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Static vs. Dynamic Agglomeration Economies: Spatial Context and Structural Evolution behind Urban Growth

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Agglomeration economies and urban growth: general aim of the paper

- A lively debate exists on the relationship between agglomeration economies and urban growth.

- This paper contributes to this debate by overcoming some of the shortcuts that are present in the theoretical approaches and presents a fully dynamic approach in the explanation of urban growth.

- An empirical analysis on the European urban system of the new approach is also presented.

Specific aim of the paper

- In particular, the aim of the paper is to explain the apparent contradiction that small cities, even with their limited urban productivity, grow as well as large ones

- This aim is achieved by distinguishing between a static and a dynamic definition of urban advantage / productivity.

  - **Static productivity advantages:** higher productivity of large cities w.r.t. small ones at any given point in time.

  - **Dynamic productivity advantages:** productivity increases over time for each city size.

Shortcuts in the existing literature

1. The presence of a higher productivity/efficiency in larger cities is used to interpret growth: an ‘equilibrium relationship’ (Henderson, 2010) and a static size-performance correlation are misinterpreted as a causal, dynamic relationship

2. Production factors determining urban productivity other than size are interpreted as perfectly malleable (dependent on urban size)

3. If higher productivity of larger cities is supposed to mean higher attractiveness and, consequently, growth, this productivity should be measured through **net** urban benefits

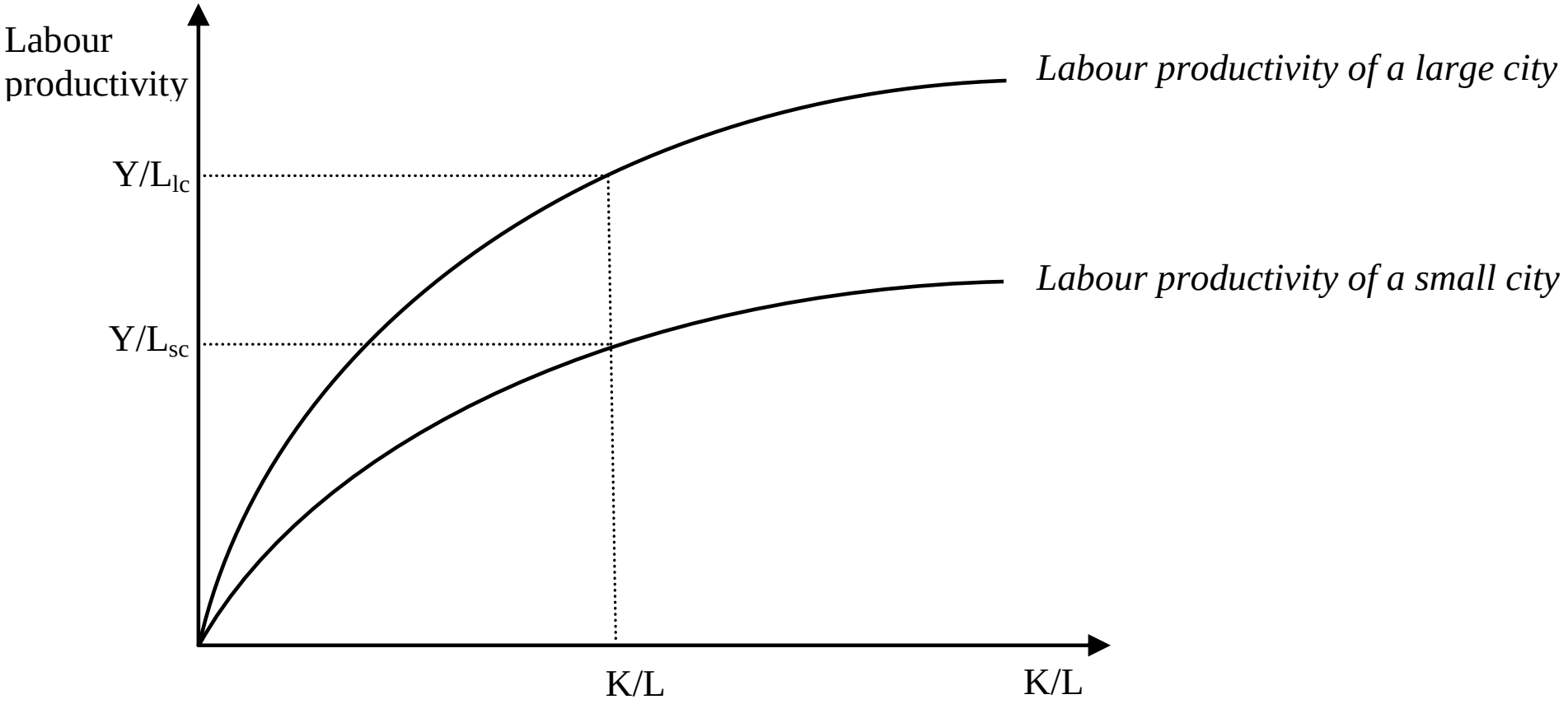
These shortcuts are overcome by analyzing in depth what the literature says, and adding some refinements:

Literature review

Conceptual organization of the existing literature

- The literature on agglomeration economies highlights three aspects inherently part of this concept (Capello, 2009):
  - Indivisibilities (micro-industrial approach)
  - Physical proximity (geographical approach)
  - Synergies (macro-territorial dynamic approach)

The existing literature: the micro-industrial approach



The existing literature: the micro-industrial approach

This approach has some limits:

- It (mis-)interprets urban dynamics in an indirect way:
  - large cities are more efficient;
  - therefore, they are more attractive;
  - therefore, they grow.

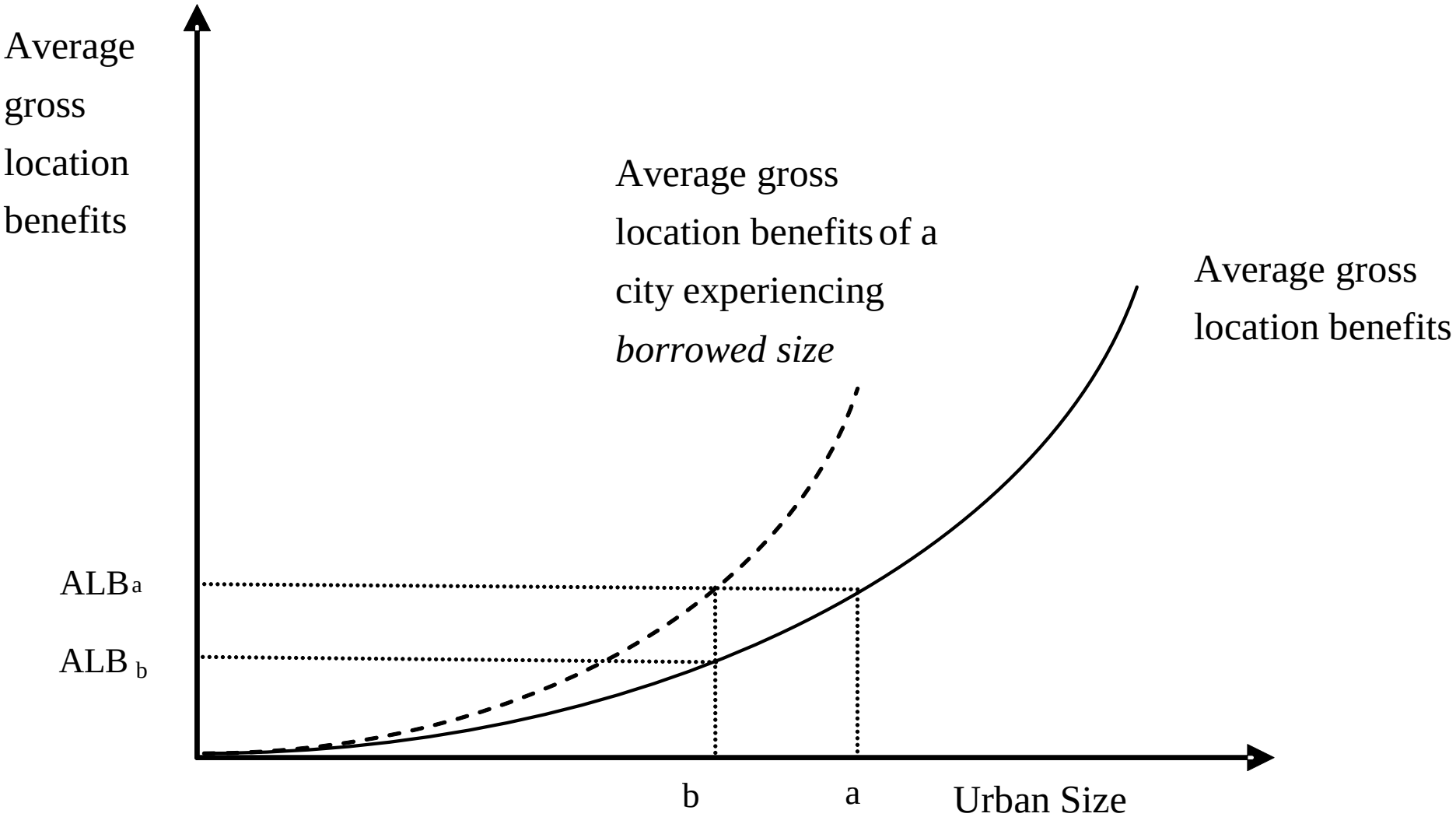
- It explains productivity advantages with pecuniary externalities. This implies that agglomeration is associated to clusters of firms, rather than to cities; and, that leaves totally aside the costs of urban agglomeration.

The existing literature: the geographical approach

- The geographical approach was included as a way to overcome the unexplained evidence that small cities may grow more than large ones.

- The concept used is that of ‘borrowed size’ developed by Alonso (1973); *“… a small city or a metropolitan area exhibits some of the characteristics of a larger one if it is near other population concentrations”* (Alonso, 1973, p. 200).

The existing literature: the geographical approach



Limits of the geographical approach

- This theory has the following limits:
  - It assumes no threshold in urban growth;
  - It describes only static agglomeration economies for urban growth;
  - It presents the same shortcut as the previous approach: productivity advantage (through borrowed size) is equated to growth potential

Our contributions to the geographical approach (1)

1. Separation between the concepts of borrowed size and borrowed functions (demand and supply effects):

   - **Demographic effect ("pure borrowed size")**: advantages coming from a pooled and diversified labor supply, from a larger market of final goods and also from population spillovers from larger cities

   - **Functional effect ("borrowed functions")**: advantages coming from a wider labor demand, from a larger accessibility to the supply of services and also from physical spatial spillovers of functions from larger cities

The two effects may have different intensities and different directions (signs) for different city sizes.

Our contributions to the geographical approach (2)

2. Separation between spatial and a-spatial networks.

   - Functions can be ‘borrowed’ also thanks to relationships and flows of a mainly horizontal and non-hierarchical nature among cities of similar size, even if located far from each other (city network theory: Camagni 1993; Boix and Trullen, 2007; Camagni and Capello, 2004).

New contributions: the dynamic macro-territorial approach

In the dynamic macro-territorial approach, a new perspective is adopted, allowing the identification of a direct link between dynamic agglomeration economies and urban growth.

- Agglomeration economies, as sources of growth, should be conceived in terms of **net** and not **gross** urban benefits, at a macro-urban (attractiveness) and not a micro-pecuniary level

- Other factors should be considered, together with pure size, in explaining urban efficiency levels. Changes in the intensity of these factors influence increases in agglomeration economies, *irrespective of* the size of the city.

Research questions (1)

Two groups of research questions

- **Static agglomeration economies:**

1. whether large cities are more productive, at increasing or decreasing rates;

2. whether urban productivity is influenced by factors other than urban size, namely urban functions, ‘borrowed size’, ‘borrowed functions’, and urban network externalities;

3. whether these effects are mediated by city size.

Research questions (2)

- **Dynamic agglomeration economies:**

1. whether urban productivity increases in time are related to urban size;

2. whether productivity increases in time are related to the increase in the quality of functions hosted, to the increase of city networks, to the increase in ‘borrowed size’ or in ‘borrowed functions’;

3. whether previous relationships hold differently for increasing city sizes

The estimated models

Formally, this translates into the following testable reduced forms.

A: Model for the static approach:

$$urban\_productivity_{c,t} = \alpha + \beta_1 population_{c,t-1} + \beta_2 population^2_{c,t-1} + \beta_3 urban\_functions_{c,t-1} +$$
$$+ \beta_4 borrowed\_size_{c,t-1} + \beta_5 borrowed\_functions_{c,t-1} + \beta_6 network\_externalities_{c,t-1} + \varepsilon_{c,t}$$

B: Model for the dynamic approach:

$$\Delta urban\_productivity_{c,T-t} = \alpha + \beta_1 population_{c,t} + \beta_2 \Delta urban\_functions_{c,t-\vartheta} +$$
$$+ \beta_3 \Delta borrowed\_size_{c,t-\vartheta} + \beta_4 \Delta borrowed\_functions_{c,t-\vartheta} + \varepsilon_{c,t}$$

The data base for the empirical analyses (1)

Variable	Indicator	Source of raw data	Years available
Urban productivity	Urban rent per square meter (prices in constant 2005 Euros)	EUROSTAT + National sources	2004 and 2011
High-level urban functions	Share of high-level occupations over total workforce	Labour Force Survey	Average 1998–2002 and 2002–2006
Urban size	Population of the metropolitan area	EUROSTAT metropolitan areas data base	Average 1998–2002 and 2002–2006
Metropolitan location – critical mass (borrowed size)	Spatial lags of population in cities discounted by geographical distance	EUROSTAT metropolitan areas data base, Authors' elaborations	Average 1998–2002 and 2002–2006
Metropolitan location – access to nearby functions (borrowed functions)	Spatial lags of share of high-level occupations in cities discounted by geographical distance	Camagni et al. (2014a), Authors' elaborations	Average 1998–2002 and 2002–2006
Cooperation networks (network externalities)	High-level urban functions in other cities, discounted by the intensity of FP5 and FP6 collaborations between city couples	CORDIS	1998–2002 (FP5) 2002–2006 (FP6)

The data base for the empirical analyses (2)

A measure of borrowed size:

$$borrowed\_size_c = \sum_{j=1}^{n} \frac{pop_j}{w_{geo_{c,j}}}, \forall c \neq j$$

A measure of borrowed functions:

$$borrowed\_functions_c = \sum_{j=1}^{n} \frac{functions_j}{w_{geo_{c,j}}}, \forall c \neq j$$

A measure of urban network externalities:

$$city\_network\_externalities_c = \sum_{j=1}^{n} \frac{functions_j}{w_{coop_{c,j}}}, \forall c \neq j$$

A. Empirical results on the static approach

Dependent variable: urban productivity

Model	(1)	(2)	(3)	(4)	(5)	(6)
Constant term	21.20***	25.17***	-8.10	-9.48	-11.70	-6.81
	(7.74)	(7.58)	(7.43)	(7.43)	(7.53)	(7.56)
City population	-2.22**	-2.41**	-2.30**	-2.70**	-2.51**	-2.18**
	(1.09)	(1.04)	(1.06)	(1.14)	(1.09)	(1.08)
Square city population	0.09**	0.09**	0.09**	0.10***	0.10**	0.09**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
High level urban functions	-	0.24***	0.24***	0.24***	0.24***	0.25***
		(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Borrowed size	-	0.06	0.06	0.08	0.06	0.06
		(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Borrowed functions	-	0.99***	1.07***	1.03***	1.00***	1.04***
		(0.24)	(0.24)	(0.27)	(0.27)	(0.26)
Network externalities	-	0.001	0.001	0.001	0.001	0.001*
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
High-level urban functions* City population	-	-	-0.01	-	-	-
			(0.06)			
Borrowed size * City population				0.16**		
Borrowed functions * City population						
Network externalities * City population						**
						(0.00)
Dummy UK	-	-	-0.07	-0.07	-0.07	-0.07
			(0.07)	(0.06)	(0.06)	(0.06)
Number of obs.	272	272	272	272	272	272
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes
Method of estimation	Pooled OLS	Pooled OLS	Pooled OLS	Pooled OLS	Pooled OLS	Pooled OLS
R^2	0.14	0.43	0.43	0.44	0.44	0.44
Joint F-test	32.46**	35.77***	29.06***	25.72***	28.29***	26.78***

Increasing returns at increasing rates characterize productivity levels

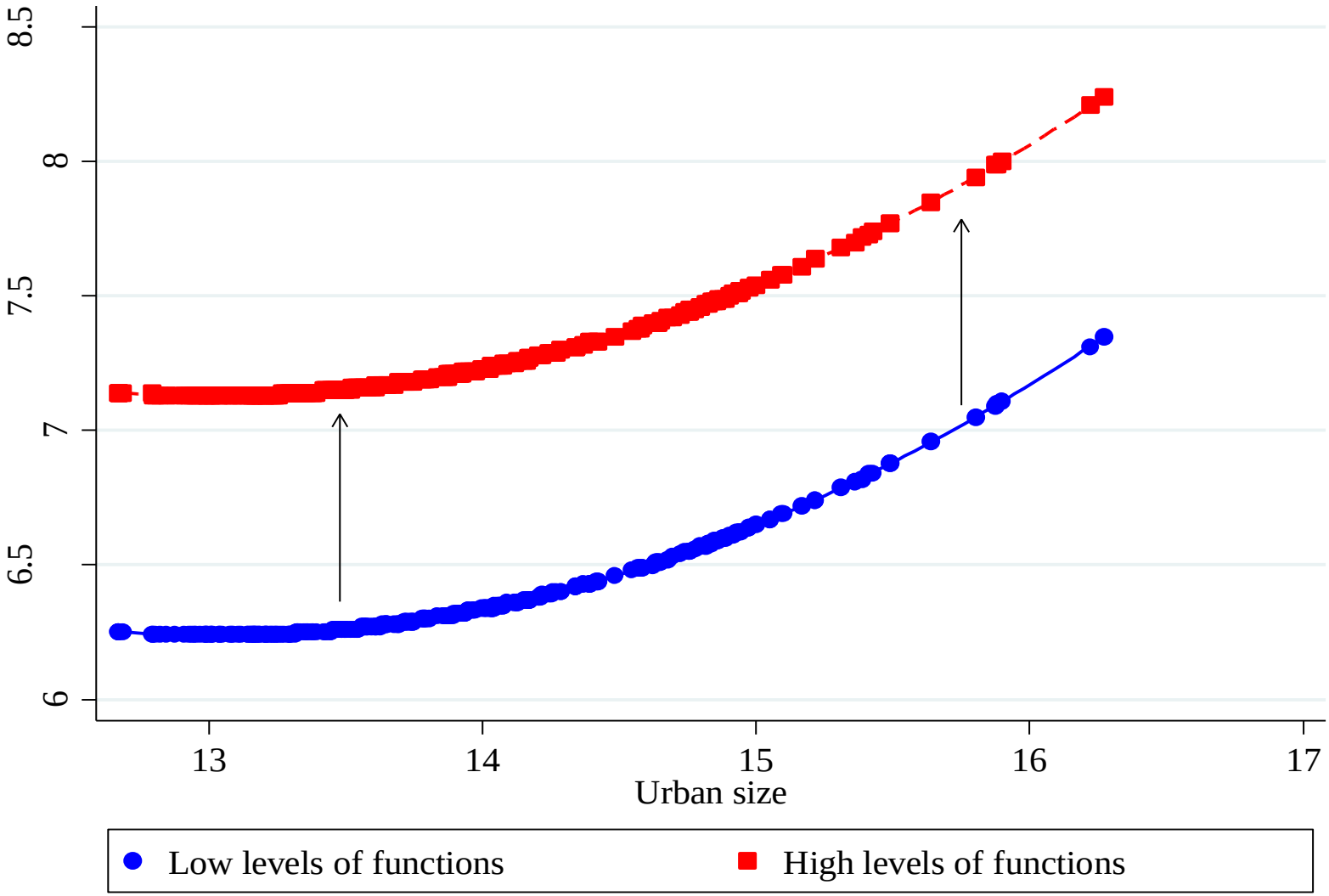
A. Empirical results on the static approach

Dependent variable: urban productivity

Model	(1)	(2)	(3)	(4)	(5)	(6)
Constant term	21.20***	25.17***	-8.10	-9.48	-11.70	-6.81
	(7.74)	(7.58)	(7.43)	(7.43)	(7.53)	(7.56)
City population	-2.22**	-2.41**	-2.30**	-2.70**	-2.51**	-2.18**
	(1.09)	(1.04)	(1.06)	(1.14)	(1.09)	(1.08)
Square city population	0.09**	0.09**	0.09**	0.10***	0.10**	0.09**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
High level urban functions	-	0.24***	0.24***	0.24***	0.24***	0.25***
		(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Borrowed size	-	0.06	0.06	0.08	0.06	0.06
		(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Borrowed functions	-	0.99***	1.07***	1.03***	1.00***	1.04***
		(0.24)	(0.24)	(0.27)	(0.27)	(0.26)
Network externalities	-	0.001	0.001	0.001	0.001	0.001*
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
High-level urban functions* City population	-	-	-0.01	-	-	-
			(0.06)			
Borrowed size * City population				0.16**		
Borrowed functions * City population						
Network externalities * City population						**
						(0.00)
Dummy UK	-	-	-0.07	-0.07	-0.07	-0.07
			(0.07)	(0.06)	(0.06)	(0.06)
Number of obs.	272	272	272	272	272	272
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes
Method of estimation	Pooled OLS	Pooled OLS	Pooled OLS	Pooled OLS	Pooled OLS	Pooled OLS
R^2	0.14	0.43	0.43	0.44	0.44	0.44
Joint F-test	32.46**	35.77***	29.06***	25.72***	28.29***	26.78***

High-level functions and borrowed functions explain productivity levels

A. Agglomeration economies and urban size: the role of functions



A. Empirical results on the static approach

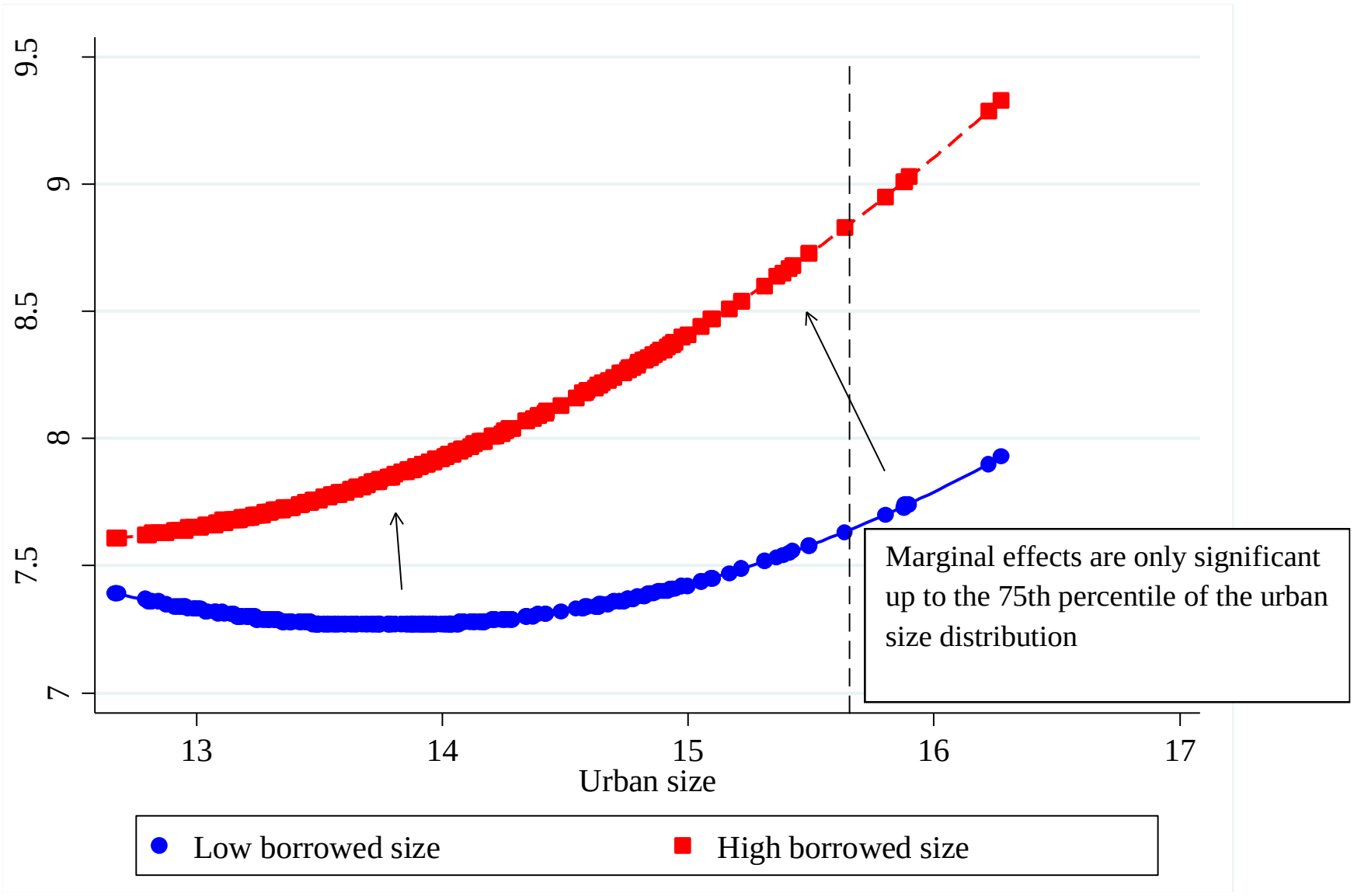
Dependent variable: urban productivity

Model	(1)	(2)	(3)	(4)	(5)	(6)
Constant term	21.20***	25.17***	-8.10	-9.48	-11.70	-6.81
	(7.74)	(7.58)	(7.43)	(7.43)	(7.53)	(7.56)
City population	-2.22**	-2.41**	-2.30**	-2.70**	-2.51**	-2.18**
	(1.09)	(1.04)	(1.06)	(1.14)	(1.09)	(1.08)
Square city population	0.09**	0.09**	0.09**	0.10***	0.10**	0.09**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
High level urban functions	-	0.24***	0.24***	0.24***	0.24***	0.25***
		(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Borrowed size	-	0.06	0.06	0.08	0.06	0.06
		(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Borrowed functions	-	0.99***	1.07***	1.03***	1.00***	1.04***
		(0.24)	(0.24)	(0.27)	(0.27)	(0.26)
Network externalities	-	0.001	0.001	0.001	0.001	0.001*
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
High-level urban functions* City population	-	-	-0.01	-	-	-
			(0.06)			
Borrowed size * City population	.			0.16**		
Borrowed functions * City population	.					
Network externalities * City population	.					
Dummy UK	.					
Number of obs.	27					
Robust standard errors	Ye					
Method of estimation	Poole					
R^2	0.14	0.43	0.43	0.44	0.44	0.44
Joint F-test	32.46**	35.77***	29.06***	25.72***	28.29***	26.78***

Borrowed size effects increase with city size, significant only up to the 75th percentile.

City networks effects decrease with urban size

A. Agglomeration economies and urban size: the role of borrowed size



B. Empirical results on the dynamic approach

Dependent variable: urban productivity increases

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant term	-0.36	-0.53	-0.10	-0.04	-0.10*	-0.10*	-0.06	-0.14**
	(0.51)	(0.52)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)
City population	0.02	0.03	0.04	0.04	0.02	0.04	0.03	0.04
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Growth of high level urban functions	0.17***	0.15***	0.15**	0.15**	0.14***	0.15***	0.16***	0.16***
	(0.06)	(0.06)	(0.06)	(0.07)	(0.03)	(0.05)	(0.06)	(0.06)
Growth of borrowed size	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.001)	(0.00)	(0.00)	(0.00)
Growth of borrowed functions	-	0.43**	0.46**	0.49**	0.45*	0.46**	0.43*	0.45*
		(0.23)	(0.23)	(0.23)	(0.24)	(0.24)	(0.24)	(0.24)
Growth of networks	-	-	-0.31**	-0.28	-0.00	-0.00	-0.00	-0.00
			(0.19)	(0.19)	(0.00)	(0.00)	(0.00)	(0.00)
Urban networks	-	-	-	0.19*	-	-	-	-
				(0.11)				
Growth of high level urban functions * City population	-	-	-	-	-	-	-	-
Growth of borrowed size * City population	-	-	-	-	-	-	-	-
Growth of borrowed functions * City population	-	-	-	-	-	-	).07 (0.31)	-
Growth of networks* City population	-	-	-	-	-	-	-	-0.00 (0.00)
Number of obs.	136	136	136	136	136	136	136	136
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Method of estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Pseudo-R^2	0.09	0.12	0.14	0.16	0.15	0.15	0.12	0.12
Joint F-test test	3.01**	3.35**	3.09**	2.97***	14.50***	5.52***	2.46**	2.33**

Population is never significantly associated to increases in urban productivity over time

B. Empirical results on the dynamic approach

Dependent variable: urban productivity increases

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant term	-0.36 (0.51)	-0.53 (0.52)	-0.10 (0.06)	-0.04 (0.06)	-0.10* (0.06)	-0.10* (0.06)	-0.06 (0.05)	-0.14** (0.06)
City population	0.02 (0.03)	0.03 (0.03)	0.04 (0.03)	0.04 (0.03)	0.02 (0.03)	0.04 (0.04)	0.03 (0.04)	0.04 (0.04)
Growth of high level urban functions	0.17*** (0.06)	0.15*** (0.06)	0.15** (0.06)	0.15** (0.07)	0.14*** (0.03)	0.15*** (0.05)	0.16*** (0.06)	0.16*** (0.06)
Growth of borrowed size	0.001 (0.00)	0.001 (0.00)	0.001 (0.00)	0.001 (0.00)	0.002 (0.001)	0.001 (0.00)	0.001 (0.00)	0.001 (0.00)
Growth of borrowed functions	-	0.43** (0.23)	0.46** (0.23)	0.49** (0.23)	0.45* (0.24)	0.46** (0.24)	0.43* (0.24)	0.45* (0.24)
Growth of networks	-	-	-0.31** (0.19)	-0.28 (0.19)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Urban networks	-	-	-	0.19* (0.11)	-	-	-	-
Growth of high level urban functions * City population	-	-	-	-	-0.15*** (0.05)	-	-	-
Growth of borrowed size * City population	-	-	-	-	-	0.003** (0.001)	-	-
Growth functions * City population	-	-	-	-	-	-	-0.07 (0.31)	-
Growth City population	-	-	-	-	-	-	-	-0.00 (0.00)
Number	-	-	-	-	-	136	136	136
Robust	-	-	-	-	-	Yes	Yes	Yes
Method	-	-	-	-	-	OLS	OLS	OLS
Pseudo-R^2	0.09	0.12	0.14	0.16	0.15	0.15	0.12	0.12
Joint F-test test	3.01**	3.35**	3.09**	2.97***	14.50***	5.52***	2.46**	2.33**

The growth of urban functions is always positively associated to urban productivity increases over time

These effects are decreasing with city size

B. Empirical results on the dynamic approach

Dependent variable: urban productivity increases

The growth of borrowed size is only significant up to the 40th percentile of the city size distribution

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant term							-0.06	-0.14**
							(0.05)	(0.06)
City population							0.03	0.04
							(0.04)	(0.04)
Growth of high level urban functions							0.16***	0.16***
	(0.06)	(0.06)	(0.06)	(0.07)	(0.03)	(0.05)	(0.06)	(0.06)
Growth of borrowed size	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.001)	(0.00)	(0.00)	(0.00)
Growth of borrowed functions	-	0.43**	0.46**	0.49**	0.45*	0.46**	0.43*	0.45*
		(0.23)	(0.23)	(0.23)	(0.24)	(0.24)	(0.24)	(0.24)
Growth of networks	-	-	-0.31**	-0.28	-0.00	-0.00	-0.00	-0.00
			(0.19)	(0.19)	(0.00)	(0.00)	(0.00)	(0.00)
Urban networks	-	-	-	0.19*	-	-	-	-
				(0.11)				
Growth of high level urban functions * City population	-	-	-	-	-0.15***	-	-	-
					(0.05)			
Growth of borrowed size * City population	-	-	-	-	-	0.003**	-	-
						(0.001)		
Growth of borrowed functions * City population	-	-	-	-	-	-	-0.07	-
							(0.31)	
Growth of networks* City population	-	-	-	-	-	-	-	-0.00
								(0.00)
Number of obs.	136	136	136	136	136	136	136	136
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Method of estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Pseudo-R^2	0.09	0.12	0.14	0.16	0.15	0.15	0.12	0.12
Joint F-test test	3.01**	3.35**	3.09**	2.97***	14.50***	5.52***	2.46**	2.33**

Conclusions: main novelties

- This paper has shed light on the debate on the role of agglomeration economies in explaining urban growth.

- A static size-performance correlation is misinterpreted as a causal, dynamic relationship.

- Three bridging links between a static and a dynamic approach are suggested:
  - The use of net benefits instead of gross ones
  - The inclusion of other determinants of urban efficiency beyond pure size
  - The explicit introduction of the time dimension in both the theoretical and the empirical analysis

Policy implications

- Productivity increases and growth may be generated not only by large and mega-cities but also by medium-size cities – solid, specialized, endowed with advanced functions – and by mid-size regional urban systems characterized by high internal accessibility, complementarities and by a relevant internal integration of the goods and labor markets.

- In a period of crisis, policy makers should concentrate their limited resources in those cities able to:
  - develop an evolutionary and innovation-oriented strategy
  - invest in renovated economic functions
  - build ‘smart’ cooperation networks.

Thank you!

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