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PERCEIVE
Perception and Evaluation of Regional and Cohesion Policies by Europeans and Identification with the Values of Europe

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PERCEIVE

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Deliverable 4.3 Report on Smart Cities and Resilience

Table of contents

1. Introduction 2
2. Resilient Cities: a theoretical framework 3
3. Resilience and smartness of EU cities: a case-study approach. 13
4. Summary and Concluding Remarks 24
5. References 25
6. Appendix 28

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1. Introduction

This report will analyse the relationship between smart cities and economic resilience at city level. The conceptual evolution of the 'smart city' is discussed in detail in Work Package 4.1. Furthermore, a new index of 'smartness', which provided a measure of the extent to which a city is smart, was constructed in Work Package 4.1 using Stochastic Multicriteria Acceptability Analysis (SMAA) at city level. The index considered both objective measures and citizens' perceptions of key dimensions offering value in assessing 'smartness' in city projects and policies. Building on the work conducted in Work Package 4.1, this report focuses on smartness (the creation and use of knowledge) and the potential link with the resilience at city level.

Economic resilience, discussed in more detail in Section 2, is concerned with the adaptive capacity and robustness of a city (amongst other things) to unforeseen or uncontrollable external shocks to the economy. A city would be more resilient if it is well placed to undertake a proper change under changed circumstances while mitigating and accommodating the impact of current shocks. Such resilient cities would suffer less in an economic downturn and are likely to experience greater growth during a positive economic environment.

The analysis explores how a higher degree of creation and use of knowledge (including the knowledge and identification with the EU discourse) is linked to a higher economic resilience and hysteresis within the urban context (at city level).

Results show that the smartness and the level of identification with the EU discourse both play a crucial role in determining the reaction to the business cycle at city level, compared to the national counterpart. This provides evidence for a potential link between smartness specialisation and resilience along with a positive contribution of the identification with the EU towards the absorption of economic shocks. Resilient Cities: a theoretical framework

This section briefly recalls the theoretical framework underpinning the empirical analysis developed in this report. To begin with, the concept of 'resilience' before gaining momentum in the economic analysis to describe transient and permanent effects of economic shocks has been developed in a multidisciplinary field. Indeed, the term has been applied in mathematics and physics to describe the reaction of stochastic systems to shock. Furthermore it has been applied to environmental and development economics to analyse the effects of shocks in such different systems (Perrings, 1998; Levin et al., 1998). Hence, it has been used as a topic of spatial and regional political economy (Reggiani et al. (2002). It is worth noting that the use of the term has been twofold. First, it has been applied with reference to the effect of 'major shocks', such as the effects of war bombing on city growth (Davis and Weinstein, 2002; Bosker et al., 2007) or, alike, important changes involving the political landscape (Redding and Sturm, 2008). A second stream of literature, beginning from 2010, has focused on regional growth (Pendall et al., 2010; Pike et al., 2010; Simmie and Martin, 2010).

Therefore, in economic terms, the resilience framework allows the analysis of both the momentary impact of exogenous disturbances (the so called engineering resilience: the ability of a given area to bounce back after a negative shock) and the persistence of out-of-equilibrium regional evolutions à la Kaldor-Myrdal (the so called ecological resilience: multiple patterns of growth experienced by a place after a recession).

Once applied at city level, the resilience approach gains even more interest. With as many as 4.027 billion inhabitants already living in cities worldwide in 2016 (World Bank[1]), roughly 6 billion expected in 2050 (UN DESA, 2014), and an expected growth of at least 1.44% until the year 2030 (World Health Organisation[2]), the potential human and economic losses arising from shocks affecting cities are considerably increasing in importance. Many cities have already experienced the effects of industrial structural change, economic crises, and natural disasters, including the attendant disruptions in energy supply (OECD, 2016).

Within this context, the concept of resilience is inflected in terms of adaptive capacity, robustness, redundancy, flexibility, resourcefulness, inclusiveness and integration (OECD, 2016). That is, in order to be resilient a city has to develop its (i) ability to undertake a proper change under changed circumstances while (ii) mitigating and accommodating the impact of current shocks. As a result of the shock, therefore, the city should show the ability to fundamentally renew its system up to the point that the shock will no longer have an impact. It is worth noting that, this approach to (the definition of) resilience entails the ability to move to an upper

[1] https://data.worldbank.org/indicator/SP.URB.TOTL. Retrieved on 04/09/2017
[2] http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/. Retrieved on 04/09/2017. The expected growth rates are as follows: 1.84% per year until 2020, 1.63% per year between 2020 and 2025, and 1.44% per year between 2025 and 2030.

equilibrium, without returning to the status quo. As the whole process will produce information and know-how in itself, to some extent, a resilient city should have the ability to learn from its past shocks creating a virtuous path-dependency in which past shocks *prepare* the city to perform better in the future ones.

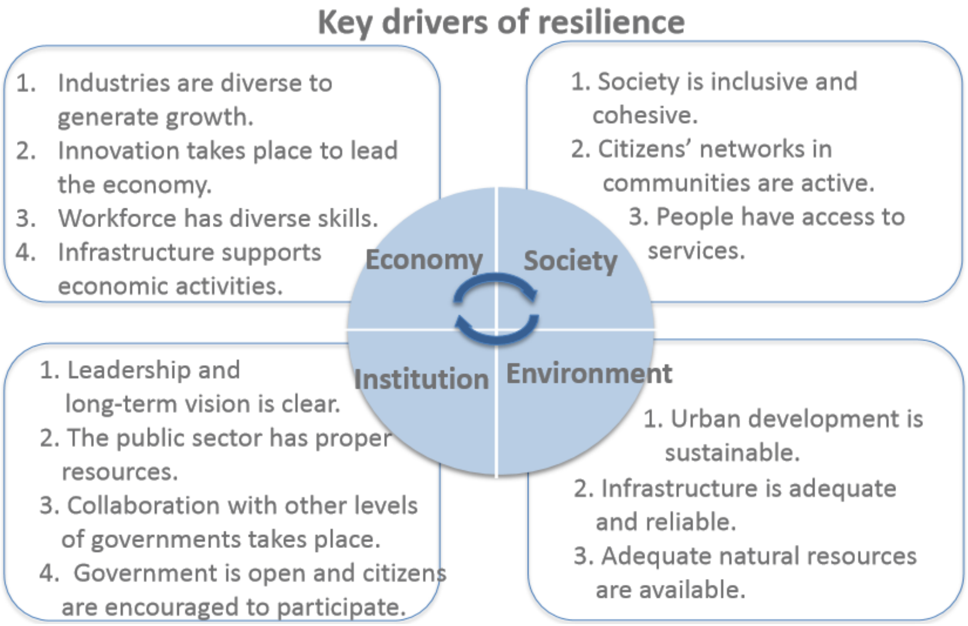
In terms of policy it is crucial to detect the drivers of the above dimensions of cities' resilience. While the resilience behaviour is somewhat case-specific, four common interconnected drivers can be detected.

1) The economic drivers such as a diversified industry attracting a workforce with diverse skills and where innovation takes place are crucial. Undeniably, this influences the overall exposure in global economic value chains and, in turn, the overall, exposure to external shocks. Moreover, the adequate and reliable infrastructure must support economic activities in a substantial way.
2) The society must be inclusive and cohesive, citizen networks must be active, and people must have access to opportunities. This enables cities to cope with shocks by adopting a co-ordinated and coherent set of economic and social policies and practices (OECD, 2014b). It has been stressed in literature that inclusiveness and citizens' access to jobs and education can help cities address change smoothly (OECD, 2016).
3) The environmental factors play an additional important role: The urban development must be able to access natural resources in a sustainable way. This will heavily affect the environmental degradation, the eventual overuse of resources and the following potential costs of climate change and natural

disasters (OECD, 2014a). It is worth stressing how environmental services represents a critical set of resource for cities mainly due to the large number of people exerting a strong pressure over a relatively small portion of territory (ICLEI, 2012). Furthermore, the complex interaction between elements of the city-system such as water and energy distribution, housing and green spaces, infrastructure network, and communication systems makes cities more vulnerable to extreme weather events (OECD, 2014k). In this respect, resilience means understanding of and preparedness for the effects of climate change on the above interconnected elements of the city-system.

4) Finally, a proper institutional framework must support the whole system with a proper leadership and long-term vision. The public sector must be endowed with adequate resources and articulated in a proper number of different levels of intervention collaborating each other. The government must be open and citizens must participate. A proper institutional setting is crucial for a responsive resilient behaviour. The institutional capacity to respond and rebound from shocks of the levels of government closer to citizens are crucial to build trust in governments and to create self-reinforcing positive feedback able to strengthen the resilience behaviour. Furthermore, investments in human resources are crucial for resilient institutions and, in turn, the capacity to reform the institution shapes the resilience behaviour (OECD, 2014c). Figure 1 summarises the main drivers of resilience.

Figure 1 – Key drivers of resilience



Source: OECD (2016)

Of course, the spatial distribution of the above drivers is (spatially) uneven across EU cities. Generally speaking, the bundle depends on economic, political, social, and environmental factors. Different bundles along with different interaction dynamics generate different capacities in terms of a city being *adaptive*, *robust*, *redundant*, *flexible*, *resourceful*, *inclusive*, and *integrated* (OECD, 2016).

According to OECD (2016) an adaptive city is able to act based on the lessons learnt from past shocks in dealing with future shocks. The ability to incorporate the lesson learnt from previous shocks is generally deemed to be essential for a city to be resilient. The robustness refers to the existence of a well-designed mechanism to absorb shocks without significant loss of functionality or capacity to function. Redundant cities have spare capacity for unexpected needs to be used to accommodate unexpected demand, a disruptive event, or extreme pressure. In order to improve the performance in this respect, cities have to intentionally develop more than one source of action, service or service provider. This allows for different groups being able to perform the same function and substitute for one another in case of emergencies or change. Flexibility refers to the ability to properly respond to changing circumstances. This attribute involves the ability of individuals, households, businesses, communities and government to promptly respond to change to ensure a minimum level of well-being under economic, social or environmental stress. Resourceful cites are those able to find the way to meet critical needs with the resources available even in a crisis or under highly constrained conditions. The attribute of being inclusive refers to the ability to bring diverse perspectives together ensuring that a plurality of actors and communities are fully involved in the policy process. This allows for plurality of perspectives and interests to be taken into account during the policy-making process potentially improving its efficiency depending on the trade-off direct and indirect costs of the decision making process. In an integrated urban system, different parties cooperate beyond both administrative and sector boundaries (e.g. public and private) throughout the whole policy making process to improve its coherence and effective commitment. This approach should increase the resilience by producing less duplication and incoherence in operations, management and policy programming, and creating, in turn, more efficient and effective response and outcomes.

Along with the analysis of the resilience, cities have attracted scholars' and practitioners' interest with respect to their 'smart transformation'. While there are many definitions of a 'smart city' a well-rounded a rather comprehensive one is offered in Caragliu et al (2011, p. 50) asserting that a city is smart when "…

investments in human and societal capital and traditional and modern communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance." A rather extensive conceptual analysis on this topic is developed in Collins et al. (2017). To the end of this report it is worth noticing that regardless of the conceptualisation of what a smart city is (or has to be), there is a strong theoretical link between the aforementioned 'resilience' and 'smartness' at city level. According to Baron (2012) the research agenda can be described and developed along the lines of the Figure 2. Indeed, the two dimensions (i.e. 'smartness' and 'resilience') can be operationalised and then measured, at least in an ordinal scale. Therefore, the cities can be ranked both in terms of smartness and resilience. By placing the former on the horizontal axis, we can categorise each city as belonging to the group characterised by low very low or no level of smartness ('business as usual' in Figure 2). Here, the known standards only are applied and very little or no innovation takes place. Placed higher in the ranking are cities where certain levels of e-service or intelligent solutions are available for city users ('medium smartness' cities) generating a more responsive local government making use of a partial integration and use of collective data. At the highest position are the cities that are systematically using smart infrastructure to deliver public services taking advantage of real time integration between different sources of data and, in turn, generating high levels of innovation ('high smartness' cities).

On the vertical axis, by contrast, is the observed (or even expected) resilience behaviour in occasion of major shocks. In this case, the lowest level in the scale is assigned by cities showing a high level of vulnerability to social and economic shocks. The middle level is characterised by cities with well-established social and physical infrastructures showing only a certain vulnerability to social, economic and environmental shocks. The upper level is assigned to cities characterised by a high level of resilience. Hence, showing the ability to absorb and react to social, economic and environmental shocks in a substantial way, mainly thanks to a sound material and immaterial infrastructure endowment.

Therefore, the different interaction between smart attitude and resilience behaviour generates 9 possible scenarios. However, from a research perspective, 6 of them are of particular interest either because signalling the existence of ‘clear and coherent’ urban strategies or because pointing out cities being somewhere ‘stuck in the middle’ between smartness and resilience strategies.

The first group, for example, are the cities in upper right quadrant (high smartness, high resilience). This seems to be a clear case of strategy focussed on investment to increase the overall quality of infrastructure endowment in order to achieve or sustain resilience. Equally, the setting registered on the upper left corner seems to be consistent with a clear strategy aiming to create “quiet places” characterised by high resilience, but with no special emphasis on smartness. The lower right corner is still signalling a clearly defined strategy focusing on ‘smartness’ as a key word in the urban programming action and decision-making process. However, here, the strong commitment and investment in smart attributes is not able to build a positive link with the resilience attitude of places. This might be due to, for example, the lack of integrity with local pre-existing conditions.

As for the 'stuck in the middle scenarios', it is worth mentioning those systems characterised by high levels of resilience linked to neither low (i.e. 'quiet places') nor high level of smartness. The systems are somewhat "half-way" in their smart specialisation process and still able to achieve high levels of resilience. In terms of policy it would be interesting exploring if they could reduce their investment in smart infrastructure (i.e. moving toward the 'quiet place' scenario) or rather reduce even more their vulnerability by enhancing their smart attitude. A similar issue, but to a higher extent is potentially faced by urban system positioned exactly in the middle (medium smartness, medium resilience). In this case the effort to build smart infrastructures, even if present, is not enough to achieve high levels of resilience. It would be worth, therefore, considering a refocussing of the urban strategy. Finally, a potential efficiency problem is present in those scenarios characterised by a high effort in terms of building smart infrastructure and not achieving as level of resilience as high as those with similar effort in the upper right corner (high smartness, high resilience).

Of course, not necessarily a city will respond to different shocks (both in time and in their nature) in a consistent way. The resilience behaviour might well be rather shock-specific and each city, as mentioned, might learn from past shocks to improve its resilience in the future ones depending on the very nature of the shock and city's adaptability. This report will present an empirical analysis on the link between smart specialisation and resilience at city level in selected case-study EU countries (Romania, Poland, Italy, UK, Spain, Austria, and Sweden).

Figure 2 - Smart City and Resilient City – research scheme

HIGH RESILIENCE sound economic, social and infrastructural tissues of a city	Hypothesis on existing “quiet and good place to be” strategies	Scrutiny over “half-way” cities’ strategies and actions	Hypothesis on existing strategies utilizing investments in smart-ness to achieve or sustain resilience
MEDIUM RESI-LIENCE well established city infrastructures, certain vulnerability to social and economic shocks	–	Scrutiny over “half-way” cities’ strategies and actions	Scrutiny over “half-way” cities’ strategies and actions
NO RESILIENCE vulnerability to social and economic shocks, basic and non-efficient infrastructures	–	–	Hypothesis on possible overinvestment and/or lack of integrity in approaching smartness
	BUSINESS AS USUAL public services or e-services delivered according to known standards and schemes, reacting local govern-ment, almost no integration and use of collective data	**MEDIUM SMART-NESS** certain level of e-services or intelligent solutions available for city users, responsive local government, partial integration and use of collective data	**HIGH SMARTNESS** plethora of public services delivered using the smart infra-structures and real-time interactions with city users, extend integra-tion and use of collec-tive data

Source: adapted from Baron (2012).

To better consider the multifaceted nature of the smartness specialisation the analysis will use a novel index of smartness addressing the weighting issue taking into account both the overall performance and its variability depending on the weight (i.e. relative importance) assigned to each dimension of smartness.

2. Resilience and smartness of EU cities: a case-study approach.

In order to explore the link between smart specialisation and resilience both concepts need to be operationalised. Let us consider the concept of resilience first. As mentioned, the concept of 'resilience' is a multidisciplinary one in its very nature. When applied to empirical analysis its multidisciplinary background results in a plurality of methodological approach to its measurement. In this study, we adopt a notion of resilience à la Martin (2012), that is, the ratio between the percentage change in employment in the city and the percentage change in the same measure in the country as a whole. It is worth stressing that according to this methodological choice, in the case of a negative shock, values higher than 1 correspond a negative reaction to shock which is higher than the national counterpart; vice versa, values lower than 1 signal a better capacity to absorb the shock at the city level. Similarly, when applied to expansionary periods, the measure denotes a more active behaviour at city level if values higher than 1 are registered and vice versa in case of values lower than 1.

As far as the concept of 'smart specialisation' is concerned, it is worth stressing, also in this case the multifaceted nature of the phenomenon and the consequent multidisciplinary interests attracted by recent development. In terms of measurement a very interesting project is represented by the 'European Smart City

Model'[3]. The 'model' creates an index and, in turn, a ranking of selected EU cities based on attributes related on 6 dimensions. Namely, economy, people, government, mobility, environment, and living conditions. While the selected dimensions are very well linked with the theoretical arguments about what a 'smart city' is, the index and the ranking share with similar initiatives the criticism about the way the different dimensions of 'smartness' are aggregated into a single index. Indeed, this is a crucial issue and the interested reader is addressed to Appendix A of this report for a deeper discussion and references about the criticism sounding the composite indices.

It is worth stressing here that, building upon SMAA (Stochastic Multiobjective Acceptability Analysis), this report addresses the issue of weighting by taking into account a plurality of individual preferences (indeed, reasonably all possible point of view by considering 1,000 different points of view). Then the different preferences, as reflected in the different weighting systems, are collapsed into a single index by mean of a novel 'sigma-mu' methodology proposed by Greco et al. (2017) (please see the appendix for technical details). This new methodology also allows one to disentangle the *overall* performance (when taking into account the different weights) from the *variability* due to the different weights. The rational being that cities that are not *well-balanced* (e.g. high-performing in all dimensions of smartness) will be 'penalised' (as denoted by the higher standard deviation, i.e. the sigma component).

[3] Available at http://www.smart-cities.eu/press-ressources.html. Retrieved on 10/09/2017

Although the two components sigma and mu, as mentioned, can be collapsed in a single composite index, to the end of this analysis they will be considered separately to better consider the effects of urban strategies focused on one particular dimension of smartness (*unbalanced*) as compared to those strategies addressing the different dimensions of smartness is a *balanced* way.

In order to adopt the 'sigma-mu' approach to the smartness of the selected 1,091 EU cities belonging to 7 case-study countries (Romania, Poland, Italy, UK, Spain, Austria, and Sweden) 17 dimensions have been considered. All the data are taken from the Urban Audit[4] dataset. The 17 indicators are perfectly consistent with those used in Collins at al. (2017)'s' Report on Urban policies for building smart cities' and share the same rationale. Hence, they aim to represent either direct or indirect (rather inverse) proxies of smartness attribute related to "investments in human and societal capital and traditional (transport) and modern (ICT) communication infrastructure" (Caraglui et al., 2011) as well as measures to "sustainable economic growth and a high quality of life" (Caraglui et al., 2011) along with "a wise management of natural resources" (Caraglui et al., 2011). In short: 'Infant Mortality per year' aims to measure quality of life of one of the most vulnerable category according to age. 'Number of deaths per year under 65 due to diseases of the circulatory or respiratory systems', measures quality of life aspect from a different angle. 'Population living in private households (excluding institutional households)' aims to address the ability of a given city to deal with the housing issue. The

[4] Available at http://ec.europa.eu/eurostat/web/cities. Retrieved on 01/08/2017.

'Number of children 0-4 in day care or school' along with the 'Students in higher education (ISCED level 5-8 from 2014 onwards)' aim to capture the educational side of the formation of human capital. The 'Number of cinema seats' jointly with 'Cinema attendance', 'Number of museum visitors', 'Number of theatres', and 'Number of public libraries' aim to complement the above information about human capital. The 'Economically active population' and the 'Total number of companies' aim to measure the overall level of economic activity. Furthermore, the set 'Share of journeys to work by car', 'Share of journeys to work by public transport', 'Share of journeys to work by bicycle', and 'Share of journeys to work by foot' aim to capture the mix of available infrastructure and its use to shape the overall city's mobility. Finally, the 'Number of days ozone O3 concentrations exceed 120 $\mu g/m^3$' measures the overall environmental quality.

Once both the measure of resilience and the measures of smartness (mu an sigma) are computed, building upon Eraydin (2015), a discriminant function analysis is used to explore and explain the differences between resilience behaviour based on the smartness indices and a set of additional indicators taking into account both two structural characteristics (population and resilience in terms of GDP) and the identification with the EU discourse, indicating which attributes contribute most to group separation.

The cities used to develop the smartness index originated from the Urban Audit, which collected a narrow set of indicators for cities and their commuting zones. However, there is no consistent annual economic data available in that dataset covering the chosen time period. Therefore, those cities needed to be matched to other relevant EU geographies. The method proposed on Eurostat has been followed: matching urban audit cities to NUTS 3 regions and then, where appropriate, matching these to metropolitan regions with more consistent data available. Metropolitan regions are approximations of functional urban areas (city and commuting zones) comprising of at least 250,000 residents that use one or more NUTS level 3 regions.5

This resulted in a collection of 524 cities represented variously at the metropolitan and NUTS 3 level. While all cities matched to NUTS 3 geography, only 316 then matched to a metropolitan region with the relevant data available. The dataset incorporates 107 unique metropolitan and 171 unique NUTS 3 regions.

The Eurostat database was used to collect economic data at the appropriate region or country level. The resilience measure uses employment data, specifically employment (thousand persons) in all NACE activities by metropolitan [met_10r_3emp] and NUTS 3 regions [nama_10r_3empers]. GDP data was collected at current market prices (million Euro) by metropolitan [met_10r_3gdp] and NUTS 3 regions [nama_10r_3gdp]. Average annual population figures (thousand persons) were retrieved by metropolitan [met_10r_3pgdp] and NUTS 3 regions [nama_10r_3popgdp].

[5] http://ec.europa.eu/eurostat/statistics-explained/index.php/Territorial_typologies_for_European_cities_and_metropolitan_regions

A measurement of citizen perceptions of the EU is approximated using data collected by the European Commission's standard Eurobarometer. The Eurobarometer is a long standing survey conducted by the European Commission consisting of face to face interviews with citizens in each EU member state[6]. The responses to three key questions are of interest, discussed in turn as follows: 'EU feeling', 'feeling European', and 'image of the EU'.

EU Feeling: Does the European Union give you personally the feeling of...? Country level data for this question are available for 2003 and 2005, this study uses the data available from the 2005 survey. Multiple answers are permitted and can include the following responses: 1.enthusiasm; 2.hope; 3.trust; 4.indifference; 5.anxiety; 6.mistrust; 7.rejecting it. A response of 'don't know' is also permitted. Responses 1-3 are considered as positive feelings towards the EU, 4 and 'don't know' as indifference, 5-7 as negative feelings. The three groups are assigned a value of 1, 0, or -1, based on the sum of the proportional categories (positive, neutral, negative). For example, the United Kingdom in 2005 is assigned a value of -1 as the sum of negative response are greater than the other categories: Positive 0.40; neutral 0.39; negative 0.49. Of the 77 countries in the survey, 63 are assigned a +1 value and 14 are assigned a -1 value.

[6] "The standard Eurobarometer was established in 1973. Each survey consists in approximately 1000 face-to-face interviews per Member State (except Germany: 1500, Luxembourg: 500, United Kingdom 1300 including 300 in Northern Ireland). Conducted between 2 and 5 times per year, with reports published twice yearly." Taken from http://ec.europa.eu/commfrontoffice/publicopinion/description_en.htm

Feeling European: Do you ever think of yourself as not only (nationality), but also European? Does this happen often, sometimes or never? The responses from the 2005 and 2006 are used. We assign a value based on the largest proportional category in each country (and time period). Such that, often is assigned 1, sometimes or don't know is 0, and never is assigned -1. For example, Austria in 2005 is assigned a value of -1 as 'never' is the largest proportion response (65%).

Image of the EU: In general, does the European Union conjure up for you a very positive, fairly positive, neutral, fairly negative or very negative image? Annual data are available for the responses to this question from 2005 to 2015. We make use of the Autumn / Winter data for consistency (usually November). Values are assigned based on the largest proportional category in each country and time period, such that: Very positive (2), Fairly positive (1), Neutral or Don't know (0), Fairly negative (-1), Very negative (-2). For example, the United Kingdom in 2015 is assigned a value of 0 as the largest response was Neutral (35%).

To illustrate the variables constructed to represent perceptions of the EU using the Eurobarometer survey data, a summary of the seven case study countries and assigned values for the corresponding survey questions from 2005 is shown in Table 1.

Table 1: Illustration of EU perception variables using Eurobarometer data.

Country	Year	Image of the EU	Feel European	EU Feeling
Austria	2005	0	-1	-1
Italy	2005	1	1	1
Poland	2005	1	1	1
Romania	2005	1	1	1
Spain	2005	1	1	1
Sweden	2005	1	-1	-1
United Kingdom	2005	0	-1	-1

A summary of results is reported below. Table 2 reports the resubstitution classification summary based on the aforementioned indicators.

Table 2 – Resubstitution classification summary (2004-2016).

True resilience index	**Classified** 0	1	**Total**
0	1,661	444	2,105
%	78.91	21.09	100
1	1,469	805	2,274
%	64.60	35.40	100

Source: authors' analysis.

Table 2 shows that the discriminant analysis[7] based on the above characteristics is able to correctly classify about 80% of cases of engineering resilience (lower responsiveness) over more than a decade (from 2004 to 2016). As for the high responsiveness, the model has a lower predictive capacity (about 35%). Hence, the set of indicators based on 'smartness' and 'identification with the EU' discourse plays a crucial role in determining the reaction to the business cycle at city level as compared to the national counterpart at least in determining a higher absorption of shocks.

[7] Similar results have been obtained adopting a logistic regression approach (on this issue see Pohar et al. (2004)).

To further address the discriminant power of each of the selected indicators Table 3 below reports the standardised canonical discriminant function coefficients.

Table 3 – Standardised canonical discriminant function coefficients (2004-2016)

Variables	Coefficients
Image of EU	-0.0405208
Feeling European	-0.0715393
EU feeling	0.0837957
Mu	-0.1441494
Sigma	0.1058805
Resilience (GDP)	-0.4187889
Population	-0.877655

Source: authors' analysis.

It is worth stressing here how both dimensions of smartness have a similar discriminant power in absolute terms (0.14 for mu and 0.10 for sigma). In terms of sign, it seems that a better overall performance (mu) increases the so-called engineering resilience making the city less vulnerable to the short-term effects of a given shock and allowing for a more stable growth path. By contrast, the variability (sigma) mitigate the above effect in terms of stability making the city, to some extent, more reactive to the economic stimulus.

Furthermore, the measures related to the citizens' EU perception seem to play a modest discriminant role. The related coefficients in absolute terms are, indeed, lower than those related to 'smart specialisation'. 'Feeling European' and 'EU feeling' share a discriminant power of about 0.08. Nonetheless, the former seems to make the city less reactive to shocks, the latter seems to decrease the engineering resilience. The 'image of the EU' with a coefficient of only -0.04 seems to play an even minor role.

As mentioned, the above analysis refers to a time sample of more than a decade. However, the resilience behaviour might well be shock-specific. In order to explore the resilience behaviour in occasion of the recent 2007 shock the above discriminant analysis is replicated using data related to 2007 only. Table 4 below reports the resubstitution classification summary with respect to the analysis focussing on the 2007 shock.

Table 4 – Resubstitution classification summary (2007 shock only).

True resilience index	**Classified**		**Total**
	0	1	
0	167	55	222
%	75.23	24.77	100
1	89	130	219
%	40.64	59.36	100
Total			

Source: authors' analysis.

Table 4 shows that the same set of indicators used for the whole time sample maintain a substantial discriminatory power when used with regard to the 2007 shock only. With a higher classification power with respect to those cities with higher short-term impact. Indeed, the model register an increased capacity to correctly classify those cities with a resilience index higher than 1, i.e. less able to absorb the shock impact as compared to the national datum. Indeed, the percentage of cases correctly classified increases from 35.40 to 59.36. The ability to correctly classify those cities suffering a higher cost from the shock in terms of employment with respect to the national datum is slightly decreased. The related datum decreased from 79.81 to 75.23%.

Alike Table 3, Table 5 reports the standardised canonical discriminant function coefficients to the case at hand.

Table 5 – Standardised canonical discriminant function coefficients (2007 shock only)

Variables	Coefficients
Image of EU	0.0741074
Feeling European	-0.2120965
Eu felling	0.2354607
Mu	0.2118395
Sigma	-0.1884258
Resilience (GDP)	0.6027344
Population	0.6258762

Source: authors' analysis.

In this particular case, the role of the smart specialisation shows an inverted pattern. The overall performance seems to have increased the engineering resilience, while its variability or *unbalance* made the cities more vulnerable to the shock. The 'Feeling European' confirms it contribution towards a more stable path. Similarly, 'EU feeling' confirms a positive contribution towards higher response to the shock. Furthermore, more populated cities seems to have been affected in a more severe way by this peculiar shock as compared to their reaction during the whole time sample (0.62 and -0.88, respectively). Similarly, the resilience as measured in terms of GDP changed its discriminatory power in occasion of the 2007 shock. Indeed, a higher response in terms of GDP contributed to a higher responsiveness in 2007, while during the whole sample the contribution was negative (-0.419). It is worth stressing that this case-specific relationship between resilience measures computed in terms of employment and GDP is consistent with Cellini et al. (2017).

3. Summary and Concluding Remarks

This report analysed the relationship between smartness and resilience of a city, moreover, the relationship between the degree of creation and use of knowledge (including the knowledge and identification with the EU discourse) and economic resilience and hysteresis within the urban context.

A discriminant function analysis was used to explore the differences between a city's resilience behaviour based on: Smartness; structural characteristics (population and resilience in terms of GDP); and the identification with the EU discourse ('positive image of the EU', 'feeling European', and 'EU feeling'). This method indicated which attributes contribute most to city level resilience.

Results showed that the smartness and identification with the EU discourse both play a crucial role in determining the reaction to the business cycle at city level, compared to the national counterpart. This, however, is not straightforward. Indeed, as testified by the focus on 2007 economic shock, the role played by each of the variable seems to shock-specific. For example, using the whole sample and focussing on the 2007 shock, the role of the smart specialisation demonstrated an inverted pattern with the overall performance contributing towards engineering resilience and the *unbalance* between the different dimensions of smartness making cities more vulnerable to the shock.

Nonetheless, this provides evidence for a potential link between smartness specialisation and resilience along with a positive contribution of the identification with the EU towards the absorption of economic shocks. This is in line with existing studies surrounding economic resilience, such as, Capello et al. (2015) and Brakman et al. (2015). The analysis also contributes to the debate about critical points of smart specialisation (e.g. Capello et al., 2016) and especially the unbalanced smart specialisation.

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5. Appendix

A smartness index for European cities

The first step in the construction of a composite index is the creation of the theoretical framework, which, in turn, leads to the choice of the proper indicators and the approaches that are to be followed in the next steps (e.g. weighting, aggregation etc.). An issue that is often encountered during the construction stage is the presence of missing values. There is a long list of available techniques that appear in the literature to overcome this issue (for a brief overview of which, see OECD, 2008, pp.24-25). In this project, we take advantage of the Stochastic Multiattribute Acceptability Analysis[8] (SMAA; Lahdelma et al., 1998; Lahdelma and Salminen, 2001) to deal with this issue, by randomly drawing values to replace the missing ones for a city in a certain indicator. Values are obtained from a normal distribution, with μ and σ computed from the indicators, for which we need an imputed value for. Therefore, in each of the 1,000 iterations, if a city has a missing value in one or more indicators, these are randomly filled as mentioned above.

A second issue in the creation of composite indices is the choice of weights for the indicators. While there is a variety of methods available (OECD, 2008), not a single one of them lacks criticism (Decanq and Lugo, 2013). The plethora of indices in existence use equal weights (Bandura, 2011), mainly due to simplicity, or lack of more information/theoretical framework (Freudenberg, 2003). A significant benefit of SMAA is that it permits to take advantage of the whole space of weight vectors (e.g. see Greco et al., 2017). Applied in a Monte Carlo simulation environment, weights are drawn from a uniform distribution (in the absence of specific information about the preferences of the decision-maker) in each of the iterations, so that the alternatives are compared in all the possible preferences, instead of a single weight vector that supposedly acts as a representative vector of the whole population (OECD, 2008). In the past, SMAA has been used in the field of composite indices to obtain a ranking for evaluated units, usually the mode ranking of the iterations (as denoted by the Ranking Acceptability Index, see e.g. Greco et al., 2017). However, if the ranking of entities is not the ultimate goal, the ordinal value obtained from SMAA, exhibiting the ranking of a unit, discards the absolute level of information found in the indices (Saisana and Tarantola, 2002). Recently, Greco, Ishizaka, Tasiou and Torrisi (2017) suggested the use of SMAA to obtain a

[8] For an application of SMAA in the field of composite indicators, the reader is referred to Greco, Ishizaka, Matarazzo and Torrisi (2017).

single value that serves as a composite index encompassing all prior information (e.g. plethora of weights and the richness in information that is lost with the ordinal scale of the rankings). In their proposed method, called σ-μ (sigma-mu), after the use of SMAA and for each unit evaluated, instead of producing a single ranking (usually mode ranking), they suggest taking into account the whole distribution of the evaluations (i.e. in the *m* iterations) by computing the arithmetic average (μ) and the standard deviation (σ) for each unit *i* for the *m* evaluations. The first measure shows the average score in the evaluations, and the latter illustrates the dispersion of each unit's scores by changing the weights. The highest the dispersion, the less "robust" a unit is to deviations in the preferences of the decision-maker. Inspired by the well-known Portfolio Theory of Markowitz, the authors suggest plotting these output measures into a plane ('σ-μ plane', named after their method), on which there exist certain Pareto-Koopmans frontiers that alternatives lie on, having the highest average score for a given level of standard deviation. Alternatives lying on the frontier are efficient, while the longer its distance from it, the less efficient a unit is. This is a classic example of a Data Envelopment Analysis (DEA; Charnes et al., 1978; Cooper et al., 2011) use in the field of composite indicators, with small modifications to fit this exact case. More specifically, to find these distances, of each unit from the frontier, the problem below is solved (once for every unit *i*, termed as *i0*):

$$\begin{aligned}
&\min_{\alpha,\beta} \delta \\
&s.t \\
&\alpha\mu_{io} - \beta\sigma_{io} + \delta \geq \alpha\mu_i - \beta\sigma_i \quad ,\forall i \qquad (1) \\
&\alpha, \beta > 0 \\
&\alpha + \beta = 1
\end{aligned}$$

In other words, the problem is given by finding the min δ (α, β varying), for which a unit has a higher average score and/or a lower score dispersion. To keep in line with the DEA literature (e.g. a value of '1' denoting efficiency), the efficiency score for each unit *i* (in the above solution fulfilling δ=0) is given as follows:

$$efficiency_i = 1 - \delta_i \qquad (2)$$

While there are many techniques to increase the discriminatory power in DEA like (for a comprehensive review see, among others, Adler and Yazhemsky, 2010; Nissi and Sarra, 2016) the authors, inspired by the concept of super-efficiency in DEA, propose to find all the subsequent frontiers (by removing the previous frontiers each time they re-compute equation 1). Then, each unit's distance is found for all frontiers existing, and, inspired by the concept of cross-efficiency in DEA, the authors propose to aggregate all these distances (one for each existing frontier 1…n) obtaining the final, σ-μ efficiency score as follows:

$$sm_i = 1 - \sum_{j=1}^{n} \delta_{ij} \qquad (3)$$

It is important to note here that this approach is strongly aligned with the penalisation approaches in the literature of composite indices (e.g. see Mazziotta and Pareto, 2016; Tarabusi and Guarini, 2013; Acs, Autio and Szerb, 2014). In other words, it highly favours units that are not only well-performers on average, but consistently high performers despite the differences in preferences (denoted with weight vectors). This means that if a unit is not well-balanced (e.g. high-performing in all indicators), it will be 'penalised' (as denoted by the higher standard deviation). However, in this project, we have chosen to take advantage of the SMAA to fill certain missing values, meaning that cities having many missing values will certainly come across higher standard deviation and thus higher penalisation. To alleviate this issue, we first find which portion of the σ in the evaluations is attributed to the weights (hence σ_{weights}) and which proportion is attributed to the missing values (hence σ_{missing}). To compute these, we first apply the 1,000 weight vectors (computing composite indices) to each and one of the 1,000 constructed datasets (one for each iteration, each containing a different draw for the missing values). For each data vector, we compute the arithmetic average and the standard deviation, thus having 1,000 arithmetic averages (μ) and 1,000 standard deviations (σ). These are then consolidated into one of each (μ, σ) by taking the quadratic mean. On the other hand, we apply the 1,000 data vectors (computing composite indices) to each and one of the 1,000 weight vectors (one for each iteration), again computing 1,000 μ and σ, consolidating them afterwards by computing the quadratic mean. The two averages $\mu_{\text{weights}}, \mu_{\text{missing}}$ are identical, while the standard deviations σ_{weights}, σ_{missing}, are different and they show the different effect arising from each source of input (missing values / weights). The quadratic mean of them is computed to serve as the final σ to be used in the σ-μ approach.

Furthermore, to the end of this analysis we keep disentangled the information about mu (overall performance) and sigma (variation), in order to test the effects on the resilience behaviour separately.

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