What makes a city “smart”: Evidence from Belgian municipalities

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Local governments and the “smart city”: Which socioeconomic factors make a territory ”smart”?

Miguel Manjón\textsuperscript{a} and Nathalie Crutzen\textsuperscript{a, b}

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Importance of smart city (SC) initiatives:

- 240 of the 486 EU cities with a population above 100,000 inhabitants (Manville et al. 2014).

- 700 cities from 150 countries represented at the 2018 Smart City Expo World Congress in Barcelona.

- In monetary terms, it is estimated “that the global smart city market will grow by 14% annually, from US$ 506.8 billion in 2012 to US$ 1.3 trillion in 2019” (2016 World Cities Report, UN Human Settlements Programme).
SC initiatives typically

→ start with a decision on which socioeconomic factors (mobility, governance, etc.) should be targeted to become a “smart territory”

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→ follow a top-down approach, i.e., local governments typically lead these SC initiatives (Estevezez et al. 2016, Mora et al. 2019).

Illustrative examples of this process: Amsterdam (Mora and Bolici 2017), Kansas City (Sarma and Sunny 2017) and Gothenburg (Brorström et al. 2018).
BUT, confronted with limited resources and/or severe financial constraints, local governments seeking to make their territories “smart” cannot simply invest in all the socioeconomic factors that characterise smart cities.
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⇒ although some SC initiatives have managed to concentrate their efforts in one or two factors (typically, mobility and/or ICT), most local governments find difficult to identify which factors make their territories “smart” (survey in Pierce and Anderson 2017).
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For local governments affected by these trends, a major question is which factors should be targeted in order to succeed (i.e., become “smart”).
There is limited evidence guiding such decisions.

- Some case studies (Angelidou 2017, Freitas-Camboim et al. 2019), one large sample study on 70 cities from all over the world (Neirotti et al. 2014).
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This paper presents results from log-linear and ordered regression models in which a set of SC indicators (i.e., socioeconomic factors) explain variations in the “smartness” of cities.
Motivation

There is limited evidence guiding such decisions.

- Some case studies (Angelidou 2017, Freitas-Camboim et al. 2019), one large sample study on 70 cities from all over the world (Neirotti et al. 2014).

This paper presents results from log-linear and ordered regression models in which a set of SC indicators (i.e., socioeconomic factors) explain variations in the “smartness” of cities.

These results may provide good guidelines for local governments.

(Ideally, results from an experimental research design, but this is challenging; leave for future research).

Goal of the paper
**Dependent Variable and Sample**

A key issue is the availability of a (dependent) variable that proxies for the "smartness" of a large sample of territories.

We use an assessment from a local public official that "is responsible for the projects associated with the phenomenon of the smart city in the municipality".

In particular, our dependent variable was obtained from a survey carried out in 2017 by the Smart City Institute of the University of Li`ege on the Belgian municipalities.
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The survey

The survey targeted all 589 Belgian municipalities and obtained a response rate of nearly 21%.

The final sample of 123 municipalities is statistically representative of Belgian territorial and institutional realities: size of the municipalities, geographical dispersion, and urban/rural areas (Bounazef et al. 2018, Desdemoustier et al. 2019).
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Officials “responsible for the projects associated with the phenomenon of the smart city in the municipality” were asked to provide an assessment about their municipalities’ degree of smartness using the question “Please indicate the level of evolution of your municipality in the process of Smart City implementation”.

We interpret this measure as the level of SC implementation in each municipality, or simply the (degree of) “smartness” of a municipality.
Note: Integer scale between 1 ("Our municipality is not a SC") and 10 ("We are a SC").
Explanatory Variables: SC Indicators

Most of the SC literature has a normative and descriptive aim (Nam and Pardo 2011, Kourtit et al. 2012). A territory is considered “smart” to the extent that it performs (comparatively) well with respect to a set of SC indicators on the different socioeconomic factors that characterise smart cities (e.g., voters’ turnout as a governance indicator). Giffinger et al. (2007) and ISO (2014) provide the main benchmark for constructing SC indicators. In essence, both define a set of socioeconomic factors (characteristics, themes) that define an SC and then a set of indicators for each factor.

Which socioeconomic factors make a territory “smart”? 59th ERSA Conference, Lyon
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Explanatory Variables: SC Indicators

Smart City Model of Giffinger et al (2007):
Illustrative example of indicators.

- **Health conditions indicators** include: life expectancy, hospital beds per inhabitant, doctors per inhabitant and satisfaction with quality of health system.
We construct a set of common “factors” (i.e., characteristics and/or themes) in these reports:

- Economy
- Social and Human capital (Education)
- Governance-participation
- Transport-ICT-Innovation
- Environment (Energy and Wastewater)
- Quality of life (Health-Safety-Recreation)
Note that:

- there are four themes of the ISO (2014) not covered by the characteristic of Giffinger et al. (2007): Finance, Fire and emergency response, Solid waste, and Water and sanitation.

- there is a number of common indicators in the common factors (e.g., the unemployment rate and the share of green areas), particularly in Governance-participation and Quality of life.

- most of the indicators proposed differ, which allows most SC factors to be proxied using the indicators of either Giffinger et al. (2007) or the ISO (2014).
## Socioeconomic Factors and Associated Explanatory Variables

<table>
<thead>
<tr>
<th>Factors</th>
<th>Explanatory Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economy</strong></td>
<td>Unemployment rate</td>
</tr>
<tr>
<td></td>
<td># Businesses per Population</td>
</tr>
<tr>
<td></td>
<td># New Businesses</td>
</tr>
<tr>
<td><strong>Social and Human</strong></td>
<td>Pop. with Primary Education</td>
</tr>
<tr>
<td></td>
<td>Pop. with Secondary Education</td>
</tr>
<tr>
<td></td>
<td>Pop. with HE degree</td>
</tr>
<tr>
<td></td>
<td>Pop. with University degree</td>
</tr>
<tr>
<td><strong>Capital</strong></td>
<td>Pop. Enrolled in Primary School</td>
</tr>
<tr>
<td></td>
<td>Pop. Enrolled in Secondary School</td>
</tr>
<tr>
<td></td>
<td>Pop. from EU Countries</td>
</tr>
<tr>
<td></td>
<td>Pop. from non-EU Countries</td>
</tr>
<tr>
<td><strong>Governance</strong></td>
<td>% of Female City Representatives</td>
</tr>
<tr>
<td></td>
<td>Voters' Turnout (%)</td>
</tr>
<tr>
<td></td>
<td>Share of children in day care</td>
</tr>
<tr>
<td><strong>Transportation</strong></td>
<td>Motorways per Inhabitant</td>
</tr>
<tr>
<td></td>
<td>Inter-city Trains</td>
</tr>
<tr>
<td></td>
<td># Private Vehicles per Household</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>Share of Woodland</td>
</tr>
<tr>
<td></td>
<td>Share of parks and gardens</td>
</tr>
<tr>
<td><strong>Quality of life</strong></td>
<td>Rate of Criminality</td>
</tr>
<tr>
<td></td>
<td>Living Area in Private Houses per Inhabitant</td>
</tr>
<tr>
<td></td>
<td>Overnights per Inhabitant</td>
</tr>
<tr>
<td></td>
<td>Sport areas per inhabitant</td>
</tr>
</tbody>
</table>

**Additional controls:** Provincial dummies and dummies distinguishing the professional category of the respondent.

**Data sources:** Belfius (2007, 2017), Bel-first (Bureau van Dijk), NMBS/SNCB and official web pages of the regional governments of Brussels, Flanders and Wallonia.
Because of the ordered nature of our dependent variable, we report (two sets of) results from log-linear and ordered probit model.
Motivation  Data  Estimates  Conclusions

Estimates

Because of the ordered nature of our dependent variable, we report (two sets of) results from log-linear and ordered probit model.

- **Specification I**: Wald tests on the joint significance of the variables associated with each of the considered socioeconomic factors (recall previous table).

  We interpret the statistical significance of each Wald test as evidence that the associated factor (Economy, Social and Human Capital, Governance, Transportation, Environment and Quality of Life) is correlated with the level of SC implementation.
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- **Specification II:** Coefficient estimates from an econometric specification that uses as explanatory variables the largest principal component (i.e., eigenvector) of the indicators that compose each factor.

  We interpret the statistical significance of the largest principal components as evidence that the associated factor (Economy, Social and Human Capital, Governance, Transportation, Environment and Quality of Life) is correlated with the level of SC implementation.
## Specification I: Result from Wald Tests

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Ordered probit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy</td>
<td>1.55</td>
<td>7.99**</td>
</tr>
<tr>
<td>Social and Human Capital</td>
<td>2.42**</td>
<td>22.16***</td>
</tr>
<tr>
<td>Governance</td>
<td>0.93</td>
<td>5.44</td>
</tr>
<tr>
<td>Transportation</td>
<td>0.77</td>
<td>2.72</td>
</tr>
<tr>
<td>Environment</td>
<td>0.09</td>
<td>0.75</td>
</tr>
<tr>
<td>Quality of Life</td>
<td>0.71</td>
<td>4.49</td>
</tr>
</tbody>
</table>

Note: Asterisks denote jointly statistically significant coefficients at the 1% level (***) , 5% level (**) and 1% level (*).
### Specification II: Result from Largest Principal Components

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Ordered probit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy</td>
<td>0.0924*</td>
<td>0.1925**</td>
</tr>
<tr>
<td></td>
<td>(0.0533)</td>
<td>(0.0978)</td>
</tr>
<tr>
<td>Social and Human Capital</td>
<td>-0.0156</td>
<td>-0.0065</td>
</tr>
<tr>
<td></td>
<td>(0.0356)</td>
<td>(0.0646)</td>
</tr>
<tr>
<td>Capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governance</td>
<td>0.0007</td>
<td>0.0037</td>
</tr>
<tr>
<td></td>
<td>(0.0539)</td>
<td>(0.0977)</td>
</tr>
<tr>
<td>Transportation</td>
<td>-0.0089</td>
<td>-0.0157</td>
</tr>
<tr>
<td></td>
<td>(0.0165)</td>
<td>(0.0300)</td>
</tr>
<tr>
<td>Environment</td>
<td>-0.0386</td>
<td>-0.0590</td>
</tr>
<tr>
<td></td>
<td>(0.0693)</td>
<td>(0.1258)</td>
</tr>
<tr>
<td>Quality of Life</td>
<td>-0.0370</td>
<td>-0.0266</td>
</tr>
<tr>
<td></td>
<td>(0.0623)</td>
<td>(0.1134)</td>
</tr>
</tbody>
</table>

Note: Asterisks denote statistically significant coefficients at the 1% level (***) , 5% level (**) and 1% level (*).
Economy and Social and Human capital are socioeconomic factors that seem to be positively correlated with the degree of smartness of a municipality.

### Robustness tests

- Replaced some of the indicators (the unemployment rate, the share of woodland and the share of parks and gardens, living area in private houses per inhabitant, and surface of sport areas per inhabitant) with their values in 2007.

- Included additional indicators such as taxable income over total population in 2015 (to proxy for the GDP per employed person), the log of the difference between the third and first quartile of the income distribution in 2015 (to proxy for the poverty rate) and density of population square to control for negative agglomeration effects (noise, pollution, etc.).

- Dropped the municipalities in which the public official responding the survey was an SCI manager (“Other respondents” being then the residual category).

- Replaced the dummy provinces for regional dummies (being Flanders the residual category).

- Replaced the principal components initially used by a set of components accounting for at least 70% of the variance of the variable.

- Included an ICT variable (% of jobs in high-tech industries, only available for Wallonia).
Our findings indicate that the stakeholders involved in SC initiatives should pay particular attention to economic and social-human indicators (see also Freitas-Camboim et al. 2019) when making their decisions (and perhaps be less concerned about other indicators).

These results cast doubts on the role played by certain socioeconomic factors, such as governance-participation and ICT-transportation, identified as critical in the public management and smart city literatures.
Conclusions

Cities all over the world seek to become "smart," i.e., they launch projects associated with the mobility of citizens and vehicles, the role of big data and its technologies, the long-term sustainability of the urban environment and/or the increase of citizen's political participation. Importantly, these projects do not come cheap and usually involve substantial amounts of public and private resources. Yet empirical assessments on what socioeconomic factors make a city "smart" are scarce.

This paper analyses the link between the assessment made by informed public officers on how "smart" their city is and a list of factors generally considered in the literature to make a city "smart." Results were obtained for a sample of Belgian municipalities.

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Our findings may provide guidelines for policy makers and local governments aiming at launching and/or investing in SC initiatives.

In particular, the message that arises from our results is that initiatives that improve economic and social-human capital factors will probably pay off.

Results are robust to the use of alternative sets of explanatory variables, different model specifications, and several controls on the respondents to the survey used to construct our dependent variable.
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