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**Strengthening scientific and research capacity of the Institute of Economics, Zagreb
as a cornerstone for Croatian socioeconomic growth through the implementation of
Smart Specialisation Strategy**

Summary of key findings

Evaluating Smart City Indicators: A tool for Strategic Decision-making for Croatian Large Cities

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Introduction

The importance of cities, among other things, is in the fact that it is a global phenomenon of urbanization, which is likely to continue in the next decades. The degree of urbanization is not the same everywhere in the world. The largest is in Europe and 72 percent of European Union's (EU) inhabitants live in urban areas. In 2005, almost half of the world's population (49.1 percent) lived in cities (EC and UN-HABITAT, 2016). Based on UN-HABITAT (2016) research, we are expecting that 58.2 percent of the world and 75.8 percent of European population will live in urban areas. According to current projections, by 2050 two-thirds of the world population will live in cities.

The high concentration of population in a relatively small space creates a large number of challenges for the development of cities³. Cities, as high density places, are faced with constant need to increase energy consumption, transportation, buildings, public spaces, etc. (OECD, 2015). That is a reason that requires “smart” solutions, which means efficient and sustainable solutions, as well as solutions that ensure economic prosperity and social wellbeing for cities' citizens. The most efficient way to achieve that is by mobilising city's resources and actors using new technologies and policies. In the literature this concept is known as Smart City (Giffinger et al., 2007; Giffinger and Gudrun, 2010; Giffinger, 2015; LazaroIU and Roscia, 2012).

Smart City concept contains several dimensions of a city that relates to *smart economy* (innovation, entrepreneurship, trademarks, productivity and flexibility of the labour market

³ City citizens' income increase measured by real per capita income in the city is a basic definition of city economic development.

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and integration in the national and international market), *smart people* (the level of education of citizens, the quality of social interactions regarding integration and public life and openness towards the world), *smart governance* (political participation, services for citizens and functioning of city's administration), *smart mobility* (local and international accessibility, the availability of information and communication technologies, modern and sustainable transport systems), *smart environment* (natural conditions such as climate, green space etc., pollution, resource management and efforts towards environmental protection), and *smart living* (quality of life in different areas such as culture, health, safety, housing, tourism etc.) (Giffinger et al., 2007, Giffinger and Gudrun, 2010).

Smart City concept has been recognized in European strategic documents and it is also a part of Europe 2020 Strategy for smart, sustainable and inclusive growth⁴ and Smart Specialisation Strategies (OECD, 2013). The Smart Specialisation approach combines industrial, educational and innovation policies to help cities in recognizing priority areas for knowledge-based investments. Smart Specialisation Strategies are promoted by the EU Cohesion Policy⁵. There is a strong link between Smart Specialisation and cities. Majority of educational and research institutions are located in cities, as well as research and development (R&D) activities (European Parliament, 2014). The role of Smart Cities is recognized by the EU's Smart Cities and Communities Innovation Partnership⁶. It links cities, industry and citizens to improve urban life through using innovation potential and more sustainable integrated solutions in the crucial areas of energy, transport and mobility. The Urban Agenda for the EU⁷ also promotes cooperation between Member States, the European Commission and cities in order to stimulate growth, liveability and innovation in EU cities.

⁴ https://ec.europa.eu/info/strategy/european-semester/framework/europe-2020-strategy_en.

⁵ <http://s3platform.jrc.ec.europa.eu/home>.

⁶ <http://ec.europa.eu/eip/smartcities/>.

⁷ <http://urbanagendaforthe.eu/>.

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Everywhere in the world, cities have been identified as carriers of development activities in the country. In addition to the definition and different measurement of urban smartness (Albino, Berardi and Dangelico, 2015; Baron, 2012), scientific literature gives some attention to the analysis of the role of cities in Smart Specialization (Giffinger et al., 2007; Deakin, 2012; Dvir and Pasher, 2004; Komminos, 2002; Kuk and Janssen, 2011) and their potentials in promoting development (Lee, Phaal and Lee, 2013; Winters, 2011; Yigitcanler, Velibeyoglu and Martinez-Fernandez, 2008; Johnson, 2008). Most available are research results on the role of the largest cities, world metropolises and capitals. One of the examples is research on making city data accessible and understandable to citizens to give them information on new public services and solutions to urban problems. For example, London, Hamburg and Rome are involved in the creation of a web platform that enables interested citizens to support the decision making process.

Our Approach and Contribution

Unfortunately, in literature there is no evidence on implementation of the Smart City concept in the new EU member countries. Therefore, the focus of this report is to implement the Smart City methodology and develop Smart City indicators for Croatian large cities with the aim of using indicators in strategic decision-making. Although Smart City is a component of the Croatian Smart Specialisation Strategy (Ministry of Economy, 2015), which is now strongly supported by the Ministry of Economy, Entrepreneurship and Crafts of the Republic of Croatia, research studies show that key decisions in Croatian larger cities have mostly been made without much strategic consideration, being primarily reduced to setting *ad hoc* goals, activities and measures for their achievement. To overcome the lack of strategic orientation, we identify the most important indicators for measuring competitiveness of the

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economy of Croatian large cities following Giffinger's et al. (2007) methodology. We use web scraping techniques to collect publicly available data to measure indicators that represent the degree of economic development of Croatian large cities through several dimensions: innovation, entrepreneurship, economic image and trademarks, productivity, flexibility of labour market and international integration. We use fifteen indicators to compare twenty five Croatian large cities and to assess their comparative advantage in a wider international context. Special attention will be given to comparison of different Croatian cities in the field of local innovation capacity. In addition, we would like to observe other components that contribute to local development, such as educational capacity, urban management and governance, social development, and environmental management in particular city.

The purpose of this report is to examine the implementation of Smart City methodology and development of Smart City indicators for twenty five Croatian large cities with special focus on local innovation capacity grouped in the six dimensions (for more detail please see Table 2). This means that in this report we are going to construct good indicators that describe local smart capacity of twenty five Croatian large cities and to interpretate their role in Smart Specialisation of the whole country. In addition, the results of this research, as a type of evaluation of local policies, should bring some recommendations and serve policy decision-makers in proposing adequate decisions in the adoption of appropriate measures to promote smart, locally led development.

Methodology and Data

Various international institutions have been involved in the development of various urban indicators. However, there is poor representation of cities from the new EU member states in development of these indicators. One of the exceptions is the UN-HABITAT Report on

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European Cities in Transition (UN-HABITAT, 2013) that includes several Southeastern European countries, including Croatia. European Commission city statistics and the Urban Audit database provide information and comparable measurements on different aspects of quality of urban life in European cities. However, the Urban Audit database provides data only for few cities from the new EU member states. Only five Croatian cities are included in the Urban Audit database⁸. Unfortunately, data for these five cities are deficient. There are also urban sustainability indicators for selected European cities⁹. These indicators are focused on urban patterns, current urban designs, infrastructures, policies, waste disposal systems, pollution and access to services by citizens. However, urban sustainability indicators database does not contain indicators for Croatian large cities.

The focus of this report is to study twenty five Croatian large cities which are crucial conductors of socio-economic development activities in the country. The most recent amendments to Croatian legislation¹⁰ resulted in a new definition of large cities. Large cities are urban settlements with more than 35,000 inhabitants, or county centres. There are twenty five Croatian cities that have the status of a large city; 17 cities have more than 35,000 inhabitants, including the City of Zagreb as capital city; and 8 cities are county centres with less than 35,000 inhabitants (see Table 1). There are in total 127 cities in Croatia.

⁸ Thy City of Zagreb, Split, Rijeka, Osijek and Slavonski Brod.

⁹ http://ec.europa.eu/environment/integration/research/newsalert/pdf/indicators_for_sustainable_cities_IR12_en.pdf.

¹⁰ Law on Local and Regional Self-Government (Official Gazette No. 33/01, 60/01, 129/05, 109/07, 125/08, 36/09, 36/09, 150/11, 144/12, 19/13, 137/15).

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Table 1: List of Croatian large cities

<i>Large cities, more than 35,000 inhabitants</i>		<i>Number of inhabitants</i>
1.	Zagreb	790,017
2.	Split	178,102
3.	Rijeka	128,624
4.	Osijek	108,048
5.	Zadar	75,062
6.	Velika Gorica	63,517
7.	Slavonski Brod	59,141
8.	Pula	57,460
9.	Karlovac	55,705
10.	Sisak	47,768
11.	Varaždin	46,946
12.	Šibenik	46,332
13.	Dubrovnik	42,615
14.	Bjelovar	40,276
15.	Kaštela	38,667
16.	Samobor	37,633
17.	Vinkovci	35,312
<i>Large cities, county centres</i>		<i>Number of inhabitants</i>
18.	Koprivnica	30,854
19.	Vukovar	27,683
20.	Čakovec	27,104
21.	Požega	26,248
22.	Virovitica	21,291
23.	Gospić	12,745
24.	Krapina	12,480
25.	Pazin	8,638

Source: Croatian Bureau of Statistics, Croatia - Census 2011.

The methodology consists of the following activities:

- collection of available data to measure indicators through one of six components of the Smart City model - Smart Economy;
- preparation activities for collecting data for other five components of the Smart City model - Smart People, Smart Governance, Smart Mobility, Smart Environment and Smart Living;
- preparation of questionnaires to collect additional information to measure Smart City indicators;
- development of about eighty indicators to compare twenty five Croatian large cities through six components of Smart City development;
- estimation of city development index using principal component analysis;

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- ranking of twenty five Croatian large cities by city development index, which will assure city majors and councillors to use available information and Smart City indicators in the preparation and implementation of strategic decisions.

The research studies show that key decisions in Croatian larger cities have mostly been made without much strategic consideration, being primarily reduced to setting *ad hoc* goals, activities and measures for their achievement (Perko Šeparović, 2006; Petak, 2009; Đulabić and Manojlović, 2011; Maleković, Puljiz and Polić, 2007; Jurlina Alibegović and Blažević, 2010; Jurlina Alibegović and Slijepčević, 2010). To overcome the lack of strategic orientation, we identify the most important indicators for measuring competitiveness of the economy of Croatian large cities following Giffinger's et al. (2007) methodology, which provides first step for cities' strategic analysis.

Our first task is to collect a set of data for these cities from national and local sources. We have started with data collection for database formation. Establishing comparable dataset by cities through creation of Smart City indicators will give sources to analyse the role of Croatian large cities in Smart Specialisation, analyse and describe the impact of local government's policies on local development in these cities, as well as for the comparison among Croatian large cities. These data will help us in constructing good indicators that describe local innovation capacity of Croatian large cities. These indicators, together with other set of Smart City indicators, will be used to emphasize the role of Croatian large cities in Smart Specialisation of the whole country and its potential on local development.

We have started to collect publicly available data to measure indicators that represent the degree of economic development of Croatian large cities through several dimensions: innovation, entrepreneurship, economic image and trademarks, productivity, flexibility of

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labour market and international integration. We use fifteen indicators to compare twenty five Croatian large cities and to assess their comparative advantage in a wider international context. The data are derived from publicly and freely available data sources to create all indicators that jointly describe the factors of a smart economy of Croatian cities. Some datasets, like labor markets indicators, are obtained from statistical institutions and other public institutions. But we have also used web scraping techniques to obtain data that are not available from statistic institutions in clean, structural form. We obtained this data from online public registers of public institutions that find it difficult to provide data in a harmonized and structural form. This allows us to use some indicators that have not been used in previous research, like number of patents in the city or number of trademarks of firms that have headquarters in the city. There are many papers that identified important indicators to measure smartness of the city, but significantly less papers measure same indicators on a regular (yearly) basis for all cities in the country. For EU, researches usually use datasets that are available in Eurostat database, but other, using data from other national registers, can generate new insights in measuring smartness of the city.

An additional advantage of our dataset is frequency of data. Other researches that measure smart city indicators use only few data points. Our dataset includes yearly data from 2010 to 2016, which allows us to analyze cities' economic performance through time. Authorities request data at least once a year when they have to make a budget for the next fiscal year, so our indicators help authorities to reach information on time. Next, our datasets do not have missing data problems like some other datasets (Giffinger et al., 2007; Auci, Mundula, 2012).

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In total fifteen indicators were selected for evaluation of smart economy in twenty five Croatian cities. Indicators measure one of six dimension/factors of smart economy. List of indicators and their descriptions are given in table 2.

Table 2: Factors and Indicators defining Smart Economy in Croatian large cities

Factor	Indicator / Smart City project	Indicator / Croatian large cities	Sources
Innovative spirit	R&D expenditure in % of GDP	The share of value of R&D and patents in the total value of the assets of all companies with headquarter in the city. (R&D intensity)	Financial Agency (FINA), http://rgfi.fina.hr/JavnaObjava-web/jsp/prijavaKorisnika.jsp
		The share of book value of plant and equipment in the total book value of the assets of all companies with headquarter in the city. (P&E intensity)	Financial Agency (FINA), http://rgfi.fina.hr/JavnaObjava-web/jsp/prijavaKorisnika.jsp
	Employment rate in knowledge-intensive sectors	The shares of employees in knowledge-intensive industries in the total number of employees in all companies with headquarter in the city. (Employees in knowledge-intensive industries)	Financial Agency (FINA), http://rgfi.fina.hr/JavnaObjava-web/jsp/prijavaKorisnika.jsp
	Patent applications per inhabitant	The number of registered patents, whose inventors stated in the patent application the place of residence in the city. (Number of patent applications)	The State Intellectual Property Office of the Republic of Croatia, http://www.dziv.hr/hr/e-usluge/pretrazivanje-baza-podataka/patent/
Entrepreneurship	Self-employment rate	The share of self-employed in the total number of employees in the city. (Self-employed intensity)	Croatian Pension Insurance Institute, http://www.mirovinsko.hr/
	New businesses registered	The share of newly registered enterprises in the total number of companies in the city. (Newly registered enterprises intensity)	Ministry of Justice, Court Register, https://sudreg.pravosudje.hr/registar/f?p=150:1
Economic image & trademarks	Importance as decision-making centre (HQ etc.)	The numbers of recognized international trademarks for companies with headquarter in the city. (Recognized international trademarks intensity)	The State Intellectual Property Office of the Republic of Croatia, http://www.dziv.hr/hr/e-usluge/pretrazivanje-baza-podataka/medjunarodni-zig/
Productivity	GDP per employed person	The ratio between value added and the number of employees in all companies with headquarter in the city. (Labour productivity)	Financial Agency (FINA), http://rgfi.fina.hr/JavnaObjava-web/jsp/prijavaKorisnika.jsp

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		The share of paid employees who work part-time and the total number of employees in all companies with headquarter in the city. (Part-time employment intensity)	Financial Agency (FINA), http://rgfi.fina.hr/JavnaObjava-web/jsp/prijavaKorisnika.jsp
Flexibility of labour market	Unemployment rate	The share of unemployed persons in the city in the total population according to 2011 Census. (Unemployment rate)	Croatian Employment Service, http://statistika.hzz.hr/Statistika.aspx?tiplzvjestaja=1
		The ratio of the number of employed and the number of unemployed persons in the city. (Employment intensity)	Croatian Employment Service, http://statistika.hzz.hr/Statistika.aspx?tiplzvjestaja=1 , http://www.mirovinsko.hr/
International presence	Companies with HQ in the city quoted on national stock market	The numbers of companies with headquarter in the city quoted on national stock market. (The number of companies quoted on national stock market)	Zagreb Stock Exchange, http://www.zse.hr/default.aspx?id=26474
	Air transport of passengers	The shares of revenue from exports in the total revenues of all companies with headquarter the city. (Export intensity)	Financial Agency (FINA), http://rgfi.fina.hr/JavnaObjava-web/jsp/prijavaKorisnika.jsp
	Air transport of freight	The ratios of revenue of enterprises with a share of foreign capital greater than 49% of the total revenues of all companies with headquarter in the city. (Foreign capital intensity)	Financial Agency (FINA), http://rgfi.fina.hr/JavnaObjava-web/jsp/prijavaKorisnika.jsp
		The value of foreign direct investment is a multiplication of changes in the share of foreign capital and the value of capital at the level of companies with headquarter in the city. It is approximated by following equation: $fdi_t = (foreignCapital_t - foreignCapital_{t-1}) * book_equity_t.$ (FDI)	Financial Agency (FINA), http://rgfi.fina.hr/JavnaObjava-web/jsp/prijavaKorisnika.jsp

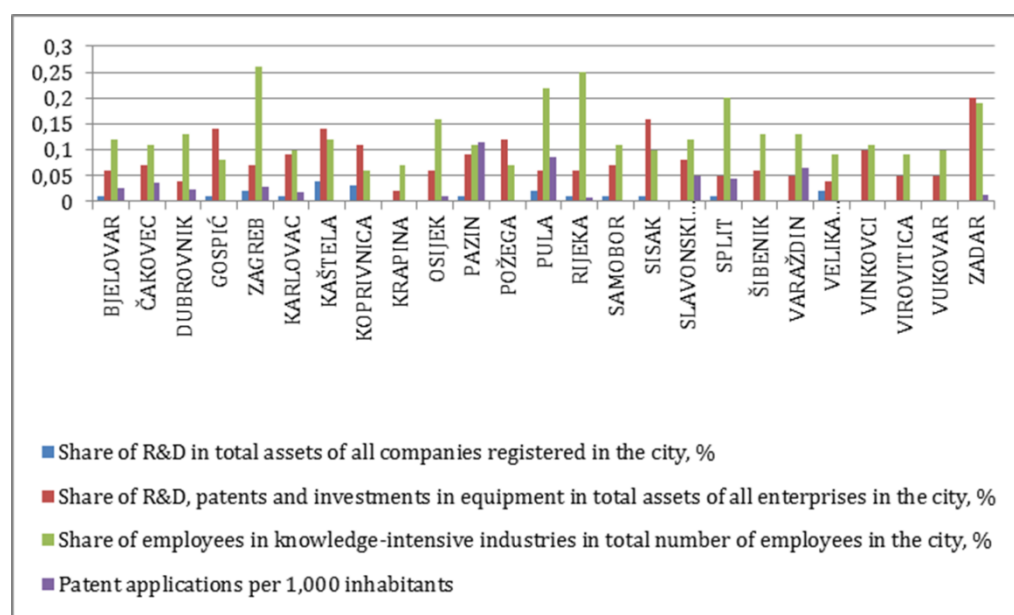
Source: Authors' systematization.

In the following eight figures, main findings of our research on implementation of Smart Economy, as the first component of the Smart City methodology, are presented. From these figures it can be clearly seen the heterogeneity of large cities in all Smart Economy indicators (innovative spirit, entrepreneurship, productivity, flexibility of labour market, international presence). Based on the presented Smart Economy indicators, Figure 7 contains a presentation of the competitiveness of twenty five large cities. We can conclude

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that only seven cities are above average in Smart Economy. The position of each city in that comparison gives the mayors and members of city councils clear information on the fact where they should direct their activities with the aim of improving the city's position in the competitiveness of the economy. Smart Economy indicators can be also use to compare two cities. Figure 8 shows a comparison of competitiveness of the economy of the two largest cities in Croatia, Zagreb and Split. The findings provide clear guidelines to city leaders in proposing measures, activities and concrete projects to strengthen competitiveness of the economy for each city.

Figure1: Croatian large cities, Innovative spirit



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Figure 2: Croatian large cities, Entrepreneurship

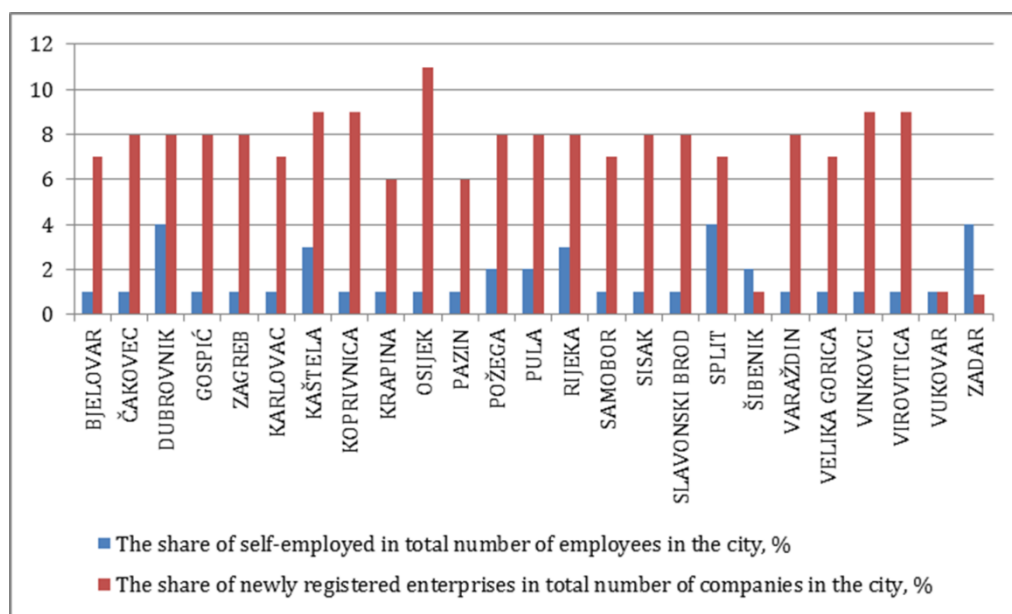
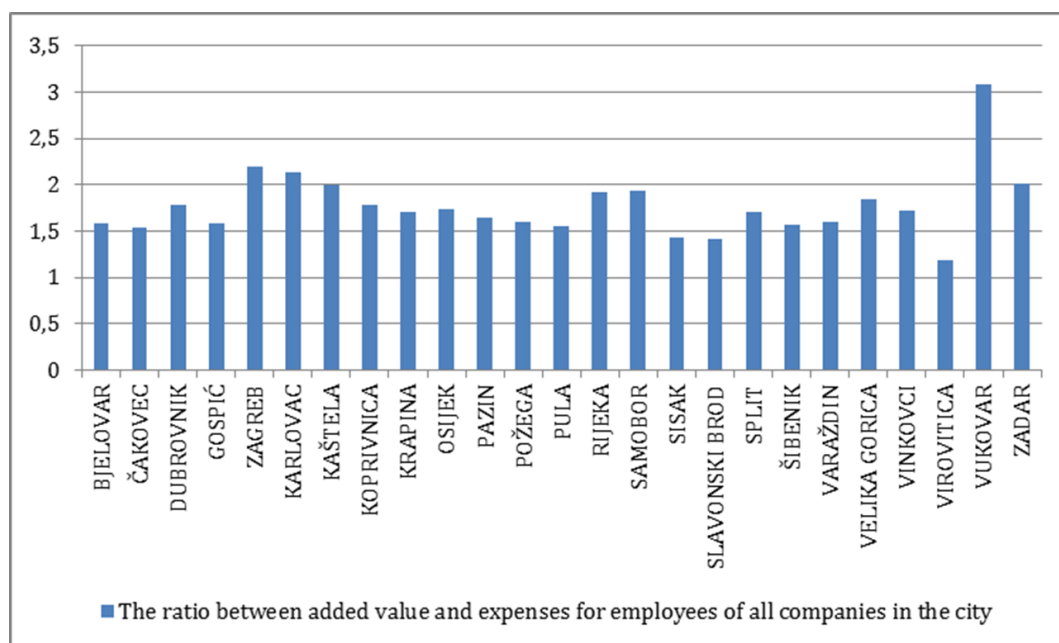


Figure 3: Croatian large cities, Productivity



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Figure 4: Croatian large cities, Flexibility of labour market

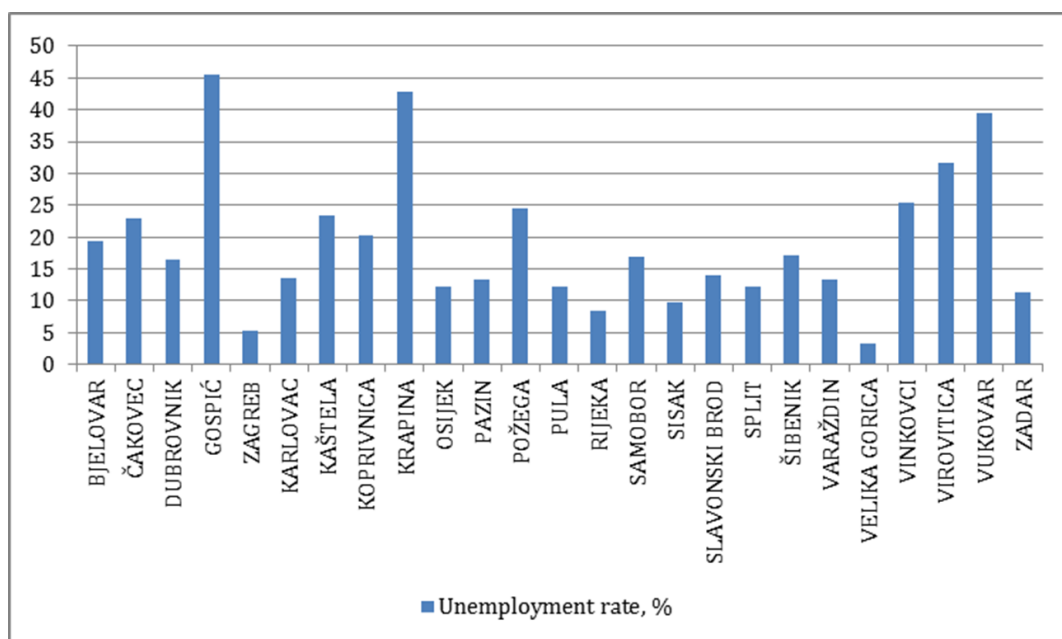
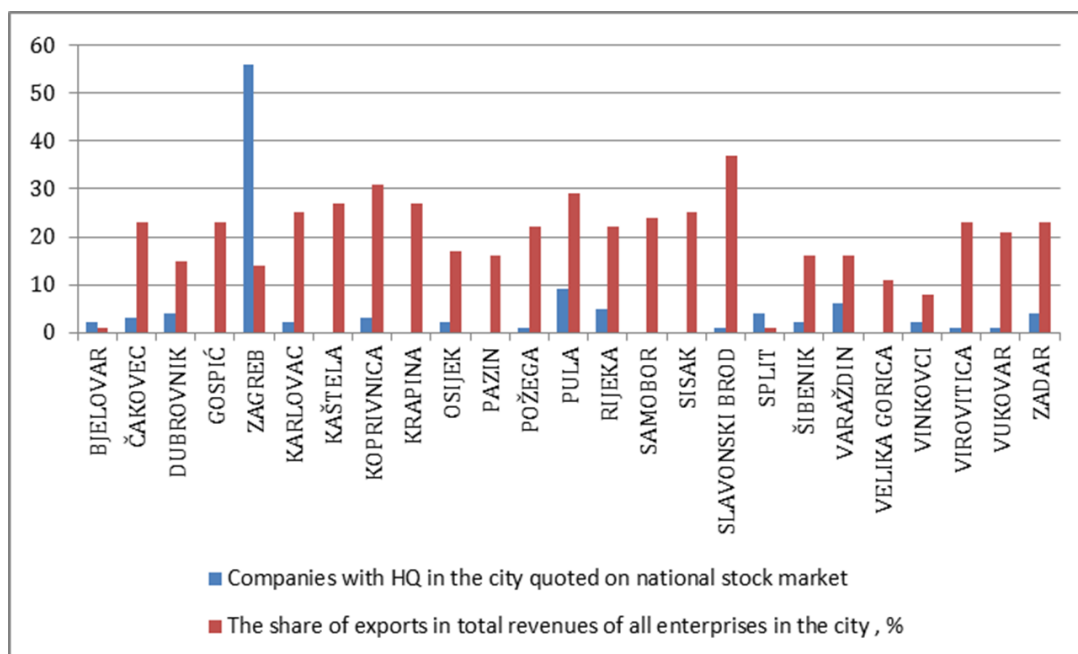


Figure 5: Croatian large cities, International presence



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Figure 6: Croatian large cities, Comparison: Smart Economy (Competitiveness)

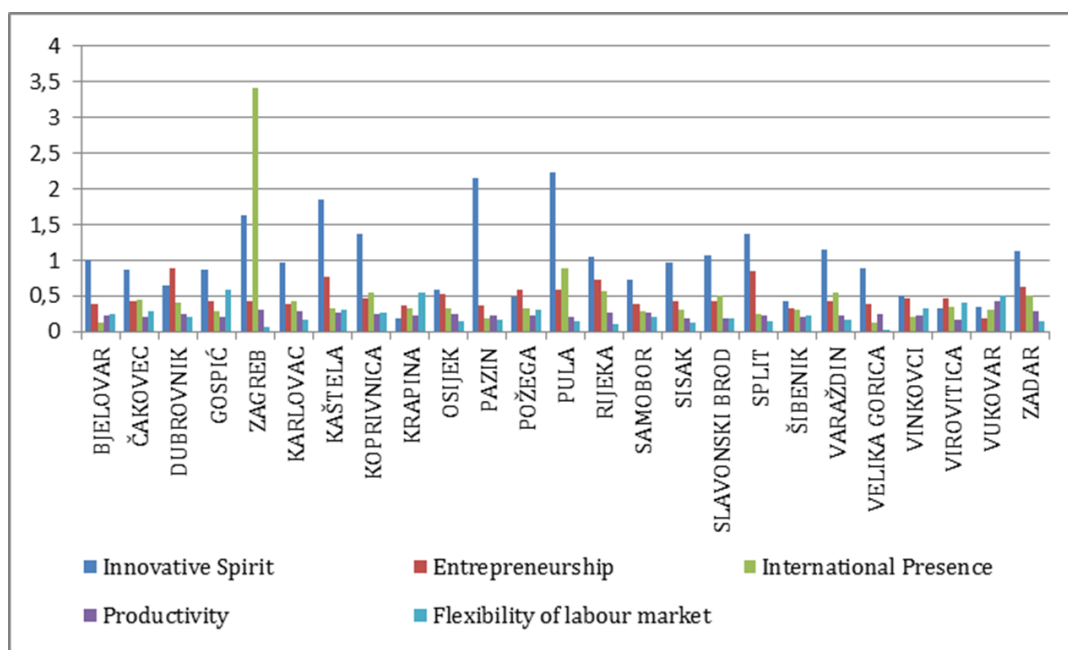
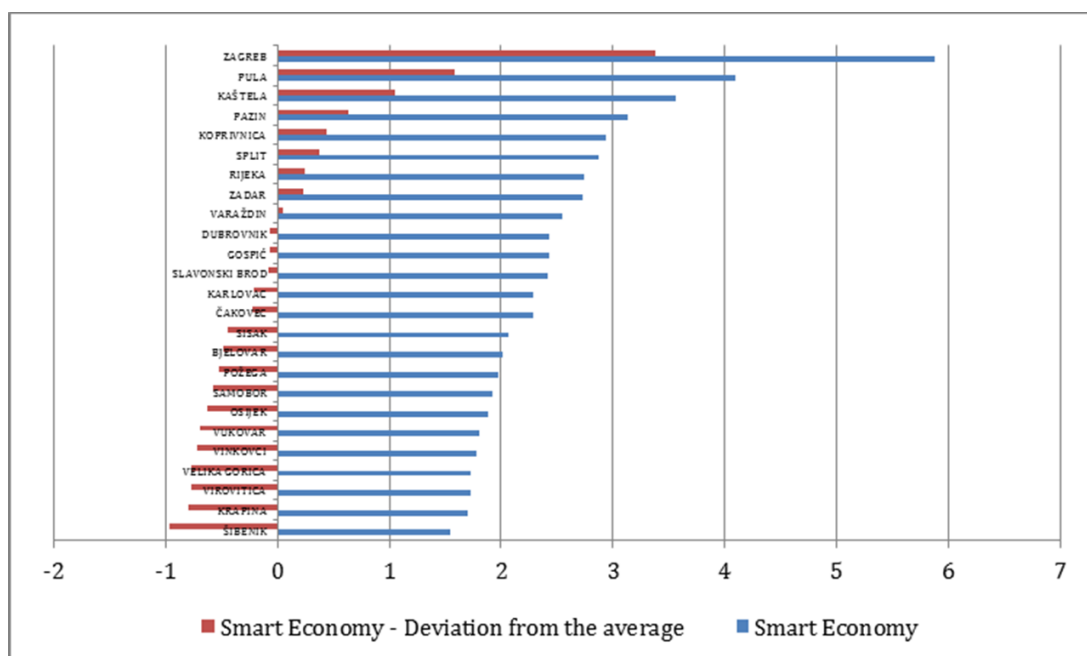
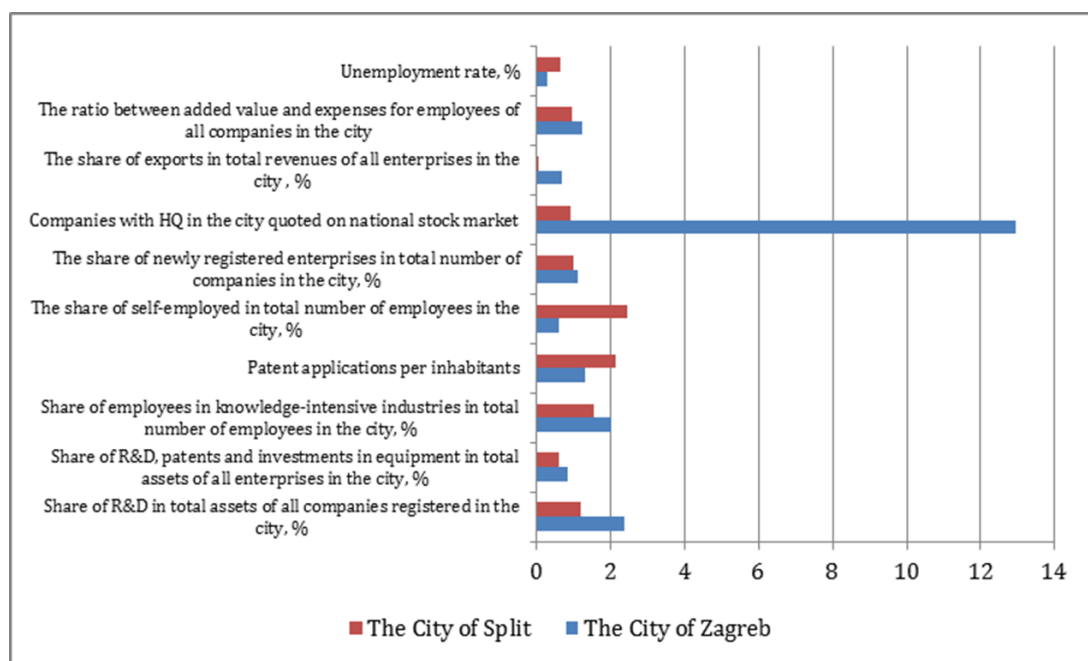


Figure 7: Croatian large cities, Comparison: Smart Economy (Competitiveness)



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Figure 8: Croatian large cities, Comparison: The City of Zagreb and the City of Split



Conclusions and recommendations

This research is based on the methodology developed under the European Smart Cities project. This research is based on data obtained from the Urban Audit database, the Croatian Bureau of Statistics, local data base of twenty five Croatian cities, interviews with experts in twenty five Croatian cities and on secondary data obtained from different research.

We have set two main contributions of this research. First, we use web scraping techniques to collect, clean and harmonize annual data that are not usually available from national statistical institutions. Second, our analysis and comparison of competitiveness of Croatian large cities is made available through a web application (in English and Croatian) that should encourage key decision-makers to use available information and apply it in preparation and implementation of their Smart City forward looking strategies. This research paves the way to future investigation through which we will measure other five dimensions of Smart City

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concepts - smart people, smart governance, smart mobility, smart environment and smart living - aiming to emphasize the use of Smart City components for evidence-based monitoring of economic and social development of Croatian large cities.

Expected outcomes of this report are obtained new methodology which will allow for the implementation of Smart City methodology and development of Smart City indicators for Croatian large cities, as well as to emphasize the role of several cities in Croatia in Smart Specialisation of the whole country. The possible outcomes of the research are recommendations to local political leaders for smart, locally led development in Croatia.

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