Please cite as: Caragliu, Andrea, and Chiara Del Bo. "Much ado about something? An appraisal of the relationship between smart city and smart specialisation policies." *Tijdschrift voor economische en sociale geografie* 109.1 (2018): 129-143.

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Much ado about something?

An appraisal of the relationship between Smart City and Smart Specialisation policies

Abstract

Smart policies at the urban (Smart City initiatives) and the regional (Smart Specialization Strategies, S3) level, both fostered by the need to better spend the reduced budget available for EU policymaking, have recently gained much attention. While some attempts have been made to explore the growth potential of the two policies separately, no empirical analysis has considered their joint contribution to regional growth.

This paper identifies two types of development (measured as 2008-2010 GDP growth) effects associated to Smart policies: one, short-run, associated to Urban Smartness initiatives, and a second, long run, linked to S3. Instrumental variables estimates are used to support the conceptual framework suggested for the link between these two types of policies, which are both found to have a positive impact on regional economic performance.

Keywords: Smart City, Smart Specialization Strategies, Regional growth, Long-run development, Policy appraisal

JEL codes: R58; L52; O40

1. Introduction

Since 2008, the European economy has been suffering from the consequences of the international and EU-wide crisis and has yet to show significant and stable signs that a full recovery has truly begun. This downturn has occurred after a decade of positive economic outlook, characterized by price stability, accessible credit and the impact of the enlargement process which has led to 28 Member States and approximately half a billion of inhabitants.

The crisis is evident in increasing unemployment in several EU countries and severe problems related to public debt sustainability, especially in Southern Europe and in some New Member States. This sobering macroeconomic picture adds to the insufficient achievement of the ambitious science and innovation targets set forth by the Lisbon Agenda and its EU2020 follow-up. Overall,

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the current outlook does not seem conducive to long-run sustainable growth, thus leading to a more innovative, and ultimately, more competitive Europe.

Therefore, the idea of a common EU market has been subject to remarkable hostility, particularly strong in peripheral areas where the crisis had the most evident effects. Besides, the crisis prompted a discussion on whether the governance of EU policymaking should be dramatically evolving, and in which direction. The current seven-year budget has recently been financed with a minor downward revision of EU federal money (EC, 2013a). Together with the influential Barca Report (Barca, 2009), the reduced availability of public funds has been confronted by the need to better tailor growth-enhancing policies. This ultimately led to the emergence of two policy avenues, receiving much attention in the EU arena, viz. Smart City (henceforth, SC) policies and Smart Specialisation Strategies (from now on, S3).

At a first glance, the two policy concepts may appear as fundamentally unrelated, the only common feature being the label "*smart*". In fact, some authors, referring in particular to the SC concept (Hollands, 2008), have suggested that the "smart" label is nothing more than a buzzword, thus implying that the policies themselves may represent nothing more than empty boxes. A more in depth analysis of the two policies under consideration, however, reveals that there are commonalities in terms of origins, objectives and implications. Both smart policies have been triggered by the increased availability of ICTs and the recognition of their positive impact on US productivity growth. Further, both policies have moved from a purely sector-based approach to a more complex concept which embraces space-specific characteristics as important determinants of their effectiveness. Finally, both policy concepts have been the object of a significant policy debate, leading to an evolution of the definition of their boundaries and scopes beyond the initial focus on ICTs, and encompassing other dimensions related to urban and regional development.

Despite the attention and relevance of these policies in the policymaking arena, both at the European and Member States' level, the academic literature has only recently paid attention to the relation between these two concepts, and if their respective outcomes may be mutually reinforcing (Caragliu and Del Bo, 2015).

The aim of this paper is to analyze the implications of S3 and SC policies in terms of regional economic performance, while accounting for their interrelations and controlling for other relevant determinants.

Initially, Smart policies initiatives, both at the regional (S3) and urban (SC) level activate "Smart" inputs which, at a later stage, are expected to have a positive impact on economic growth. This paper focuses on the second stage of the process, while at the same time not discarding the first. The empirical findings of this paper stress the link between Smart inputs and growth, thus indirectly identifying possible outcomes of Smart policies. However, this paper does not provide an appraisal of the growth effects of *actual*, *implemented* Smart policies; instead, these empirical findings can be seen as an indication of the growth potential associated to Smart policies, while explicitly uncovering the existing links between the two specific sets of policies at the regional and urban scale.

The empirical results suggest that the two Smart policies considered are significantly correlated in EU regions. The implications of successful *ante-litteram* S3 in the 1990s are positively associated with the emergence, in the late 2000s, of SC. Further, the productive inputs activated by Smart policies are significantly and positively associated with short run regional economic performance.

Policy implications of our results are twofold. First, by examining the potential outcomes and relationship between Smart policies at the regional and urban level, we provide an empirical assessment of these initiatives and a possible justification for public support in these areas. Second, the positive correlation between Smart policy outcomes and economic growth provides initial evidence in favor of these initiatives.[2]

In order to reach the above discussed goal, we first provide a synthetic and critical review of the literature on both types of Smart policies (Section 2). Section 3 presents a conceptual framework that describes the logic and time frame of the two main Smart Policies that have been put forward in the EU since the early 2000s. This setup is used to frame the subsequent empirical test of the effectiveness of such policies. In Section 4 the data set assembled for such empirical test, and the indicators of S3 and SC used for the present analysis, are discussed in detail. Section 5 shows the empirical estimates of the model linking Smart policies and regional economic performance. Finally, Section 6 concludes and summarizes a few relevant policy implications of this work.

2. A Smart policies' overview: S3 and SC

2.1 S3

This Section presents a critical summary of the literature on S3, framing the evolution of this concept in the historical context in which it first emerged. The aim is in fact to highlight a few similarities with the notion of SC (Section 2.2), as well as to set the foundations for the empirical S3 index adopted in the empirical analyses of the following Sections.[3]

The origins of S3 dates back to the 2000s debate on the so called "Transatlantic productivity gap" (van Ark et al., 2008); in those years, data evidenced an emerging halt in the process of productivity convergence across the Atlantic Ocean between the EU and the United States. The reasons for the EU productivity lag have been identified in a "*slower rate of adoption of investment in information and communication technology in Europe, the relatively small share of technology-producing industries in Europe, and slower multifactor productivity growth*" (van Ark et al., 2008, p.25).

In order to stimulate productivity growth in the EU, in 2005 a "Knowledge for growth" experts' group was created by the former EU commissioner Janez Potočnik. This group eventually suggested that a S3 could represent a possible way out of this relative but growing gap with respect to the US.

The S3 concept has been described in a series of policy documents ("*Knowledge economists policy briefs*"), initially, attributing to an insufficient endowment with ICTs the main reason for the EU gap (Foray et al., 2009; Venturini, 2015). As a consequence, S3 has initially mainly focused on R&D functions. However, this idea gradually shifted towards the institutional elements indirectly related to science and technology, and ultimately linked to the process of diffusion and exploitation

[2] Our findings do not aim at providing direct evidence about the effectiveness of Smart Specialisation Strategies (see also Section 3), but rather at suggesting whether industrial development patterns that have been following gudielines similr to the S3 philosophy are associated to positive economic outcomes. Thus, whether place-based policies can be effectively welfare optimising – an objective that should be clearly in the policymakers' objective function (Thissen and Van Oort, 2010) – is here not taken into account.

[3] For further details on these two concepts, and the ways in which they are conceptually and empirically related, please refer to Caragliu and Del Bo (2015).

of General Purpose Technologies (henceforth, GPTs), and in particular ICTs, in as many industries as possible (Mc Cann and Ortega-Argilés, 2013). These developments have recently gained momentum as the currently ongoing EU economic crisis determined the need to concentrate R&D investment.

The evolution of the theoretical S3 construct towards an implementable policy-oriented concept has been underlined in two recent contributions which pave the way for a more concrete approach to S3, amenable of empirical verification. Mc Cann and Ortega-Argilés (2013) describe the shift of S3 from an industrial to a regional concept; Camagni and Capello (2013) present instead a new regional typology with the aim to meet the EU challenge for S3, and classify regions according to their capability to innovate (i.e., according to their territorial patterns of innovation). In both cases, the aim is to improve the one-size-fits-all type of innovation policies that the EU has previously adopted, and that also characterizes the EU2020 agenda. Both works suggest the need for S3 of going beyond the focus on pure industrial and R&D strengths of EU regions, and identify, with a bottom-up approach, the *competitive advantages* of each EU region.

The academic literature on S3 is, however, still in its infancy and needs development, specifically in the following directions:

- S3 needs to be defined on a continuum of innovation modes, with the aim of including the vast differences in the EU's geography of innovation.
- The focus must also reach beyond pure ICTs, and encompass other types of GPTs in the definition of S3.
- Empirical verification of S3 needs to be based on the notion of competitive advantage: EU regional growth can be fostered by stimulating excellence across all areas, beyond the traditional core regions (the so called 'European Research Area'), and technological diversification, in order to avoid technological lock-in.
- More accurate measures and empirical tests should be identified and carried out.

In order to reach these targets, the empirical S3 indicator proposed in this paper (Section 4), and the empirical verification presented (Section 5), innovate along these development needs.

2.2 The SC concept

In the last few years, the notion of SC has emerged as a policy and business idea, and has recently been the object of much academic buzz. Exactly as in the S3 case, research around this concept has initially been mostly focusing on ICTs as the means though which cities can enhance their long-run development. Previous and related versions of the concept include the "wired city" (Dutton et al., 1987) in which the focus was on networked urban spaces and the "intelligent city" (Komninos, 2002) which extends the concept of wired city to the cognitive elements of the digital dimension. During the shift from earlier constructs towards the SC concept, the focus has been increasingly centered around the positive role of ICTs. This has also implied a more bottom-up approach (and increased participation of citizens) to urban development. In fact, one additional aspect, with respect to earlier concepts, stressed in the definition of a SC is the diffusion of e-government technologies, which blend the pure technological aspect with issues of governance (Deakin et al., 2011).

Another closely related concept is that of "resilient city" (Newman et al., 2009), which focuses the attention of planners and policymakers to the environmental sustainability goals of the EU2020 framework. This new label is strongly related to the smart energy pillar of research on SCs (Gans et al., 2013).

The business sector is also paying close attention to the SC concept, in particular by providing software solutions and management models based on both smart ICTs and energy applications.

In the remainder of the paper we focus, however, on the policy vision of the SC concept, as the overall aim is to evaluate the link between the outcomes of the SC policy process and economic performance, rather than the success of a specific business venture.

Focusing specifically on the SC concept, early definitions of urban smartness imply a strong human capital component (Winters, 2011). Berry and Glaeser (2005) demonstrate that cities with a high density of educated workforce *ceteris paribus* grow faster. Shapiro (2008) identifies a direct link between a city's endowment with human capital and its economic performance, while Winters (2011) defines cities as smart as they grow faster, on the basis of a higher availability of college educated population.

The synthetic description of these various and at times contradicting streams of literatures testifies the complex set of definitions of urban smartness so far emerging. In this paper we follow Caragliu et al. (2011),[4] which to date provide one of the few definitions allowing for the inclusion of both technological elements and context conditions within the idea of SC. This definition is based on the idea that the all actors, and not only firms and institutions, can co-participate in enhancing the effectiveness of a local economy by dynamically interacting (Van Hemert and Nijkamp, 2010). We therefore define a city as Smart "*when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance*" (Caragliu et al., 2011, p. 70).

3. A conceptual framework for Smart policies and regional growth

This Section presents the conceptual framework that allows to empirically estimate the relationship between the two Smart policies considered, on the one hand, and their role as growth-enhancing factors on the other.

A horizontal reading of the literature summarized in Section 2 suggests that the economic performance of regions and countries is determined, among other economic and institutional growth determinants, by their specialization structure and by the emergence of SCs, in the sense attributed by the definition provided in Caragliu et al. (2011). Additionally, SCs can be thought of as emerging also because of a virtuous process of S3, as summarized in Figure 1. Figure 1, which represents the conceptual approach behind the empirical estimates of this paper, also shows that the process of emergence of SCs (cities that invested time and money in the digitalization of their production function, in their human and social capital, and benefit from a participatory governance mode) can in turn be associated to higher regional growth rates.

As anticipated in the Introduction, our definition of S3 refers to the long-run; therefore, it is measured prior to the emergence of S3 policies proper. The empirical analyses presented in this paper, thus, reflect a RIS3 type of thinking, although no Smart Specialisation Strategy proper may have been put in place over the observed time frame.

[4] This definition is in turn based on the work by Giffinger and coauthors (e.g. Giffinger et al., 2007).

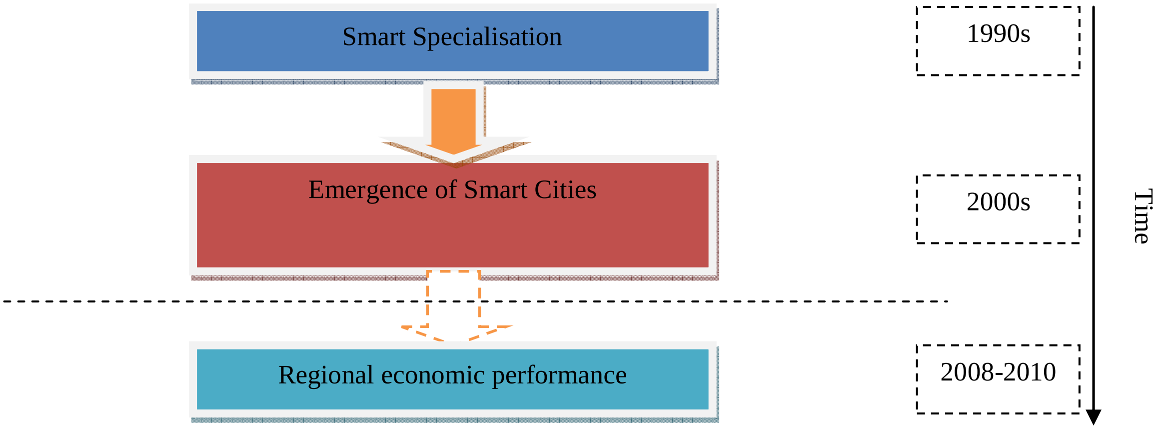


Figure 1. A conceptual framework for the emergence of Smart Cities as a consequence of Smart Specialization Strategies

Source: Authors' elaboration

The proposed timeline, summarized in Figure 1, is based on the nature of the phenomena under analysis and is related to the timing of their growth-enhancing effects. S3, as defined in Section 2.1, are inherently connected to a region's industrial specialization pattern and, as such, to its structural characteristics. Besides, the choice of the region as the ultimate spatial scale of the present analysis is also motivated by the fact that regions are the beneficiaries of EU policies, and, thus, receive funds[5] on the basis of their (self-assessed) degree of S3. EU NUTS2 regions are, therefore, the best choice for any empirical analysis aiming at assessing the effectiveness of these policies.

The potential growth implications of this structural factor will thus show up in the medium-long run, suggesting to consider this aspect with a lag. This is also in line with the practical perspective taken on by the S3 platform itself, which suggests that S3 represent a vision for future economic development, rather than a direct and short-run policy instrument. "*S3 involves a process of developing a vision, identifying competitive advantage, setting strategic priorities and making use of Smart policies to maximise the knowledge-based development potential of any region, strong or weak, high-tech or low-tech*" (EC, 2013b).

The outcome of a SC policy, instead, is more akin to an organizational feature of a regional economy, since it reflects the path cities in the region have undertaken to better organize and combine previously existing factors in the context of an urban production function. The potential growth effects, at the regional level, of hosting one or more SCs will thus more likely be visible in the short run, since urban smartness, as defined in Section 2.2, is mainly a re-organization of existing urban level assets and success factors.

This simple conceptual framework provides a justification for the empirical model (Section 3.2), and is the basis for the estimates, analyzed in Section 5.[6] On the basis of the proposed conceptual framework, the impact of S3 on regional economic performance can be thought of as indirect, although not necessarily of minor importance. As such, the overall impact of EU Smart policies can be translated into an empirical model whereby such direct and indirect effects are properly taken into account by means of Two Stages Least Squares (henceforth, TSLS) techniques.

[5] Previous examples of major EU funds being allocated at the regional level include cohesion, competitiveness, and INTERREG programme funds.
[6] An earlier version of this model has been described in Caragliu and Del Bo (2015).

3.2 The empirical model

The empirical framework adopted is based on a two-stages approach. At the beginning of the first time period, each region is characterized by a given level of competitive advantage (which is measured by a given level of productivity growth w.r.t. to the EU productivity growth rate). Each region can then either specialize, or de-specialize, in the economic activities presenting positive growth of competitive advantage,[7] irrespective of the technological content of the economic activity characterized by higher competitiveness (EC, 2013b).

Let us define as *i* all regions, *i=1,…,m*, *j* all the industries, *j=1,…,n*, and indicate three time periods with time indices *0*, *t* and *T*. Let us also define $CA_{i,j,t}$ the competitive advantage of region *i* at time *t* in sector *j* as the difference in the region's industry-specific growth of labor productivity w.r.t. the average EU27 labor productivity growth. In other words, if $VA_{i,j,t}$ is value added produced in industry *j* in region *i* at time *t*, $VA_{EU,j,t}$ is value added produced in industry *j* in the European Union at time *t*, $L_{i,j,t}$ is employment in industry *j* in region *i* at time *t*, and $L_{EU,j,t}$ is employment in industry *j* in the European Union at time *t*, then $CA_{i,j,t}=(VAi_{,j,t}/L_{i,j,t} -(VA_{EU,j,t}/ L_{EU,j,t}))$. In dynamic terms, this implies that the process of industrial structural change for each region-industry can be defined as

$$\Delta CA_{i,j,t-0} = \Delta\left[\left(VA_{i,j,t} / L_{i,j,t}\right) - \left(VA_{EU,j,t} / L_{EU,j,t}\right)\right]. \quad (1)$$

Thus, in this conceptual framework (and, as shown in Section 4, in the suggested indicator of S3), *regions can be defined as smartly specializing if they display a higher-than-average capability to specialize in the industries where they present positive growth of competitive advantage*, i.e. if $\Delta CA_{i,j,t}$. is greater than 0 in sector *j*. This definition is stemming from previous literature on S3, as summarized in the previous Section 2.1. In fact, although initially focusing on science-related industries, the literature on S3 has been evolving towards focusing on the capability of the regional actors to increase their specialization in industries where they present competitive advantage, irrespective of the scientific content of the activity involved. The one-size-fits-all Innovation Agenda synthesized in the Lisbon Strategy has in fact been consistently found to have failed in providing a unique solution valid across all regions (Pontikakis et al., 2009).

In this framework, competitive advantage (eq. 1) is used as a market signal that is received by entrepreneurs and institutions; economic activity in each region can in turn specialize in industries with competitive advantage, or disadvantage. Let us define $SPEC_{i,j}$, as the share of employment in region *i* in industry *j*: $SPEC_{i,j}=L_{i,j}/L_i$ and $\Delta SPEC_{i,j}$, as the change in regional industrial specialization over the period *T-t*. We can thus define $S3_{i,,j,T}$ as the degree to which, between periods *t* and *T*, the level of specialization in region-industry *i-j* has been able to grow *more than the EU average* if presenting competitive advantage w.r.t. the EU27. The following equation, therefore, defines the measure of (industry-specific) S3 used in the empirical estimates:

$$3S_{i,j,T} = \left(\Delta SPEC_{i,j,T-t} - \Delta CA_{i,j,t-0}\right) \quad (2)$$

Each region is thus assumed to be able to specialize in an economic activity which presents some degree of competitiveness at the continental level, irrespective of the level of technology embedded in the economic activity. The proposed indicator of S3 addresses the main conceptual feature of this

[7] This may come as a result of either individual, non-coordinated firm activity (entrepreneurs looking for better economic opportunities), or else because of a centrally-coordinated policy initiative (e.g., economic incentives to open production facilities active in the industries where the region presents growth of competitive advantage).

type of policy, viz. whether a region has been specializing in economic activities where it has some form of competitive advantage; however, this index leaves out two additionally relevant issue in the S3 literature (the degree of connectivity of a region and the positioning of the region within global value-chains).[8]

At a more aggregate level, each region i presents different industries in which it has been structurally specializing. All eqs. (2) can be thus aggregated to obtain a region-specific measure of S3 S3i,T as follows:

$$3S_{i,T} = \sum_{j=1}^{n} w_j 3S_{i,j,T} \tag{3}$$

In eq. (3), *w*s are weights assigned to each industry in the generation of the region-specific S3. As the S3 literature usually revolves around the fact that being specialized in scientific industries would constitute the "real" S3 (Foray et al., 2009; McCann and Ortega-Argilés, 2013), eq. (3) allows to test such hypothesis, by letting *w*s vary in order to reflect the different weights associated to more research intensive-industries.[9]

S3 can in turn be related to the emergence of SCs, which thrive on the existence of a set of growth-enhancing urban characteristics as explained in Section 2. For this concept we follow the theoretical definition laid down in Caragliu et al. (2011), and work out a model whereby the concepts of S3 and SC are interrelated. This is done as follows. We assume that the probability of region *i* to cradle the emergence of a SC, π_i, to obey the following functional form:

$$\pi_{i,T} = \alpha_1 + \beta_1 3S_{i,T} + \gamma Z_i + \eta_1 \tag{4}$$

where $\eta_1 \sim i.i.d.(0,1)$, while Z_i is a matrix of region-specific controls. Since the real probability of the existence of a SC within each region is not known ex-ante, we resort on calculating an indicator of smartness for each city, and then aggregate city-specific indicators at the regional level using city population levels as weights.[10]

Eq. (4) represents a reduced form which can be estimated, provided all the above mentioned assumptions are met. However, since in this conceptual framework the level of S3 does not directly affect regional economic performance, this equation will represent the auxiliary regression in the empirical analyses presented in Section 5.

Eq. (4) is also instrumental for obtaining a measure of regional smartness, encompassing both concepts of SC and S3. Estimates of eq. (4), which will be used in the final step of the empirical model, are available upon request from the Authors.

The model is thus completed with an equation measuring the impact of regional smartness (including the effects of both Smart policies) on regional economic performance, while also controlling for the economic and institutional factors that have not yet included in the model (eq. 5).

$$\Delta GDP_{i,k} = \alpha_2 + \beta_2 \pi_{i,k} + \varsigma INST_{i,k} + \chi CRISIS_k + \phi_{i,k} \tag{5}$$

[8] We would like to thank an anonymous reviewer for pointing at this possible future research avenue.
[9] See also Caragliu and Del Bo (2015) for an empirical verification of this hypothesis.
[10] Details available upon request from the Authors.

where i indicates the regions and k the Country. In eq. (5), the growth of GDP in region i between 2008 and 2010,[11] ΔGDP_i, is a function of regional smartness, $\pi_{i,k}$, of the regional institutional quality, $INST_{i,k}$, and of the macroeconomic conditions of the Country k where region i is located.

Eq. 5 thus suggests that only regional smartness is expected to have a direct impact on regional economic performance. In fact, it is reasonable to assume that such measures as ICT intensity, human and social capital, and transport infrastructure may exert a positive influence on regional performance via productivity and competition effects. However, processes of structural industry specializations usually take place in the medium and long-run, and, as a consequence, in the medium to long run exert their effects. Ideally, such research hypothesis can be tested in a TSLS setting, which also allows to improve the quality of causal inference between regional smartness and economic performance.

Eq. 5 includes institutional and macro factors that are expected to exert a positive influence on regional economic performance, while at the same time not belonging to the portfolio of urban and regional characteristics that can be related to urban smartness and S3 that have been accounted for in the previous steps of the empirical model. The aim of this last equation is thus to complement regional 'Smart characteristics' in explaining regional economic performance, thus providing a framework that will allow the identification of the impact of such Smart characteristics, net of other growth-enhancing factors.

The additional economic and institutional factors are mainly of two types:

- *Regional institutions*: The quality of the institutional setting at the regional level allows economic actors to fully take advantage of available inputs, without wasteful loss due to corruption, unclear rule of law, poor voice and accountability. A measure of regional institutional quality (Charron et al, 2013), based on the WGI (World Government Indicator) index is thus added to the regression to account for the institutional factors which may hamper or boost the contribution of regional inputs to the economic growth process.
- *Macroeconomic conditions*: endogenous factors do not suffice to fully explain regional economic performance. Even when local characteristics correspond to the maximum regional economic potential, the stage of the business cycle of the Country where each region is located has deep influences on the region's growth rate. This point is taken into account by building a dummy variable, equal to 1 when the Country has been in recession during the observed period. The idea is to fully account for the context in which the economic development of each region evolves.

Eq. (5) is the basis of the empirical estimates presented in Section 5; before discussing the empirical validation of this equation, however, Section 4 will introduce the data set assembled for this empirical exercise.

4. Smart policies: data set and measurement

The empirical validation of the conceptual framework described in Section 3 requires data amenable to measuring both region-specific S3 characteristics, as well as city-specific Urban

[11] The choice of this relatively short time span is motivated by data availability. In fact, to date there is no sufficient evidence about actual smart specialisation projects at regional level, other than qualitative case studies.

smartness; in both cases, the definitions of both the S3 and SC concepts need to be taken into account.

Table 1 provides a synthetic overview of the data set assembled for the empirical estimates.

The first step in our conceptual and empirical framework refers to the S3 concept. Our proposed indicator aims at satisfying the criteria listed in Section 2.1; thus, data on the industrial composition of the labour force and sources of value added are used in order to build an indicator of relative regional competitive advantage, which is observed over the time period 1990-2008 (Table 1).

The second logical step in our empirical procedure implies the calculation of a *regional* urban smartness indicator. Because the concept of SC is inherently urban, we first collect data on a cross section of EU cities on the 6 axes listed in Section 2.2; next, urban scores are averaged at the regional (NUTS2) level. Wherever more than one city is located in a single region, cities are weighted in terms of their regional population shares.[12]

The third step in our empirical strategy is the assessment of the relationship between the two types of Smart characteristics. In order to minimize endogeneity issues, this auxiliary stage includes the level of development of the region, measured by the level of per capita GDP (Table 1), as well as the predicted values of the auxiliary regression.

Table 1. The data set

Logical step	Raw data	Source	Available years
1. Smart specialisation indicator	Sectoral data (15 NACE 2 digits industries) on: • Value added in constant 2000 prices • Labour force	Cambridge Econometrics	1990-2008
2. Regional smartness indicator	• Human capital • Social capital • Transport infrastructure • ICT infrastructure • Natural resources • E-government	Urban Audit	2004-2011
3. Instruments in the main regression	Per capita GDP in constant 2000 prices	EUROSTAT	1999-2001
	Predicted S3 indicator (see step 1)	Own calculation	1990-2008
4. Control variables in the main regression	Regional Quality of Government	QoG EU Regional Data	2009
	Dummy macroeconomic crisis	Own calculation on the basis of EUROSTAT GDP data	2007-2008

Source: Authors' elaboration

[12] Details available upon request from the Authors.

This step is conducive to the fourth and final one, which involves the assessment of the relationship between regional smartness, comprising the Smart inputs activated by both Smart policies, and regional economic performance. Again, in order to control for other potentially biasing growth-enhancing factors, at this stage empirical estimates also control for elements that have been so far missing from the framework, that are mostly of aggregate nature. Macroeconomic conditions are taken into account by means of a dummy variable, equal to 1 when the Country where each region is located experienced recession in the period 2007-2008; the institutional framework is instead captured with a measure of regional quality of government (Table 1).

5. Empirical results

Are Smart characteristics, enhanced and "activated" by Smart policies, a possible determinant of economic performance and ultimately growth? In order to provide a tentative answer to this question, the results obtained in the previous sections in relation to the characterization of both S3 and SCs and their interrelation are used in a regional short-run growth setting. The basis for our empirical approach is related to the literature on potential growth determinants, which highlight the importance of a set of economic and institutional factors. As shown in Section 3, such growth-enhancing factors are classified according to the spatial scale and the time frame where they best fit and conceptualized and linked via the two Smart indicators presented in the previous Section.

5.1 Regional smartness and economic performance

According to the conceptual framework described in Section 3, while S3 is assumed to have a direct effect on the likelihood that regions will cradle the emergence of SCs, the existence of the latter is expected to directly impact regional economic performance. This implies that in an Instrumental Variables framework, S3 could act as a valid instrument for assessing the (positive) correlation between regional smartness and economic performance.

Table 2 follows this rationale and shows the empirical estimates of eq. (5). In Table 2, columns 1 through 3 show OLS estimates of eq. (5) where the measure of regional smartness the two relevant controls (regional quality of government and the dummy crisis) are included one per column. Across all specifications, heteroskedasticity-robust standard errors and country fixed effects are used.

This empirical exercise includes the macroeconomic and institutional factors that are expected to influence regional economic performance, while at the same time not belonging to the portfolio of urban and regional characteristics that can be related to urban smartness and S3 that have been measured as described in Section 4.

The main variable of interest in Table 2 is the presence of SCs (regional smartness), as captured by the average regional smartness indicator. This variable is found to be positively and significantly associated to regional economic performance, measured with the growth of constant 2005 prices Euros between 2008 and 2010. The precision of this estimate is considerable, as with the addition of the two main control variables (viz. regional institutional quality and the dummy crisis) no change in either the estimated parameter or the associated standard error can be identified at the third digit.

As for the control variables, regional institutional quality (Charron et al., 2013) is not associated with regional performance; the estimated parameter is never found to be significant across all specifications. This lack of significance could be read as due to an incorrect measure of the quality of regional institutions;[13] an alternative reason could instead be related to the period necessary for institutions to exert a positive effect on economic performance, which could be observed only in the medium to long run. An additional explanation could finally be related to the correlation of this variable with social capital at the urban level, that was included in a previous step of the analysis.

Table 2. Smart policies and regional growth

Dep. Var. GDP growth 2008-2010	(1)	(2)	(3)	(4)	(5)
Constant term	-0.01***	-0.03	-0.01	0.03**	-0.04
	(0.00)	(0.02)	(0.02)	(0.01)	(0.01)
Regional smartness	0.005**	0.005**	0.005**	0.057***	0.02***
	(0.002)	(0.002)	(0.002)	(0.013)	(0.01)
Regional Institutional Quality	-	0.004	0.004	0.00	0.00
		(0.005)	(0.005)	(0.00)	(0.00)
Dummy crisis	-	-	-0.014***	-0.06***	-0.01
			(0.004)	(0.01)	(0.01)
Obs.	200	200	200	200	200
R^2	0.84	0.84	0.85	0.82	0.76
Joint F test	37.08***	18.32***	13.77***	28.93***	25.14***
Country Dummies	Yes	Yes	Yes	Yes	Yes
Robust standard errors	Yes	Yes	Yes	Yes	Yes
Estimation method	OLS	OLS	OLS	TSLS	3SLS
Variable instrumented				Regional smartness	
Instruments used				Time-lagged smart specialisation; regional per capita GDP	
Partial R^2 of the ancillary regression				0.13	0.33
Underidentification tests:		-			-
- Anderson LR statistic				27.46***	
- Cragg-Donald statistic				29.44***	
Cragg-Donald weak identification statistic				13.10***	
Anderson-Rubin χ^2 test of significance of the endogenous regressor (regional smartness)				22.77***	

*Note: *,**,*** associated to statistical significance at the 10, 5, and 1% level, respectively.*

Table 2 also controls for the current effect of the financial crisis on regional performance. In fact, regional growth is not exempt from the positive or negative effects exerted by country-varying characteristics; in other words, how the Country each region belongs to performs has a relevant influence on the performance of the region, irrespective of the local (endogenous) characteristics of the region. This second element is accounted for with a dummy variable, taking on value one if the country experienced at least two consecutive quarters of falling GDP in 2007 and 2008 (Shiskin, 1974). Even after controlling for structural characteristics, the negative effects of the country-level recession are significantly related to regional growth in the short run. Finally, country fixed effects are also mostly statistically significant, which further corroborates the importance of country-specific determinants for regional economic performance.

[13] Although to the best of our knowledge this is the only indicator capturing regional quality of government in the same way as its country version.

Clearly, regional smartness could present serious problems of endogeneity. The presence in each region of cities scoring high in smartness could in fact be related to performance itself, thus causing a bias in the estimates presented in Table 2.

In order to correct this potential distortion, we resort on Two Stages Least Squares regressions. This technique allows us to reach two main goals. Firstly, the estimated smartness parameter is netted out of potential co-variation with regional growth. Secondly, we opt for a set of instruments that allows to evaluate the two-stage conceptual framework described in Section 3. Such estimates are shown in Table 2, Column 4.

In particular, regional smartness is instrumented by the region's initial stage of development, measured with per capita GDP, and with our measure of S3. This second step is the crucial identifying assumption in our empirical exercise. In fact, our ancillary regression tests the relationship between S3 process and regional smartness (eq. 4); the second-stage regression identifies instead the correlation between the average regional smartness values predicted in the first stage regression, in turn reflecting S3, and regional economic performance. This empirical structure reflects indeed the timeline for the S3-smartness-economic performance nexus described in Section 3.

The link between the long-run process of S3 and the emergence of SCs is motivated by the need, in order for SCs to emerge, for a rich portfolio of diversified industries, where the region has competitive advantage. Such industries add to the local demand for new technologies, thereby stimulating the production of ICT that is at the core of the initial definition of urban smartness. Besides, specialized industries are also often associated with an increase in human and social capital (Mahdavi and Azizmohammadlou, 2013), that represent the fertile soil for the effectiveness of urban smartness, as argued in Section 2.2.

Moreover, there should be a rather weak – if any- direct effect of S3 process on regional short-run economic performance. As argued above, S3 policies should be considered as fostering long-run economic development, rather than being a short-run policy tool. In the present empirical analyses economic growth is measured in the very short run, covering the years 2008-2010.

The third and last condition for the validity of the exclusion restriction, viz. the absence of reverse impact of the instrument onto the dependent variable, can be ruled out on the basis of the time structure of our estimates.

Estimates in Table 2, Column 4 suggest that regional performance is positively associated to Smart policies, in particular to S3 and SC initiatives. This suggests the existence of a positive correlation between the potential outcomes of Smart polices and short run regional performance, thus lending indirect empirical evidence in favor of these policies. S3 are in the direction of helping regions to specialize in the sectors and activities for which a competitive advantage exists. SC policies are based instead on the strengthening of a city's human, social, technological, infrastructure, governance and environmental capital with the ultimate aim of supporting economic performance and growth. Our measures of S3 urban smartness are indirectly accounted for in the short run growth regression by means of the fitted values variable.

All the main statistics associated to our instruments (and in particular to the measure of S3) are strongly significant. Both under-identification tests run (the Anderson LR statistic and the Cragg-Donald statistic) strongly reject the null hypothesis of under-identification, thus suggesting that the regression is at least just identified. Besides, the Cragg-Donald weak identification statistic also rejects the null hypothesis of weak identification. Finally, the Anderson-Rubin χ^2 test of significance of the endogenous regressor (in our case regional smartness) rejects the null that the parameter estimated for the endogenous variable is statistically equal to zero.

A final consistency check for the robustness of our empirical identification strategy requires the use of three-stages least squares (henceforth, 3SLS; Zellner and Theil, 1962). In fact, heteroskedasticity in the error terms could be correlated in our empirical strategy's two stages.[14] By means of simultaneously estimating the first and second stage, such heteroscedasticity would be amended. Results of this final consistency check (Table 2, Column 5) show that the parameters estimated with 3SLS are statistically identical to those estimated by means of the more standard 2SLS (p-value equal to 0.000). The impact of Smart policies on regional performance is positive and significant at all conventional levels, although the absolute coefficient is roughly halved by using 3SLS. This suggests that correlated heteroscedasticity in the error terms does not drive our findings.

5.2 Graphical analysis: S3, smartness and regional economic performance

A second way of empirically verifying the S3-smartness-economic performance nexus is to resort on graphical analysis.

This is done in Figures 2 and 3, which represent the relation between the measure of regional smartness and the intensity of S3 (Figure 2) and the relation between regional smartness and regional growth (Figure 3).

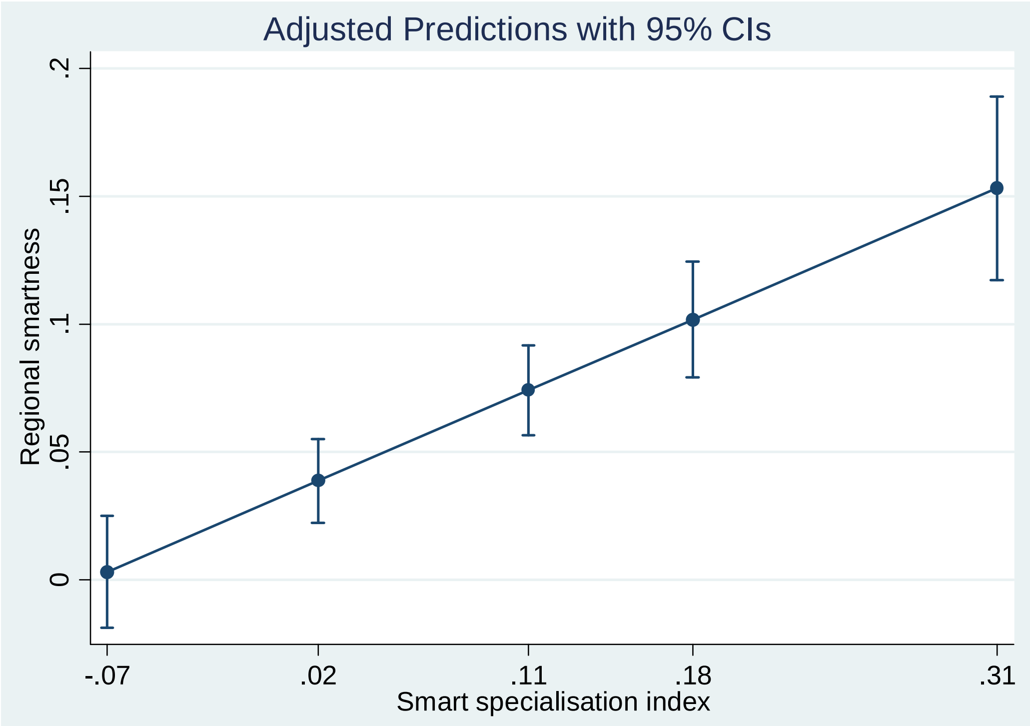
Figure 2 shows the relationship between regional smartness and S3, stemming from the ancillary regression used in the 2SLS regression (Table 2, Column 4). The positively (and increasingly so) sloped curve confirms the positive association between the two Smart policies identified in Caragliu and Del Bo (2015). The estimated 95% confidence intervals suggest a slight decrease in the precision of the estimates for the validity of this relationship, which is evidenced by an increasing width of the interval.

Figure 3 shows instead the relationship between economic growth and regional smartness, i.e. the main regression in Table 2. Once again a positively sloping curve testifies for the validity of the proposed conceptual framework, with particularly precise estimates in a neighborhood of 4^{th} decile of the smartness indicator.

Figures 2 and 3 suggest that the two smart policies recently proposed in the EU may fact jointly have a positive impact on regional performance. As one type of policy is positively associated to the other, which in turn is positively associated to regional growth, these results suggest that both types of policies, on the basis of the present analysis, may be in fact growth-enhancing, although on two different time horizons (S3 policies needing more time to positively influence growth, smartness measures being instead more suitable to the short run).

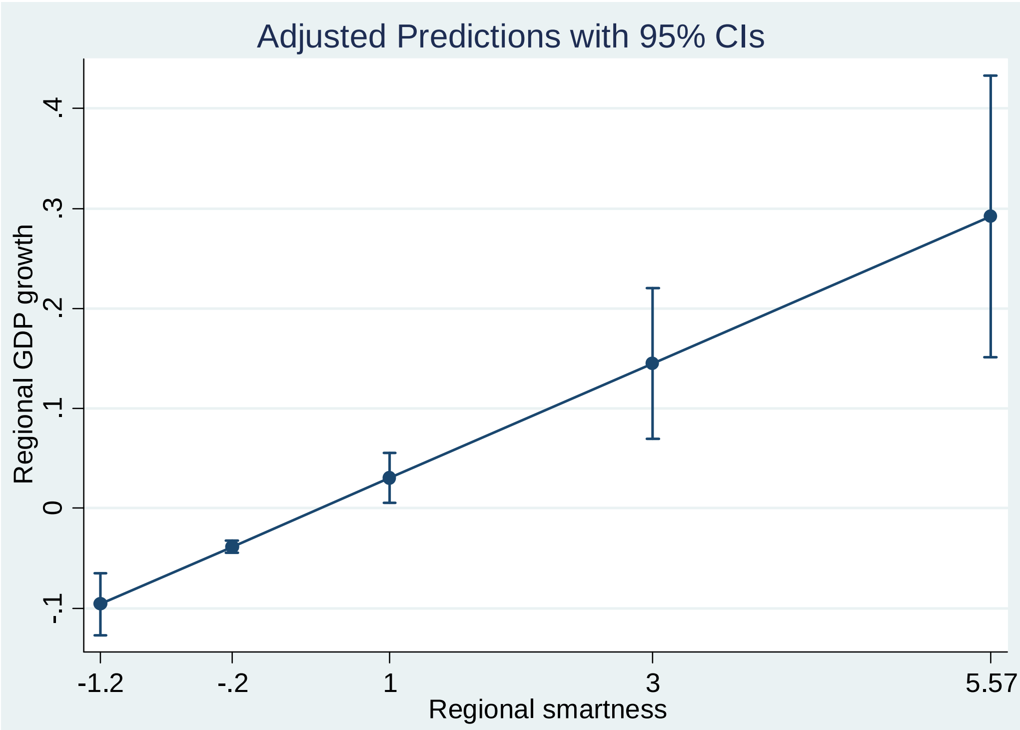
[14] We would like to thank an anonymous reviewer for suggesting this possible issue.

Figure 2. Marginal effects for different outcomes of the regional smartness parameter



Source: Authors' elaboration

Figure 3. Predicted regional GDP growth as a function of regional smartness



Source: Authors' elaboration

Some possible shortcomings of this analysis should, however, be taken into account. Although all standard techniques used to rule out possible distortions in the estimates have been employed, we cannot be sure that the bias from potentially omitted variables does not affect these results. Besides, given the time frame observed for the dependent variable, we may have captured mostly ways for regions to be resilient to the crisis; these results may thus be invalid for long-run economic performance.

6. Conclusions

Public resources in a situation of widespread economic and financial distress are both much needed and increasingly scarce. In such a situation, a critical assessment and evaluation of the growth-enhancing prospects of different policy options is a necessary empirical exercise. In the context of EU-wide policies, this paper examined two recent Smart policies, S3 at the regional level and SC initiatives at the urban level, with the aim of investigating whether there is a rationale for their pursuit in terms of economic performance. We have also examined and exploited the existing interrelations between the Smart characteristics activated by these Smart policies to gauge their impact on short run economic performance of EU regions.

Our results suggest, on the one hand, that the two Smart policies, albeit operating at a different spatial scale and time frame, are positively correlated, lending empirical support to their use as policy instruments. On the other hand, the outcomes of both policies appear to be exerting a positive effect on short run economic performance, while explicitly accounting for institutional characteristics and the aggregate macroeconomic conditions.

While additional data on a longer time period would be needed to assess the actual long-run growth potential of Smart policy actions, a matter which is left for future research, our findings are suggestive of a positive assessment of both S3 and SCs policies at the EU level. Further research would be also beneficial in the direction of a more direct empirical assessment of real applications of Smart policies. In both the S3 and SC case, in fact, the aim should be a more evidence-based approach to regional policymaking, which necessarily requires more solid verification than what presently available.

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Appendix 1: indicators of regional smartness and Smart Specialisation[15]

Measuring Smart Specialisation

Following the model of Smart Specialization discussed in Section 3, our empirical analysis needs to be complemented by an indicator of Smart Specialization which is transparent, amenable to interregional comparisons, and subject to possible tests of the relative relevance of science-intensive industries in assessing the smartness of specialization processes.
On the basis of eq. (3), data on industry specialization and labor productivity have been collected for the period 1990-2008 for 279 EU NUTS2 regions and the following 15 NACE 2-digit industries (Table A.1).

Table A.1. List of industries used for the calculation of the Smart Specialization Indicator

NACE industry Code	Full Industry Name
A+B	Agriculture
C+E	Mining, quarrying and energy supply
DA	Food, beverages and tobacco
DB+DC	Textiles and leather etc.
DF+DG+DH	Coke, refined petroleum, nuclear fuel and chemicals etc.
DL	Electrical and optical equipment
DM	Transport equipment
DD+DE+DN+DI+DJ+DK	Other manufacturing
F	Construction
G	Distribution
H	Hotels and restaurants
I	Transport, storage and communications
J	Financial intermediation
K	Real estate, renting and business activities
L+M+N+O+P	Non-Market Services

Empirically, in order to obtain the indicator of S3, we firstly regress the change in regional industry specialization between 1990 and 2008 on the initial level of competitive advantage, i.e. the difference between the regional labor productivity and the average level of labor productivity at the EU27 level for each industry, plus a full battery of industry fixed effects, to rule out structural differences across industries. Formally, we estimate an ancillary regression of the form:

$$\Delta SPEC_{i,j,T-t} = \alpha_0 + \beta_0 \sum_{j=1}^{n} w_j \Delta CA_{i,j,T-t} + \beta_j \eta_j + \varepsilon_0 \qquad \text{(A.1.)}$$

where ε_0~*i.i.d.(0,1)*, and the η_js are the industry fixed effects. The results of estimating eq. (A.1.) are presented in Table A.2.

The regression presented in Table A.2 divides a hypothetical chart (Figure A.1), showing a scatterplot of comparative advantage on the X-axis, and the subsequent change of industrial specialization on the Y-axis, in two areas:

[15] These indicators are first described in Caragliu and Del Bo (2015).

- Regions specializing more than the average in industries initially presenting comparative advantage;
- Regions specializing less than the average in industries initially presenting comparative advantage.

Table A.2. Estimates of the ancillary regression for regional Smart Specialization

Dep. variable	Change in regional industrial specialization 1990-2008
Constant term	-0.38***
	(0.01)
Initial level of comparative advantage	1.83*
	(1.18)
R^2	0.12
Joint F test	133.21***
Number of observations	4185
Industry fixed effects	Yes
Robust standard errors	Yes

*Notes: ***,**,*: significance at the 10, 5 and one per cent, respectively.*
Robust standard errors in brackets.

In Figure A.1, these areas are identified with the regression line whose estimated equation is shown in Table A.2. As a final step, our Smart Specialization indicator is defined as the residual of this regression, i.e. (Figure A.1), as the vertical distance between the regression line and the Y-axis coordinates, indicating regional specialization. Formally, this implies calculating the fitted residuals $\hat{\varepsilon}$ in eq. (A.1), and aggregating them at the regional level. This indicator measures therefore the potential of a region to specialize in industries presenting comparative advantage more than the EU average.

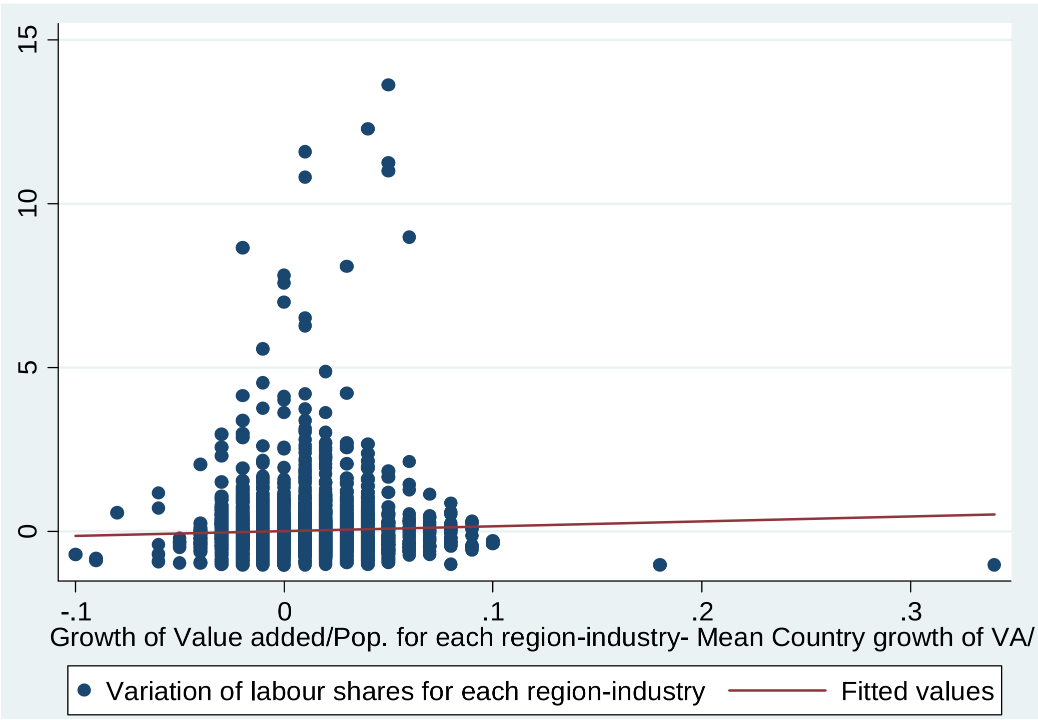

Figure A.1 Regional Smart Specialization

Source: Caragliu and Del Bo (2015)

Measuring regional smartness

Since smartness has been originally proposed as an urban policy instrument, our measure of regional smartness is based on calculating a city-specific indicator, that is then aggregated at the regional level.

At the urban level, the 6 axis in the urban smartness definition are instead measured with the following basic indicators (Table A.3). Such indicators are then summarized by means of a Principal Component Analysis, performed for each axis presented in Table 5; in other words, for each axis one principal component is identified (all identified PCs are those associated to greater than unity eigenvalues, as suggested in Kaiser, 1961, and for which the factor loadings are reasonable, as discussed in Dunteman, 1989). The six Principal Components are then aggregated at the regional level, on the basis of a weighted average, with weights assigned to each city on the basis of the share of total regional population living in each surveyed city.

Table A.3 Indicators for the 6 axes of the Smart City definition

Urban smartness axis	Raw data
1. Human capital	Proportion of population aged 15-64 qualified at tertiary level (ISCED 5-6) living in Urban Audit cities - %
	Students in tertiary education (ISCED 5-6) living in Urban Audit cities - number of students per 1000 inhabitants
	Proportion of employment in financial intermediation business activities
	Proportion of employment public administration health education
	sum of the previous 2
	Number of companies with headquarters in the city quoted on the national stock market
2. Social capital	Car thefts per 1,000 pop.
	Burglaries per 1,000 pop.
	Crimes per 1,000 pop.
	Number of elected city representatives
3. Transport infrastructure	Length of public transport network per inhabitant
	Share of restricted bus lanes from public transport network
	Number of buses (or bus equivalents) operating in the public transport per 1,000 pop
	Number of stops of public transport per 1,000 pop.
4. ICT infrastructure	Percentage of families with internet access at home
	Number of local units producing ICT products
	Number of local units producing ICT-related services
	Number of local units producing web content
5. Natural resources	Proportion of solid waste arising within the boundary processed by recycling
	Proportion of the area in green space
	Green space (in m2) to which the public has access, per capita
	Annual average concentration of PM10
	Annual average concentration of NO_2
6. E-government	% of internet users who interacted via internet with the public authorities in the last 12 months (Country data)
	% of internet users who sent filled forms to public authorities in the last 12 months (Country data)
	Number of administrative forms available for download from official web site
	Number of administrative forms which can be submitted electronically

Source: Caragliu and Del Bo (2015)

In other words, indicating each city as *i* (*n* Smart cities exist within each region j) and each region as *j*, the indicator of regional smartness, $Smartness_{j,t}$, is calculated as follows (eq. A.2):

$$Smartness_{j,t} = \begin{cases} Smartness_{i,t}, \forall j : n = 1 \\ \sum_{i=1}^{n} w_{i,t} * Smartness_{i,t}, \forall j : n > 1 \end{cases} \quad \text{(A.2.)}$$

with $w_{i,t} = \frac{pop_{i,t}}{pop_{j,t}}$, whereas $pop_{i,t}$ is population in city *i* at time *t* and $pop_{j,t}$ is population in region *j* at time *t*.

This is the final indicator of regional smartness.