Defining Intangible Capital Indices to Compare Creative Cities

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Introduction: The need for objectivity in ranking

- How to objectively rank cities in terms of intangibles (investment & leveraging)?
  - What is the best way to group variables?
  - How relevant are the resulting groups?

We propose the creation and evaluation of indices based on statistical analysis.

1. From a number of variables, we derive factors which capture the correlations in the data.
2. We then use regressions to prompt for significant relationships between the factors and GDP per capita.
3. We apply this procedure in two datasets: Eurostat+OECD (32 indicators, 20 European cities) and OECD+PwC (18 indicators, 16 global cities).

Main Findings

1. The Intellectual Capital perspective can help improve the framework for classifying cities and building indices.
   - E.g., European cities oriented towards service economies tend to have higher levels of human capital.

2. The pertinence of intangible capital indices can be verified by the means of econometric analysis with an output variable (in this case GDP per capita).

3. Among all variables considered, those pertaining to *Human Capital* are essential to the "best" indices.

Background 1/2

Why we need indices

We need to somehow elucidate performance of the complex systems which define creative cities.

- Benchmark.
- Foster creative imitation of effective policies.

Background 2/2

Criticism

> *"In particular, the current emphasis on [...] the "buzz" of a city or a city-region is often based upon the presumption that there is a link between competitiveness and the presence of particular assets such as cultural workers, trade fairs and exhibition spaces or airport passenger numbers."*

> *"[In city-region studies] competitiveness [...] is simply a function of what is measured."*

Green, F. J., Tracey, P. and Cowling, M. (2007). "Recasting the City into City-Regions: Place Promotion, Competitiveness Benchmarking and the Quest for Urban Supremacy." Growth and Change, 38: 1–22.

> *"[T]hose constructing suitable indices are confronted with a number of key challenges not least of these being what variables to include and how to aggregate them into a composite index for ranking purposes."*

> *"[I]ndices perform poorly as a policy-making tool in terms of their ability to predict and rank national economic performance."*

Berger, T. and Bristow, G. (2009). "Competitiveness and the Benchmarking of Nations—A Critical Reflection." International Advances in Economic Research, 15: 378–392.

Quantitative Approach

1. *Principal-component Factor Analysis* identifies factors which represent the common variance in the data.
   - 1.1 We classify variables in factors (groups) of common correlations. We then interpret these factors based on their key variables.
   - 1.2 We create associated indices (factor scores) for each city based upon the resulting structure of factors.
     - The weight of a variable in the index is determined by the correlation with the factor.

2. We proceed to define econometric models which include these indices as independent variables and GDP per capita as the dependent variable. We use regressions to check the pertinence of each index in terms of economic output.

3. We then rank cities using the significant portion from the dataset, i.e., employing the index/indices with a significant statistical correlation with GDP per capita.

[Eurostat + OECD] — Dataset A

Sources

- (32) Indicators [2003-2010]:
  Eurostat (Urban Audit & Regional Statistics)
  - (8) Science, Technology and Education
  - (9) Economic Variables
  - (7) Environment/Health and Culture
  - (7) Demographics
- (3) Output and Control Variables [2005]:
  OECD (Competitive Cities in the Global Economy)

20 Cities

1. Barcelona
2. Berlin
3. Budapest
4. Copenhagen
5. Frankfurt
6. Hamburg
7. Helsinki
8. Lille
9. Lisbon
10. London
11. Lyon
12. Madrid
13. Milan
14. Munich
15. Paris
16. Rome
17. Stockholm
18. Turin
19. Valencia
20. Vienna

[Eurostat + OECD] — Indicators (1/2)

Science, Technology and Education

	Context	Code
Patent app. (per million of inh.) to the EPO	Region	patent
High Tech Patent app. (per million of inh.) to the EPO	Region	hpatent
Total intramural R&D exp. (GERD) (% of GDP)	Region	rnd
ICT patent app. (per million of inh.) to the EPO	Region	patent-ct
Researchers (% of total emp.)	Region	rnd-personnel
Human resources in science and technology (% of EAP)	Region	hrst
Students in ISCED level 3-4 per 1000 inh.	City	students
Prop. of working age pop. qualified at level 3 or 4 ISCED	City	qual

Economic Aspects

	Context	Code
Prop. of emp. in commercial services	City	emp-com
Prop. of emp. in financial intermediation business activities	City	emp-finan
Prop. of emp. in [primary and secondary] industries	City	emp-indCE
Prop. of emp. in [tertiary] industries	City	emp-indGP
Prop. of emp. in trade hotels restaurants	City	emp-thr
Self-employment rate	City	emp-self
% of employed in manufacturing ICT products	City	ict-manu
% of employed in providing ICT services	City	ict-serv
% of employed producing ICT content	City	ict-cont

[Eurostat + OECD] — Indicators 2/2

Environment/Health and Culture

	Context	Code
Accumulated ozone concentrations in excess 70 $\mu g/m^3$	City	ozone
Available hospital beds in Urban Audit cities per 1000 inh.	City	hospital
Average number of hours of sunshine per day	City	sunshine
Cinema seats per 1000 inh.	City	cinema
Number of museums per million inh.	City	museums
Number of libraries per million inh.	City	libraries
Number of theatres per million inh.	City	theatres

Demographics

	Context	Code
Total annual pop. change over approx. 5 years	City	popchange
Prop. of total pop. aged 15-64	City	age15-64
EU nationals as a prop of total pop.	City	nat-eu
Prop. of females to males in total pop.	City	fem-males
Live births per 1000 residents	City	fertility
Nationals as a prop of total pop.	City	nat-prop
Non-EU nationals as a Prop of total pop.	City	nat-noneu

[Eurostat + OECD] — Factor Analysis

	F1	F2	F3	F4	F5
patents		X	X		
hpatent		X			
gerd		X			
patentsict		X			
researchers	X				
hrst	X				
students				X	
qual		X			
empcom			X		
empfinan			X		
empindce	X				
empindgp	X		X		
empthr	X				
empself	X				
ictmanu		X			X
ictserv	X				
ictcont	X		X		
ozone	X				
hospital				X	
sunshine			X		
cinema			X		
museums					X
libraries					X
theatres	X				
popchange		X		X	
age1564	X				
nateu		X			
femmales				X	
fertility	X				
natprop		X			
natnoneu		X			

Five factors explain 75.58% of total variance.

The table shows the relationship with each factors with the variables.

X: Denotes relatively high, *positive* correlation with the factor.
X: Denotes relatively high, *negative* correlation with the factor.

Based on this data, the factors can be defined as follows:

F1: Human Capital (S&T) + Service Economy
F2: Diversity + Structural Capital
F3: Tertiary & Finance
F4: Hospitals, Students, Dec. Population
F5: Culture + ICT Manufacture

[Eurostat + OECD] — Regressions: Setup

Output and Control Variables

Type		Context	Code
Output	GDP per capita in PPPs (USD)	Metropolitan	GDP
Control	Employment Rate (%)	Metropolitan	EMP
Control	Labor Productivity (USD)	Metropolitan	PROD

Definitions

Model	Expression
1	$GDP_i = \sum_{j=0}^{5} \beta_j F_{ji} + c + \epsilon$
2	$GDP_i = \sum_{j=0}^{5} \beta_j F_{ji} + \beta_6 EMP_i + c + \epsilon$
3	$GDP_i = \sum_{j=0}^{5} \beta_j F_{ji} + \beta_6 EMP_i + \beta_7 PROD_i + c + \epsilon$

[Eurostat + OECD] — Regressions: Results

Variables	Coefficients		
	Model 1	Model 2	Model 3
F1	.0328**	.0342**	.0185***
	(.0125)	(.0148)	(.0037)
F2			
F3	.0476***	.036**	
	(.0104)	(.0121)	
F4			
F5			
EMP		.0118**	.0076***
		(.0053)	(.0018)
PROD			.772***
			(.0724)
c	4.496***	3.410***	
	(.0175)	(.489)	
Obs.	20	20	20
R-sq.	0.47	0.62	0.96

Note: Robust standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

- F1 (Human Capital + Service Economy) has a significantly positive correlation with GDP per capita. This effect remains consistent in all the models.
- F3 (Commercial Economy) has a positive and significant relationship. However, this effect is lost when considering productivity levels.

[Eurostat + OECD] — Rankings

	Criteria			
	HC+SE Index	Productivity	Employment	GDP per Capita
Copenhagen	**1**	13	3	10
Stockholm	**2**	10	5	4
Paris	**3**	2	16	2
London	**4**	1	9	1
Helsinki	**5**	12	8	8
Lyon	**6**	3	14	6
Munich	**7**	11	4	7
Berlin	**8**	19	20	20
Frankfurt	**9**	9	10	9
Lille	**10**	15	19	17
Vienna	**11**	4	13	3
Hamburg	**12**	8	15	13
Lisbon	**13**	16	12	15
Madrid	**14**	14	7	14
Budapest	**15**	18	2	18
Valencia	**16**	20	18	19
Barcelona	**17**	17	17	16
Rome	**18**	5	11	11
Turin	**19**	7	6	12
Milan	**20**	6	1	5

[OECD + PwC] — Dataset B

Sources

- (18) Indicators [2003-2010]: PricewaterhouseCoopers & OECD (Metropolitan and Regional Statistics)
  - (9) Science and Technology
  - (5) Human Capital
  - (4) Demographics
- (3) Output and Control Variables [2005]: OECD (Competitive Cities in the Global Economy)

16 Cities

1. Berlin
2. Chicago
3. Houston
4. Istanbul
5. London
6. Los Angeles
7. Madrid
8. Mexico City
9. New York
10. Paris
11. San Francisco
12. Seoul
13. Stockholm
14. Sydney
15. Tokyo
16. Toronto

[OECD + PwC] — Indicators (1/2)

Science and Technology

	Context	Code
Co-patent applications by inventor and priority year - level	Metropolitan	copat
Domestic ownership of foreign patents (% of total patents)	Metropolitan	dofp
Foreign ownership of domestic patents (% of total patents)	Metropolitan	fodp
Patent applications per million inhabitants by inventor and priority year - level	Metropolitan	patapp
Percent of co-patent applications that are done with foreign regions	Metropolitan	copat-foreing
Percent of co-patent applications that are done within the country	Metropolitan	copat-national
Percent of patent applications in ICT	Metropolitan	patapp-ict
Research performance of top universities	Metropolitan	uni
R&D expenditure total (as % of GDP)	Region	rnd

Human Capital

	Context	Code
Classroom size	City	class
Entrepreneurial environment	City	entrepreneur
Libraries with public access	City	libraries
Percent of population with higher education	City	educ
Enrollment at tertiary level (as a % of total population)	Region	tertiary

[OECD + PwC] — Indicators (2/2)

Demographics

	Context	Code
Population density (inhabitants per sq km)	City	pop
Number of private vehicles per 100 inhabitants	Region	vehicles
Murders per 100 000 population	Region	murders
Number of physicians per 1000 inhabitants	Region	doctors

[OECD + PwC] — Factor Analysis

	F1	F2	F3	F4
copat	X			
dofp		X		X
fodp		X		
patapp	X			
copat-national				X
copat-foreing		X		
patappict	X			
pop			X	
class		X		
entrepreneur	X			
libraries		X		
educ	X			
uni	X			
rnd	X			
tertiary	X			
vehicles	X			
murder			X	
doctors			X	

Four factors explain 76.16% of total variance.

Based on this data, the factors can be defined as follows:

F1: Human Capital + Structural Capital
F2: Transfer of Structural Capital
F3: Demographics
F4: Domestic-centered Structural Capital

[OECD + PwC] — Regressions: Setup

Output and Control Variables

Type		Context	Code
Output	GDP per capita in PPPs (USD)	Metropolitan	GDP
Control	Employment Rate (%)	Metropolitan	EMP
Control	Labor Productivity (GDP per worker, USD)	Metropolitan	PROD

Definitions

Model	Expression
1	$GDP_i = \sum_{j=0}^{4} \beta_j F_{ji} + c + \epsilon$
2	$GDP_i = \sum_{j=0}^{4} \beta_j F_{ji} + \beta_5 EMP_i + c + \epsilon$
3	$GDP_i = \sum_{j=0}^{4} \beta_j F_{ji} + \beta_5 EMP_i + \beta_6 PROD_i + c + \epsilon$

[OECD + PwC] — Regression: Results

Variables	Coefficients		
	Model 1	Model 2	Model 3
F1	.4037**	.3982**	.1331***
	(.0551)	(.03911)	(.0299)
F2	.1453*	.1358*	.0607*
	(.0623)	(.0666)	(.0275)
F3			
F4			
EMP		.0269**	.0118***
		(.0070)	(.0027)
PROD			.7921***
			(.0773)
c	10.389***		5.904***
	(.0665)		(.3093)
Obs.	16	16	16
R-sq.	0.78	0.83	0.99

Note: Robust standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

- F1 (Human & Structural Capital) is highly significant in the three regressions. Its coefficient is greater in magnitude than that of the HC+SE in the previous dataset.
- F2 (Transfer of Structural Capital) reports a slight significance.
  - Its coefficient's value is less than a half in comparison to F1, meaning the relationship between the H&SC index and GDP per capita is stronger.

[OECD + PwC] — Rankings

	Criteria				
	H&SC	H&SC & SC Transfer	Productivity	Employment	GDP per Capita
San Francisco	1	2	1	3	1
Stockholm	2	1	8	10	8
Los Angeles	3	6	3	6	6
New York	4	5	2	7	2
Chicago	5	8	7	9	5
Paris	6	4	6	14	7
Tokyo	7	13	11	5	11
Houston	8	9	4	8	3
Toronto	9	3	12	12	10
Seoul	10	14	14	2	14
Sydney	11	7	9	4	9
Berlin	12	12	13	16	13
Madrid	13	10	10	11	12
London	14	11	5	13	4
Istanbul	15	16	16	15	16
Mexico City	16	15	15	1	15

Conclusions

1. We identified factor structures based on variable correlation.
   - This structure differs greatly from the original (discrete) classification groups.
     - The factor analysis allows to consider relationships between variables from different groups.

2. For both datasets, the main index highlights the importance of Human Capital.
   - Taking into account Structural Capital increases the explanatory power of the index (Dataset B).

3. These indices complement Employment and Productivity rankings in the explanation of the success of creative cities.

Outlook

- Further studies should explore other output variables and data grouping techniques.
- Poorness and heterogeneity of the data remains a big issue. More surveys and standardization is needed,
- The methodology presented here is an opportunity for adding value to other indices of creative cities.
- This would lead to more robust rankings of cities.
  - A better understanding of what determines the success of cities.
  - Superior tools for policymakers.

Annex: Geographical definitions.

- **City** [Eurostat (applies for PwC)]: "[A] city could be designated as an urban settlement or as a legal, administrative entity. The Urban Audit [...] defines [cities] by political boundaries."
- **Metropolitan** [OECD]: Based on four criteria.
  - Population size: $\geq$ 1.5 million people.
  - Population density: $\geq$ 150 people per km^2.
  - Area represents a contained labor market (commuting rate $\leq$ 10% of the population).
  - Cities that account for $\geq$20% of national population.
- **Region** [OECD]: The administrative territorial unit and political subdivision defined by each country (e.g., Régions (France), States (USA), Government Districts (Germany)).

Examples

City	Metropolitan	Region
Paris	Paris	Île-de-France
Tokyo	Tokyo	Kantō
London	London	Inner London
Brussels	Brussels Capital Region	Brussels Capital Region
Lisbon	Region of Lisbon	Great Lisbon
Frankfurt (Main)	Frankfurt (Main)	Darmstadt
Madrid	Madrid	Comunidad de Madrid
New York City	New York City	New York State
Los Angeles	Los Angeles	California