003	.009*** .002
Business environment Index							
Public R&D spending	.099* .050	.210*** .090	.104 .097	-.058 .060	.049 .074	.355*** .106	.295*** .086
HR in science and technology	.004*** .002	.008*** .003	.009*** .003	.006*** .002	-.001 .003	.013*** .003	.004 .003
Potential vocational skills (flow)	.001* .001	.004*** .001	-.001 .002	.001 .001	.001 .001	.006*** .002	.002 .002
Potential academic skills (flow)	-.001*** .000	-.001 .001	-.001*** .001	-.001 .000	-.000 .000	-.001 .001	-.000 .001
Education skills level (stock)	.001* .001	-.002*** .001	.003*** .001	.001* .001	-.003*** .001	-.002 .001	-.002** .001
lifelong learning	.005*** .002	.009*** .003	.020*** .002	.006*** .002	-.001 .002	.000 .003	-.005* .002
Public sector employment	.007*** .001	.009*** .003	.016*** .002	.007*** .002	-.002 .002	.004 .003	.002 .003
Labor rigidity	.000 .001	.002 .001	-.001 .001	.001 .001	.002* .001	.005*** .001	.004*** .001
Agriculture (%)	-.003*** .001	-.005*** .002	-.006*** .002	-.002 .001	-.003* .001	-.006*** .002	-.002 .001

Blue indicates coefficient is significant and sign is as expected.
Red indicates coefficient is significant but sign is not as expected.
Black indicates coefficient is not significant for 10% confident level

For Cluster index, the impact is still not significant as static way.   Only observatory star in high tech is significant in explaining EPO, but not the other six innovative variables.

For Firm behaviors, the result is also very similar to static regressions, except Non-R&D expenditures (Channel 3), all other six innovation performances could be largely explained by firm behaviors index and its individual variables. Even the sign and strength of coefficients are very similar to static perspective.

For the business environment index, the performance are strong to explaining five innovation activities, namely EPO patent, Non-R&D expenditures, in-house, collaborating, and product and process innovations. However, the index cannot explain Channel 4 and Type 2. This result is consistent with static regressions; moreover, also supported by insignificant separate variables. However, comparing with static regressions, the business environment's individual variable is slight different. Firstly, for EPO patent, the public R&D is significant with a positive support. This may imply public sector R&D will take time to come into effects for innovations. Secondly, for Non-R&D expenditures (Channel 3), labor rigidity is not as important as we expect for Non-R&D expenditures. Thirdly, students in academic became insignificant from negatively significant in static studies for innovating in house (Channel). It is a good trend to show us that academic students' participation might have a lag time influence on innovations, especially when we consider longer period. For the remaining innovative activities, the dynamic approach is quite consistent with the static way.

To sum up, when we use dependent variables of 2009 to explain the innovative activities in 2011, the result is very consistent and compatible. As a result, the policy implications in former section enjoy more credibility, though if longer time period could be studied, the findings will be more valid.

6. Limitations and future studies

1) Dependent variable only measure SMEs

Since the dependent variables, all six indicators, are concerning only to SMEs, this study can only reveal how cluster, firm behaviors, local business environment together influence SMEs innovative performances. However, apparently, all cluster, firm behaviors, business environment will impact innovative activities of all sizes firms. Unfortunately, it is also due to the drawbacks of Community Innovation Survey methodology. Four innovative indicators, namely in-house innovating, collaborating, product/process, and marketing/organizations only measure SMEs' performance, because almost all big firms in every region will response Yes to these binary questions (Regional Innovation Scoreboard, 2014) Nevertheless, these binary questions could not catch the level the frequency and intensity of innovative activities, given there must be large difference between big firms, which are so important to understand regional difference. Furthermore, in Innovation Union Scoreboard (2014), another two innovative variables non-R&D expenditures and sales of new-to-firm over turnover are available for all size of firms in country level; however not for regional level. As a result, all regional innovative data is provided in terms of SMEs. Differences in observations scope of independent variable and dependent variables are one limitation for this paper.

2) Lack of considering the interactions between competitive drivers

RCF methodology background I (Aranguren et al, 2010b) has clearly explain the interactive relationships between clusters, firm behavior, and business environment. Their relationship can be understood as interactive, bi-directional, and accumulative. Moreover, RCF methodology background paper III (Aranguren, 2010a) discusses how business environment and firm behavior will shape the mergence and strengths of clusters; further, it takes empirically studies, to demonstrate how relatively different importance of variables from business environment and firm behavior will influence the strength and quality of clusters.

Consequently, this paper's another shortcoming is lack of considering the interaction relationship of three competitive drivers, but only assumes that they impact the innovative activities independently. For example, the result of weak functions of cluster might because of lacking combining cluster's functions with weak or strong regional business environment. This paper results would be considerably complemented by including the interplay between these three competitive drivers. Taking firm behavior as example, we know this competitive driver is quite important for most innovation activities. However, we also want to know how clusters and business environment influence on firm's choice, and maybe there is underlying impetus from other drivers would affect firm's decision. If it is the case, we would motivate policy to target the underlying impetus instead the firms themselves. Their relationship is important to determine policy priority

The following function is proposed to address this shortcoming; however, to identify the interaction functions are still very challenging.

$$\begin{aligned}\text{Innovation variable}\\ &= \alpha + \beta_1 Cluster\ Index + \beta_2 Firm\ behavior\ index\\ &+ \beta_3 Business\ Enviroment\ index + \beta_4 f_4(cluster, firm\ behavior)\\ &+ \beta_5 f_5(cluster, business\ environment)\\ &+ \beta_6 f_6(firm\ behavior, business\ environment)\\ &+ \beta_7 f_7(cluster, firm\ behavior, business\ environment)\\ &+ \varepsilon \qquad (2)\end{aligned}$$

Similar to equation (1), but adding interaction functions f_4, f_5, f_6, f_7 as complements to lack of considerations of this paper. However, it is not easy to specify the forms of these functions. However, it is highly possible that merely single equation cannot catch the varying interactions of these three competitive drivers, let alone their respective individual variables. Besides quantitative variables, these underlying explainers might be qualitative, institutional relevant variables, which could capture the variances of innovative activities in different regions. For example, social proximity, institutional proximity would impact how the local persons interact with each other, and follow which kind of norms and legislations. All these arrangement will impact local firm behaviors in cooperation and knowledge exchange method (Boschma, 2005). Therefore, more qualitative results and case studies should be taken into considerations, as a complement to quantitative studies.

3) Panel data study

Actually from Regional Innovation Scoreboard 2012, 2009, more Community Innovation Survey data could get access to. However, unfortunately, all these CIS variables are standardized by maximum and minimum method from zero to one. Consequently, data is more like a relatively ranking position of certain region within Europea each year, and cannot be compared year to year. In this case, panel studies cannot be carried out. If the CIS original data is accessible, panel study would be helpful to understand how three competitive drivers' impact different innovation activities in both static and dynamic way with time period's effects. The results will be more solid and systematic. Right now, this paper only study CIS 2011 data.

4) Limitations of cluster measurement

As discussed in summary report part for cluster, ECO cluster measurement is disputed. In later ECO project (Franco et al, 2015, Ketels and Protsiv 2014) modified the measuring methodology, by deleting focus, but adding two criteria. One will use to capture the dynamic of cluster by annual growth rate, while the other will capture the productivity of cluster from wages of employees. These four stars methodology could make ECO project more convincing in understanding different stages and strengths of clusters. Unfortunately, this new methodology has not been public yet.

7. Conclusion remark

This paper has carried out Regional Competitiveness Framework to understand how three competitive drivers impact different innovative activities in Europe, measured from Community Innovative Surveys. Three competitive drivers are classified as cluster, firm behavior, and business environment. Each of them is within policy influence, and working together to generate intermediate and final outcome of regional economies. Community Innovation Surveys provide six innovative variables for us to understand multidimensional of innovations. Four variables reveal different channel of knowledge and innovation acquired, namely by self-generation (Channel 1), by collaboration (Channel 2), by purchasing (Channel 3), and by learning (Channel 4). Two variables represent different types of innovations, that is product and process innovation (Type 1), and marketing and organizational innovations (Type 2). Moreover, patent applications are also studied as reference.

This paper find out very interesting result. Generally, three competitive drivers are better in explaining the object patent-measured innovation, Channel 1,2 and Type 1,2 innovations, while very limited in explaining Channel 3, 4 innovations. Cluster is very weak in explaining every subjective innovation measures, but only significant for patent applications. This result brings very weak support to existing cluster effectiveness theories. This may due to measurement or model problem, or it could add support to statement "not all cluster is beneficial". Firm behavior is predominantly important in explaining every innovation result except Channel 3. Business environment, as a whole, could explain majority of CIS innovations, except Channel 4 and Type 2. However, the individual variables inside business environment are very different and inconclusive for supporting different innovation channels and types. However, basically, a good business environment, where there are sufficient public R&D, high education skills flows and stock, scientific and technological employment trend, complicated human resource with lifelong learners, and active public sector with flexible labor market, are beneficial for innovation activities. However, their relatively importance vary from one innovative activities to the other. Thus, different policy should be implemented to promote varying innovative activities, as discussed in this paper.

Finally, this paper is far from perfect, considering several limitations discussed; further studies could be carried out with more data availabilities.

Reference:

Aranguren, M.; Ketels, C.; Wilson, J. (2010a). Methogology Background Paper 3 “Clusters and Regional Business Environments”, European Cluster Observatory – Phase II, deliverable D10a-3.

Aranguren, M., Franco, S., Ketels, C., Murciego, A., Navarro, M., Wilson, J. (2010b),”Methodology Background paper 1: Benchmarking Regional Competitiveness in the European Cluster Observatory”, European Cluster Observatory-D10a-1

Asheim, B., Gertler,M.(2005) Chapter 11 Geography of innovation: Regional Innovation Systems Fagerberg, J., Mowery, D.C. and Nelson, R.R. (eds) (2005), The Oxford Handbook of Innovation. New York: Oxford University Press.

Bach, M, Lojpur, A, & Pekovic, S (2014), 'INFLUENCE OF DIFFERENT INFORMATION SOURCES TO INNOVATION PERFORMANCE: EVIDENCE FROM FRANCE, NETHERLANDS AND CROATIA', Conference Proceedings: International Conference Of The Faculty Of Economics Sarajevo (ICES), pp. 282-291

Battisti, G, & Stoneman, P (2010), 'How Innovative are UK Firms? Evidence from the Fourth UK Community Innovation Survey on Synergies between Technological and Organizational Innovations', British Journal Of Management, 21, 1, pp. 187-206

Boschma, R 2005, 'Proximity and Innovation: A Critical Assessment', Regional Studies, 39, 1, pp. 61-74

Capello, R, & Lenzi, C 2013, 'Territorial Patterns of Innovation and Economic Growth in European Regions', Growth And Change, 44, 2, pp. 195-227

Cheshire P. and Magrini S. (2000) Endogenous processes in European regional growth: convergence and policy, Growth and Change 31, 455–479.

Cheshire, P., and E. J. Malecki. (2004). Growth, development, and innovation: A look backward and forward. Papers in Regional Science 83:249–67.

Christian Ketels and Sergiy Protsiv (2014), European Cluster Panorama 2014, European Cluster Observatory REPORT, available: http://www.clusterobservatory.eu/

Colino, A, Benito-Osorio, D, & Armengot, C (2014), 'How much does innovation matter for economic growth?', Management Decision, 52, 2, pp. 313-325

Cooke, P. (2006). Regional innovation systems as public goods. Vienna: UNIDO Strategic Research and Economics Branch.

Cooke, P. 2001. Regional innovation systems, clusters, and the knowledge economy. Industrial and Corporate Change 10:945–74.

Crescenzi, R, Rodríguez-Pose, A, & Storper, M 2007, 'The territorial dynamics of innovation: A Europe-United States comparative analysis', Journal Of Economic Geography, 7, 6, p. 673-709, Scopus

Doloreux, D., and S. Parto. (2005). Regional innovation systems: Current discourse and unresolved issues. Technology in Society 27:133–53.

European Commission (2011), Europe 2020 a strategy for smart, sustainable and inclusive growth, http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

European Commission (2014), Regional innovational scoreboard 2014, weblink: http://ec.europa.eu/enterprise/policies/innovation/files/ris/ris-2014_en.pdf

Fagerberg, J. (2005), Chapter 1 Innovation: A guide to the literature, Fagerberg, J., Mowery, D.C. and Nelson, R.R. (eds) (2005), The Oxford Handbook of Innovation. New York: Oxford University Press.

Franco, S, Murciego, A, Wilson, J (2014), Methodology and findings report for correlation analysis between cluster strength and competitiveness indicators, European Cluster Observatory Report 2014 October, available: http://www.clusterobservatory.eu/

Franco, S., Ketels, Murciego, A., Wilson, J. (2011). Business Environment Secondary Data Report, European Cluster Observatory – Phase II, deliverable D13.

Franco, S., Murciego, A., Wilson, J (2011). Business Environment Secondary Data Report, European Cluster Observotory-D13

Frenz, Marion; Ietto-Gillies, Grazia. (2009). Impact on innovation performance of different sources of knowledge: Evidence from the UK Community Innovation Survey. Research Policy 2009 38(7):1125-1135

Gallego, J.; Rubalcaba, L.; Sua´rez, C.(2013). Knowledge for innovation in Europe: The role of external knowledge on firms' cooperation strategies, Journal of Business Research Oct. 2013, vol.66, no.10, pp. 2034-41

GROSSMAN G. M. and HELPMAN E. (1991) Innovation and Growth in the Global Economy. MIT Press, Cambridge, MA

Härdle, W, & Simar, L 2007, Applied Multivariate Statistical Analysis. [Elektronisk Resurs], n.p.: Berlin : Springer, c2007

Hashi, I, & Stojcic, N 2013, The impact of innovation activities on firm performance using a multi-stage model: Evidence from the Community Innovation Survey 4, Research Policy, 42, pp. 353-366

International Institute for Management Development (2009). IMD World Competitiveness Yearbook 2009, Lausanne: IMD.

Ketels, C.,Protsiv, S. (2013), Clusters and the New Growth Path for Europe, Work Package 301 MS47 Research paper on the role of clusters for the new growth path, http://www.foreurope.eu/fileadmin/documents/pdf/Workingpapers/WWWforEurope_WPS_no014_MS47.pdf

Lundvall B. A. (1992) National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. Pinter, London

Malmberg, A, & Power, D 2005, '(How) Do (Firms in) Clusters Create Knowledge?', Industry & Innovation, 12, 4, p. 409-431

Martin,R., and P. Sunley. 2003. Deconstructing clusters: Chaotic concept or policy panacea? Journal of Economic Geography 3:5–35.

Moore, G., and R. McKenna. (1999). Crossing the chasm: Marketing and selling high tech products to mainstream customers. New York: Harper.

Morgan K. (2004) The exaggerated death of geography: learning, proximity and territorial innovation systems, Journal of Economic Geography 4, 3–21

Navarro, M., Franco, S., Ketels, C., Murciego, A., Navarro, M., Wilson, J. Methogology Background Paper 4 "Benchmarking of Regional Competitiveness: The Need to Identify Reference Regions", European Cluster Observatory – Phase II, deliverable D10a-4.

OECD (2004), Chapter 2 Employment Protection Regulation and Labour Market Performance , OECD Employment Outlook, http://www.oecd.org/employment/emp/34846856.pdf

OECD (2013) Overview, OECD Factbook 2013: Economic, Environmental and Social Statistics, http://www.oecd-ilibrary.org/sites/factbook-2013-en/07/02/02/index.html?itemId=/content/chapter/factbook-2013-58-en

Porter, M. E. (1990). The Competitive Advantage of Nations. London: The MacMillan Press

Porter, M. E. (2003). The economic performance of regions. Regional Studies, 37(6,7), 549.

Rodríguez-Pose, A, & Comptour, F (2012), 'Do Clusters Generate Greater Innovation and Growth? An Analysis of European Regions', Professional Geographer, 64, 2, p. 211-231
Rodriguez-Pose, A, & Crescenzi, R (2008), 'Research and Development, Spillovers, Innovation Systems, and the Genesis of Regional Growth in Europe', Regional Studies, 42, 1, pp. 51-67

Schumpeter, J. (1934), the Theory of Economic Development, Cambridge, MA, Harvard University press.

Smith, Keith (2005), Chapter 6 Measuring innovations, Fagerberg, J., Mowery, D.C. and Nelson, R.R. (eds) (2005), The Oxford Handbook of Innovation. New York: Oxford University Press.

Sölvell ,O., Ketels, C., Lindqvist, G. (2009), EU Cluster Mapping and Strengthening Clusters in Europe, European Cluster Observatory project.

STORPER M. and VENABLES A. J. (2004)Buzz: face-to-face contact and the urban economy, Journal of Economic Geography 4, 351–370.

Trippl, M., Asheim, B., Miorner, J. (2015), Identification of regions with less developed research and innovation systems, Papers in Innovation Studies, Paper no. 2015/1, CIRCLE, Lund university.

World Economic Forum (2009). The Global Competitiveness Report 2009-10, Geneva: WEF.

Appendix

Appendix A: Principal Component Analysis for cluster, firm behaviors, business environment

Eigen analysis of the correlation matrix: Cluster Index

Component	Eigenvalue	Proportion	Cumulative
Comp1	2.06703	0.6890	0.6890
Comp2	0.739265	0.2464	0.9354
Comp3	0.193705	0.0646	1.0000

Coefficients of the principal components analysis: Cluster Index

Variable	Comp1	Comp2
Observatory star	0.5285	0.7204
Observatory star high tech	0.6560	-0.0107
Employ in high and medium-high technological manufacturing and knowledge intensive service	0.5388	-0.6935

Comp1 will be used as cluster index.

Cluster index=0.5285* Observatory star+0.6560*Observatory star high tech+0.5388*Employ in high manufacturing and knowledge intensive service

Eigen analysis of the correlation matrix: Firm behaviors

Component	Eigenvalue	Proportion	Cumulative
Comp1	2.11593	0.7053	0.7053
Comp2	0.815554	0.2719	0.9772
Comp3	0.0685131	0.0228	1.0000

Coefficients of the principal components analysis: Firm Behaviors

Variable	Comp1	Comp2
Firm R&D share of GDP (%)	0.6317	-0.3914
Firm R&D personnel (% of total)	0.6671	-0.1652
Firm investment (thousand EUR/employee)	0.3949	0.9052

Comp1 will be used as Firm Behavior Index

Firm behavior index=0.6317* Firm R&D share of GDP+0.6671* Firm R&D personnel+0.3949* Firm investment

Eigen analysis of the correlation matrix: Business Environment

Component	Eigenvalue	Proportion	Cumulative
Comp1	3.54162	0.3935	0.3935
Comp2	1.35989	0.1511	0.5446
Comp3	1.11845	0.1243	0.6689
Comp4	0.949941	0.1055	0.7744
Comp5	0.796365	0.0885	0.8629
Comp6	0.494723	0.055	0.9179
Comp7	0.356487	0.0396	0.9575
Comp8	0.225381	0.025	0.9825
Comp9	0.157143	0.0175	1

Coefficients of the principal components analysis: Business Environment

Variable	Comp1	Comp2
public sector R&D Expenditures	0.3469	-0.0603
Employment in science and technology %	0.4738	0.134
Students in pre-vocational and vocational program (% of 15-24 years old)	0.0742	0.5958
Students in tertiary program with academic orientation (% of 20-24 years old)	0.1897	0.4058
Population with upper-secondary or tertiary education	0.1244	0.5894
Lifelong	0.4466	-0.2347
Public sector, education and health employment	0.4033	-0.2106
Long term unemployment	-0.3485	0.1037
Agriculture populations%	-0.3387	0.0332

Comp1 will be used as Business environment index,

Business Environment index=0.3469*public sector R&D Expenditures+0.4738* Employment in science and technology+0.0742* Students in prevocational and vocational program+0.1897* Students in tertiary program with academic orientation+0.1244* Population with upper-secondary or tertiary education+0.4466*Lifelong percentage+0.4033* Public sector, education and health employment-0.3485* Long term unemployment-0.3387* Agriculture percentage

Appendix B: The Cluster observatory stars of Size, Specialization and Focus

These formulas were drawn from Europe Cluster Observatory's Web site http://www.cluster observatory.eu.

Size:

$$S_{r,s} = \frac{e_{r,s}}{E_s}$$

Specialization (Location Quotient)

$$LQ_{r,s} = \frac{e_{r,s}/E_s}{E_r/E}$$

Focus:

$$F_{r,s} = \frac{e_{r,s}}{E_r}$$

$e_{r,s}$ = the number of employees for region r and cluster sector s

E_s = the total number of employees in all regions for sector s

E_r = the total number of employees in all cluster sectors for region r

E = the total number of employees in all regions and all cluster sectors

- Size star: The top 10% of all clusters in Europe within the same cluster category in terms of the number of employees received one 'star'.
- Specialization star: A cluster with a specialization quotient (LQ) of 2 or more received a 'star'.
- Focus star: The top 10% of clusters which account for the largest proportion of their region's total employment received a 'star'.

Observatory stars=size star+ specialization star+ focus star

Hence, observatory stars range from 0 (without any star) to 3 (with all three stars) for certain industry in certain region (NUTS 2 level), then all industries stars in this NUTS2 region will be added together as observatory stars for this region.

The observatory stars are calculated to NUT1 level by average stars in respective NUTS2 weighted by total employment number in each NUTS2 regions.

Note: If the number of employment in a cluster is less than 1,000 persons, the cluster will not been given any stars to prevent very small insignificant clusters.

Appendix C: Definition observatory star in high-tech

Aerospace; Automotive; Biotech; Business services; Chemical products; Education and knowledge creation; Financial services; Heavy Machinery; Instruments; IT; Lighting and electrical equipment; Medical devices; Pharmaceuticals; Power generation and transmission; Production technology; and Telecom (Franco et al, ECO project-D13 2011) also from their website (http://www.clusterobservatory.eu/index.html)

Appendix D: European 156 regions studied in this paper.

Country	NUTS	Code	Region	Country	NUTS	Code	Region
Austria	1	AT1	Ostösterreich			ITF3	Campania
		AT2	Südösterreich			ITF4	Puglia
		AT3	Westösterreich			ITF5	Basilicata
Belgium	1	BE1	Brussels			ITF6	Calabria
		BE2	Vlaams Gewest			ITG1	Sicilia
		BE3	Région Wallonne			ITG2	Sardegna
Bulgaria	1	BG3	Severna i Iztochna	Netherland	2	NL11	Groningen
		BG4	Yugozapadna i Yuzhna Tsentralna			NL12	Friesland
Czech	2	CZ01	Praha			NL13	Drenthe
		CZ02	Stredni Cechy			NL21	Overijssel
		CZ03	Jihozapad			NL22	Gelderland
		CZ04	Severozapad			NL23	Flevoland
		CZ05	Severovychod			NL31	Utrecht
		CZ06	Jihovychod			NL32	Noord-Holland
		CZ07	Stredni Morava			NL33	Zuid-Holland
		CZ08	Moravskoslezsko			NL34	Zeeland
Germany	1	DE1	Baden-Württemberg			NL41	Noord-Brabant
		DE2	Bayern			NL42	Limburg (NL)
		DE3	Berlin	Norway	2	NO01	Oslo og Akershus
		DE5	Bremen			NO02	Hedmark og Oppland
		DE6	Hamburg			NO03	Sør-Østlandet
		DE7	Hessen			NO04	Agder og Rogaland
		DE8	Mecklenburg-Vorpommern			NO05	Vestlandet
		DEA	Nordrhein-Westfalen			NO06	Trøndelag
		DEC	Saarland			NO07	Nord-Norge
		DED	Sachsen	Poland	2	PL11	Lodzkie
		DEE	Sachsen-Anhalt			PL12	Mazowieckie

		DEF	Schleswig-Holstein			PL21	Malopolskie
		DEG	Thüringen			PL22	Slaskie
Greece	1	GR1	Voreia Ellada			PL31	Lubelskie
		GR2	Kentriki Ellada			PL32	Podkarpackie
		GR3	Attiki			PL33	Swietokrzyskie
		GR4	Nisia Aigaiou, Kriti			PL34	Podlaskie
Spain	2	ES11	Galicia			PL41	Wielkopolskie
		ES12	Asturias			PL42	Zachodniopomorskie
		ES13	Cantabria			PL43	Lubuskie
		ES21	País Vasco			PL51	Dolnoslaskie
		ES22	Navarra			PL52	Opolskie
		ES23	La Rioja			PL61	Kujawsko-Pomorskie
		ES24	Aragón			PL62	Warminsko-Mazurskie
		ES3	Madrid			PL63	Pomorskie
		ES41	Castilla y León	Portugal	2	PT11	Norte
		ES42	Castilla-La Mancha			PT15	Algarve
		ES43	Extremadura			PT16	Centro
		ES51	Cataluña			PT17	Lisboa
		ES52	Valencia			PT18	Alentejo
		ES53	Illes Balears	Romania	2	RO11	Nord-Vest
		ES61	Andalucía			RO12	Centru
		ES62	Murcia			RO21	Nord-Est
		ES7	Canarias			RO22	Sud-Est
France	1	FR1	Île De France			RO31	Sud - Muntenia
		FR2	Bassin Parisien			RO32	Bucuresti - Ilfov
		FR3	Nord - Pas-De-Calais			RO41	Sud-Vest Oltenia
		FR4	Est			RO42	Vest
		FR5	Ouest	Sweden	2	SE11	Stockholm
		FR6	Sud-Ouest			SE12	Östra Mellansverige
		FR7	Centre-Est			SE21	Småland med öarna
		FR8	Méditerranée			SE22	Sydsverige
Hungary	2	HU10	Kozep-Magyarorszag			SE23	Västsverige
		HU21	Kozep-Dunantul			SE31	Norra Mellansverige
		HU22	Nyugat-Dunantul			SE32	Mellersta Norrland
		HU23	Del-Dunantul			SE33	Övre Norrland
		HU31	Eszak-Magyarorszag	Slovakia	2	SK01	Bratislavsky kraj
		HU32	Eszak-Alfold			SK02	Zapadne Slovensko
		HU33	Del-Alfold			SK03	Stredne Slovensko
Italy	2	ITC1	Piemonte			SK04	Vychodne Slovensko
		ITC2	Valle d'Aosta	UK	1	UKC	North East
		ITC3	Liguria			UKD	North West
		ITC4	Lombardia			UKE	Yorkshire And The Humber
		ITD3	Veneto			UKF	East Midlands
		ITD4	Friuli-Venezia Giulia			UKG	West Midlands
		ITD5	Emilia-Romagna			UKH	East Of England
		ITE1	Toscana			UKI	London
		ITE2	Umbria			UKJ	South East

		ITE3	Marche			UKK	South West
		ITE4	Lazio			UKL	Wales
		ITF1	Abruzzo			UKM	Scotland
		ITF2	Molise			UKN	Northern Ireland

Appendix E: Table 5 to Table 11

Table 5	Regressions															
Dependent Variable: EPO patent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Constant	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cluster index	.013** .006				.014*** .005	.010 .006	.034*** .006	.009 .006	.006 .005	.008 .005	.013** .005	.005 .006	.013** .006	.021*** .006	.012** .006	.007 .005
Firm Behavior Index	.062*** .007	.066*** .007	.060*** .007	.068*** .007				.077*** .006	.063*** .007	.079*** .005	.080*** .005	.082*** .005	.071*** .007	.064*** .006	.075*** .006	.074*** .006
Business Environment Index	.020*** .005	.021*** .006	.019*** .005	.017*** .005	.026*** .004	.023*** .005	.045*** .005									
Cluster																
Observatory star		.002 .001														
Observatory star high tech			.006*** .001													
Employment in knowledge-Intensive jobs				.026 .054												
Firm Behaviors																
Firm R&D share of GDP (%)					.115*** .012											
Firm R&D personnel (% of total)						.225*** .029										
Firm investment (thousand EUR/employee)							.002 .001									
Business environment																
Public R&D spending								.046 .046								
HR in science and technology									.006*** .001							
Potential vocational skills (flow)										.0015* .0009						
Potential academic skills (flow)											-.001*** .0002					
Education skills level (stock)												.001** .0005				
lifelong learning													.003** .001			
Public sector employment														.006*** .001		
Labor rigidity															-.001 .0007	
Agriculture (%)																-.002** .001
F statistics	97.17	94.77	102.61	92.59	106.43	90.41	51.08	85.47	98.49	86.94	94.91	88.11	87.88	108.35	87.27	89.89
Adjusted R2	0.65	0.64	0.667	0.64	0.67	0.63	0.50	0.62	0.65	0.62	0.64	0.63	0.63	0.67	0.63	0.63
Number of Observations	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156

Table 6	Regressions															
Dependent Variable: SMEs innovating in house	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Constant	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cluster index	-.002 .011				.002 .010	-.002 .011	.021** .010	-.007 .010	-.013 .010	-.009 .010	-.005 .011	-.001 .011	.007 .010	.005 .011	-.011 .011	-.011 .010
Firm Behavior Index	.072*** .013	.071*** .013	.071*** .013	.077*** .013				.090*** .012	.074*** .013	.097*** .010	.100*** .010	.098*** .011	.066*** .013	.082*** .012	.108*** .012	.088*** .011
Business Environment Index	.029*** .009	.030*** .010	.030*** .009	.032*** .009	.041*** .009	.038*** .009	.051*** .009									
Cluster																
Observatory star		.000 .002														
Observatory star high tech			.000 .004													
Employment in knowledge-Intensive jobs				-.094 .098												
Firm Behaviors																
Firm R&D share of GDP (%)					.111*** .024											
Firm R&D personnel (% of total)						.229*** .053										
Firm investment (thousand EUR/employee)							.007*** .002									
Business environment																
Public R&D spending								.157* .083								
HR in science and technology									.010*** .003							
Potential vocational skills (flow)										.004*** .002						
Potential academic skills (flow)											-.001* .0005					
Education skills level (stock)												-.002* .001				
lifelong learning													.011*** .002			
Public sector employment														.008*** .002		
Labor rigidity															.001 .001	
Agriculture (%)																-.005*** .001
F statistics	39.03	39.01	39.01	39.55	35.47	34.00	28.81	35.84	39.77	37.89	35.44	35.97	43.13	39.43	35.09	38.18
Adjusted R2	0.43	0.43	0.43	0.43	0.40	0.39	0.35	0.40	0.42	0.42	0.40	0.40	0.45	0.43	0.40	0.42

Number of Observations	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156

Table 7	Regressions

Dependent Variable: **collaborating with others**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Constant	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cluster index	-.021* .010				-.025** .010	-.024**	-.007 .009	-.029** .011	-.038*** .010	-.029** .012	-.023** .012	-.041*** .011	-.008 .011	-.000 .011	-.023* .012	-.033*** .011
Firm Behavior Index	.038*** .013	.040*** .012	.029** .013	.033** .013				.082*** .013	.040*** .013	.090*** .011	.089*** .011	.093*** .011	.041*** .013	.050*** .011	.076*** .012	.074*** .012
Business Environment Index	.056*** .010	.044*** .010	.058*** .009	.061*** .009	.054*** .009	.056*** .009	.081*** .008									
Cluster																
Observatory star		- .006*** .002														
Observatory star high tech			-.002 .004													
Employment in knowledge-Intensive jobs				-.114 .099												
Firm Behaviors																
Firm R&D share of GDP (%)					.100*** .023											
Firm R&D personnel (% of total)						.156*** .052										
Firm investment (thousand EUR/employee)							-.004* .002									
Business environment																
Public R&D spending								.093 .091								
HR in science and technology									.018*** .003							
Potential vocational skills (flow)										-.001 .002						
Potential academic skills (flow)											- .002*** .001					
Education skills level (stock)												.003*** .001				
lifelong learning													.016*** .003			
Public sector employment														.016*** .002		
Labor rigidity															-.003** .002	
Agriculture (%)																-.006*** .001
F statistics	35.32	40.08	33.44	34.04	41.41	36.03	32.93	20.65	36.95	20.37	23.85	25.34	34.78	42.24	22.39	24.29
Adjusted R2	0.4038	0.43	0.39	0.39	0.44	0.41	0.39	0.27	0.41	0.27	0.31	0.32	0.40	0.44	0.30	0.31
Number of Observations	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156

Table 8	Regressions															
Dependent Variable: Non R&D innovation expenditures over sales	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Constant	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cluster index	-.010 .007				-.012* .006	-.009 .007	-.010* .006	-.015** .007	-.018*** .007	-.015** .007	-.014* .007	-.019*** .007	-.007 .007	-.002 .007	-.010 .007	-.016** .007
Firm Behavior Index	.001 .009	-.002 .008	.000 .008	.000 .008				.021*** .008	.004 .008	.022*** .007	.023*** .007	.024*** .007	.005 .009	.006 .007	.014* .007	.019** .007
Business Environment Index	.023*** .006	.022*** .007	.024*** .006	.026*** .006	.021*** .006	.025*** .006	.025*** .005									
Cluster																
Observatory star		-.001 .001														
Observatory star high tech			-.003 .002													
Employment in knowledge-Intensive jobs				-.086 .064												
Firm Behaviors																
Firm R&D share of GDP (%)					.014 .015											
Firm R&D personnel (% of total)						-.008 .034										
Firm investment (thousand EUR/employee)							-.001 .002									
Business environment																
Public R&D spending								.022 .056								
HR in science and technology									.007*** .002							
Potential vocational skills (flow)										.001 .001						
Potential academic skills (flow)											-.001 .0003					
Education skills level (stock)												.001* .0006				
lifelong learning													.006*** .002			
Public sector employment														.007*** .001		
Labor rigidity															- .002** .001	
Agriculture (%)																-.002 .001
F statistics	8.60	8.14	8.53	8.37	8.92	8.62	8.74	3.76	8.03	4.16	4.50	4.93	7.09	10.68	5.29	4.29
Adjusted R2	0.13	0.12	0.13	0.12	0.14	0.13	0.13	0.05	0.12	0.06	0.06	0.07	0.10	0.16	0.08	0.06
Number of Observations	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156

Table 9	Regressions															
Dependent Variable: SMEs new to firm sales	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Constant	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cluster index	-.002 .009				.006 .009	-.001 .009	.009 .007	-.001 .008	-.001 .008	-.002 .008	-.000 .009	.009 .008	-.003 .010	-.006 .009	-.011 .009	-.003 .008
Firm Behavior Index	.039*** .011	.037*** .011	.042*** .011	.036*** .011				.024** .010	.035*** .011	.028*** .008	.029*** .008	.025*** .008	.034*** .011	.035*** .010	.049*** .009	.023** .009
Business Environment Index	-.011 .008	-.011 .008	-.012 .008	-.011 .008	.002 .007	-.005 .008	-.011* .006									
Cluster																
Observatory star		.000 .002														
Observatory star high tech			-.002 .003													
Employment in knowledge-Intensive jobs				.022 .083												
Firm Behaviors																
Firm R&D share of GDP (%)					.020 .020											
Firm R&D personnel (% of total)						.103** .045										
Firm investment (thousand EUR/employee)							.012*** .002									
Business environment																
Public R&D spending								.066 .069								
HR in science and technology									-.002 .002							
Potential vocational skills (flow)										.001 .001						
Potential academic skills (flow)											-.000 .000					
Education skills level (stock)												-.003*** .000				
lifelong learning													-.002 .002			
Public sector employment														-.002 .002		
Labor rigidity															.005*** .001	
Agriculture (%)																-.002 .002
F statistics	5.04	5.01	5.32	5.03	1.37	2.84	12.32	4.70	4.64	4.44	4.55	11.48	4.50	4.86	12.63	5.25

Adjusted R2	0.07	0.07	0.08	0.07	0.01	0.04	0.18	0.07	0.07	0.06	0.06	0.16	0.06	0.07	0.19	0.07
Number of Observations	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156

Table 10	Regressions															
Dependent Variable: product process innovation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Constant	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cluster index	.006 .013				.015 .013	.008 .013	.028** .011	.003 .012	-.004 .013	-.001 .013	.004 .013	.007 .013	.007 .013	.008 .014	-.008 .013	-.002 .013
Firm Behavior Index	.069*** .016	.072*** .015	.068*** .016	.072*** .016				.067*** .014	.060*** .016	.085*** .013	.090*** .013	.087*** .013	.075*** .017	.081*** .015	.110*** .014	.075*** .014
Business Environment Index	.021* .012	.021* .012	021* .012	.020* .012	.037*** .011	.030** .011	.033*** .010									
Cluster																
Observatory star		.001 .002														
Observatory star high tech			.003 .004													
Employment in knowledge-Intensive jobs				.005 .120												
Firm Behaviors																
Firm R&D share of GDP (%)					.081*** .030											
Firm R&D personnel (% of total)						.202*** .065										
Firm investment (thousand EUR/employee)							.012*** .003									
Business environment																
Public R&D spending								.341*** .098								
HR in science and technology									.011*** .003							
Potential vocational skills (flow)										.006*** .001						
Potential academic skills (flow)											-.001 .001					
Education skills level (stock)												-.002 .001				
lifelong learning													.004 .004			
Public sector employment														.004 .003		
Labor rigidity															.005*** .001	
Agriculture (%)																-.005*** .002
F statistics	21.64	21.57	21.83	21.53	17.39	18.38	20.71	25.71	24.34	24.76	20.74	21.27	20.85	20.80	25.27	156

Adjusted R2	0.29	0.29	0.29	0.29	0.24	0.26	0.28	0.32	0.31	0.32	0.28	0.28	0.28	0.28	0.32	0.30
Number of Observations	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156

Table 11	Regressions															
Dependent Variable: market organization innovation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Constant	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cluster index	.013 .010				.021* .011	.016 .011	.032*** .010	.014 .010	.011 .011	.012 .011	.014 .011	.019* .011	.009 .011	.014 .011	.003 .011	.012 .011
Firm Behavior Index	.055*** .013	.061*** .013	.054*** .014	.057*** .014				.037*** .012	.044*** .013	.054*** .011	.056*** .010	.053*** .010	.063*** .013	.053*** .012	.076*** .011	.052*** .011
Business Environment Index	-.000 .010	.000 .011	-.000 .009	-.004 .009	.012 .009	.007 .010	.010 .009									
Cluster																
Observatory star		.001 .002														
Observatory star high tech			.006 .004													
Employment in knowledge-Intensive jobs				.097 .098												
Firm Behaviors																
Firm R&D share of GDP (%)					.068*** .024											
Firm R&D personnel (% of total)						.158*** .053										
Firm investment (thousand EUR/employee)							.009*** .003									
Business environment																
Public R&D spending								.271*** .080								
HR in science and technology									.004 .003							
Potential vocational skills (flow)										.002 .002						
Potential academic skills (flow)											-.000 .001					
Education skills level (stock)												-.002** .001				
lifelong learning													-.003 .003			
Public sector employment														.001 .003		
Labor rigidity															.005*** .001	
Agriculture (%)																-.002 .002

F statistics	14.67	14.11	15.07	14.37	11.46	11.77	13.32	19.39	15.32	15.22	14.92	16.47	14.93	14.59	21.49	14.77
Adjusted R2	0.21	0.21	0.22	0.21	0.17	0.18	0.20	0.26	0.22	0.22	0.21	0.23	0.21	0.21	0.29	0.21
Number of Observations	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156