A panel data modelling of agglomeration and growth: cross-country evidence

Leitão, Nuno Carlos

ESGTS, Polytechnic Institute of Santarém, Portugal, and
Researcher of CEGAGE, Èvora University, Portugal

20 March 2012

A panel data modelling of agglomeration and growth: cross-country evidence

Nuno Carlos Leitão

ESGTS, Polytechnic Institute of Santarém, Portugal, and Researcher of CEGAGE,
Èvora University, Portugal.
Email: nunocarlosleitao@gmail.com

Abstract

This manuscript analysis the relationships between urban agglomeration and economic growth. We apply a static and dynamic panel data approach from European Union (EU-27), the United States, Japan, New Zealand and Mexico for the period 1990 to 2008. The results show that growth is highly correlated with urban agglomeration. The econometric models show that international trade is an important vehicle to expand the economic growth. The models also indicate that human capital promotes the economic growth.

Key words: economic growth; urban agglomeration and panel data approach.

INTRODUCTION

The literature developed a theoretical model of economic geography based on two regions (Centre and Periphery). The Centre is a developed region typical of the neo-classical Solow. The southern region is based on assumptions of a developing economy. Paul Krugman has already reformulated the theories of economic geography and economic growth, as it develops a model based on the relative centre - periphery and semi-peripheral regions.

The new economic geography (NGE) promoted by Krugman (1991), Venables (1995) and Fujita et al. (1999) aroused interest in the academic community, particularly the relationship between agglomeration and economic growth[1]. In other words, spatial concentration promotes economic growth. One of the earliest references comes up with Williamson (1965). The author believes that agglomeration can contribute to economic

[1] In pioneering studies of the urban economy, which applies to Zipf's law, where there is total agglomeration, means that economic activity is concentrated in a city. These studies use size as the dependent variable. Recent studies (Brulhat and Sbergami, 2009) evaluate the relationship between agglomeration and economic growth, and the dependent variable is real GDP per capita.

growth at an early stage of development. However, the model of Martin and Ottaviano (1999) considers that economic growth and geographic agglomeration are interconnected, ie is a process that sustains each other. Following this idea, Fujita and Thisse (2002) found a correlation between growth and agglomeration. The same is shared by Baldwin and Martin (2004).

The vast majority of literature finds a positive correlation between agglomeration and economic growth (Bairoch, 1993; Hohenberg and Lees, 1985; Hohenber, 2004), and even Brulhart and Sbergami (2008) have again validated the hypothesis of Williamson (1965). That is, the urban agglomeration promotes economic growth at an early stage of development.

The choice of the explanatory variables of economic growth is no easy matter in view, we have models that assess the relationship between economic growth and trade, economic growth and foreign direct investment (FDI), economic growth and globalization, entrepreneurial activity, investment and public spending and still others who seek to introduce variables not as frequent as religion, culture, life expectancy, among others.

In an attempt to assess the relationship between agglomeration and economic growth we have selected those that seem most appropriate with the study of Sala-i-Martin et al. (2004), focusing our analysis on the urban agglomeration.

This manuscript uses the panel data approach from European Union (EU-27), the United States, Japan , New Zealand and Mexico for the period 1990 to 2008. We also introduced the Tobit model to estimate economic growth. This methodology is important in forecasting, having policy implications. We analyse the determinants of growth considering a series of variables such as urban population, human capital, labour force, international trade flows, and surface area.

The paper is organized as follows. The second section presents the review of literature and the empirical models. The third presents the methodological approach model and model specification using panel data approach. In static panel data, pooled OLS, fixed-effects (FE) and random-effects (RE) estimators are used in this type of study. The RE estimator was excluded because our sample is not random. Furthermore, the Hausman test rejects the null hypothesis RE versus FE. We also introduced Tobit model to evaluate the expected signs. With dynamic panel data we used GMM-system estimator. This estimator permits the researchers to solve the problems of serial correlation and endogeneity. These econometric problems were resolved by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) who developed the first –differenced GMM (GMM-DIF) estimator and the GMM system (GMM-SYS) estimator. We introduced the criterium of Windmeijer (2005).The forth section concludes the paper results.

AGGLOMERATION, ECONOMIC GROWTH AND EMPIRICAL STUDIES

The new economic geography was driven by Paul Krugman (1991). The author emphasized the monopolistic competition models of increasing returns to scale in international trade, specifically the intra-industry trade with the classical theories of location. The article of Leitão (2011) presents a survey of these theories.

The central question was based on the optimal production. A few years later, with Martin and Ottaviano (1999), Fujita and Thisse (2002) and Baldwin and Martin (2004) could explain the phenomena of urban agglomeration on economic growth.

Modern economic growth theory (Romer 1990) incorporates endogenous growth where it coexist technological progress and international trade under imperfect competition. In this context, we present the following formalization:

$$Y = K^{(1-\beta)}(AL)^{\beta} \qquad (1)$$

Where Y is national income, K = physical capital, L = human capital; The technical progress is embedded in human capital.

However, the question of our study, the correlation between agglomeration and economic growth dates back to the hypothesis of Williamson (1965). The author suggested that the agglomeration contributes to economic growth at an early stage of development of an economy.

Empirical studies show that most explanatory variables used to assess this relationship are the urban agglomeration, international trade, human capital and labour force.

Regarding the correlation between agglomeration and economic growth there are different types of point of view. Martin and Ottaviano (1999), Fujita and Thisse (2002), Crozet and Koeing (2007) and Baldwin and Martin (2004) argue that agglomeration promotes economic growth. From Williamson's (1965) point of view, this relationship is not peaceful. The empirical study of Ades and Glaeser (1995) at the country level for the time period from 1970 to 1985 shows that the variables are negatively correlated with urban and economic growth. Also Henderson (2003) shows a negative correlation existing between the agglomeration and real growth.

Despite the importance of international trade for economic growth, this topic is the subject of debate for decades (Rodriguez and Rodrik, 2000; Krugman and Livas 1996) seems to show some disbelief for impact, since this has an impact on human capital and labour force. Recently, the empirical studies show that international trade promotes economic growth (Levine and Carkovic 2002; Jallab et al. 2008; and Wijeweera et al. 2010) and this is also our understanding.

As regards human capital (education), empirical studies (Levine and Carkovic 2002; Bertinelli and Black 2004 and Wijeweera et al. 2010) found a positive association.

The literature (Jonhhson 2006; Wijeweera et al.2010) shows a positive association between labour force and economic growth. Empirical studies corroborate the theoretical models of endogenous growth (Romer, 1990).

ECONOMETRIC MODEL: EXPLANATORY VARIABLES AND DATA MODEL DESCRIPTION

For the researchers, urban population living in the biggest city is the most common variable used in econometric models of agglomeration and economic growth.

In our empirical analysis, the estimation considers the economic growth from European Union (EU-27), the United States, Japan, New Zealand and Mexico. The collected data cover the period from 1990 to 2008.

First of all the descriptive statistics for panel data is reported in table 1.

Table 1: Descriptive statistics for panel data

Variables	Mean	Std Dev	Minimum	Maximum	Skewness	Kurtosis	Coefficient of Variation
LogGDP	6.181	0.976	4.846	8.989	1.442	1.798	0.953
LogURBAN	1.335	0.260	0.632	1.781	-0.587	0.452	0.068
LogSCHOOL	9.260	1.193	5.155	12.643	0.247	0.698	1.423
LogLABOUR	0.601	0.052	0.506	0.713	0.039	-1.103	0.002
LogTRADE	1.847	0.208	1.278	2.266	-0.295	0.176	0.043
LogAREA	7.231	0.518	6.870	8.710	1.986	2.235	0.269

Following the literature review, we consider that agglomeration and economic growth is a function of urban population, human capital, and labour force, international trade, and surface area.

$$GDP = f(URBAN, SCHOOL, LABOUR, TRADE, AREA) \quad (2)$$

Where

GDP, is the real GDP per capita; *URBAN* is population in urban agglomeration; *SCHOOL* is the human capital, i.e schooling; *TRADE* is the bilateral trade; *AREA* is the surface area.

A series of hypothesis were formulated, considering how the selected variables will influence the growth.

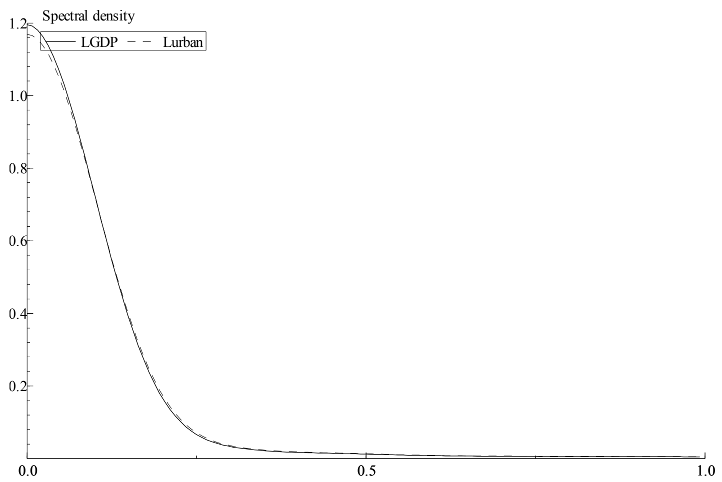
Hypothesis 1: The growth will be influenced by urban agglomeration.

We employ two proxies to evaluate the urban agglomeration. First, *URBAN* is the population in urban agglomerations of more than one million in the country's population living in metropolitan areas and was collected from United Nations, World Urbanization Prospects. We also consider the surface area (*AREA*), i.e, a country's total area, including areas under inland bodies of water and some costal waterways. The source of this variable is Food and Agriculture Organization.

According to the dominant paradigm, we expected that urban agglomeration promotes the economic growth. Therefore, the expected sign for the estimated coefficient of this variable is positive (Martin and Ottaviano 1999, Fujita and Thisse, 2002).

In figure 1 we can see the relationship between economic growth and urban agglomeration.

Figure 1: The Density between economic growth and urban agglomeration



However Williamson (1965) suggested that agglomeration promotes economic growth at an early stage of development. The results of Bertinelli and Black (2004) and Brulhart and Sbergami (2008) prove this.

Hypothesis 2: The agglomeration induces human capital accumulation.

The human capital (schooling) data were collected from the World Bank. According to empirical works (Henderson et al. 2001; Carkovic and Levine 2002; Wijeweera et al. 2010, Brullhart and Sbergami 2009) we expected a positive sign.

Hypothesis 3: The labour force enhances economic growth.

This variable is introduced in the study aimed at evaluating the effect of labour on growth. The variable was collected in the OECD.

LABOUR, represents the annual growth rate of the labour force. Jonhson (2006) and Wijeweera et al. (2010) found a positive sign.

Hypothesis 4: Economic growth is directly influenced by international trade flows.

In our study we consider that the volume of trade is hypothesized to affect the economic growth. We enclose trade flows in economic growth estimation is in line with that of Wijeweera et al. (2010), Jallab et al. (2008). Trade openness was estimated as:

$$TRADE = \frac{X_i + M_i}{GDP} \quad (3)$$

Where

X_i represents the annual exports of each country at time t and M_i represents the annual imports from each country. GDP is GDP per capita. The data were collected from World Bank. We expect a positive sign for this variable.

The econometric model on growth takes the following representation:

$$LogGDP_{it} = \beta_0 + \beta_1 Log(URBAN)_{it} + \beta_2 Log(SCHOOL)_{it} + \beta_3 Log(LABOUR)_{it} + \beta_4 Log(TRADE)_{it} + \beta_5 Log(AREA)_{it} + \partial t + \eta_i + \varepsilon_{it}$$

Where GDP_{it} the real GDP per capita; X is a set of explanatory variables. All variables are in the logarithm form; η_i is the unobserved time- invariant specific effects; δt captures a common deterministic trend; ε_{it} is a random disturbance assumed to be normal, and identically distributed (IID) with E (ε_{it}) =0 ; Var(ε_{it})=σ^2 >0.

The model can be rewritten in the following dynamic representation:

$$LogGDP_{it} = \rho LogGDP_{it-1} + \beta_1 Log(URBAN)_{it} + \beta_2 Log(SCHOOL)_{it} + \beta_3 Log(LABOUR)_{it} + \beta_4 Log(TRADE)_{it} + \beta_5 Log(AREA)_{it} + \delta t + \eta_i + \varepsilon_{it}$$

RESULTS AND DISCUSSION

Given the model and data in which fixed effects estimation would be appropriate, Hausman-test whether random-effects estimation would be almost as good. The Hausman test rejects the mull hypothesis random-effects versus fixed effects. In our case, the random-effects were excluded because our sample is not random.

Table 2: Hausman test

Null Hypothesis : GLS estimates are consistent
Asymptotic test statistic : Chi- square (2) = 20.794
P-value=0.000

The results of fixed effects estimator are reported in table 3. The general performance of the model is very satisfactory. The explanatory power of the agglomeration and growth regression is very high (Adjusted R- squared=0.944). According to the results, the variables have the expected signs and level of significance. The estimative show that *LogSCHOOL*, *LogLABOUR*, *LogTRADE*, and *LogAREA* are significant level of 1%. *LogURBAN* is significant at 5%.

Table 3: Agglomeration and growth: Fixed Effects

Variables	**Coefficient**	**t-Statistics**	**Expected Sign**
LogURBAN	3.192	(2.078)**	(+;-)
LogSCHOOL	0.042	(2.579)***	(+)
LogLABOUR	28.042	(12.427)***	(+)
LogTRADE	0.582	(3.917)***	(+)
LogAREA	0.073	(3.713)***	(+)
Observations	234		
Adjusted R-squared	0.944		

T- Statistics (heteroskedasticity corrected) are in brackets.
***/** - statistically significant at 1% and 5% level, respectively.

The sign of *LogURBAN* is positive, indicating that growth is highly correlated with urban agglomeration (Martin and Ottaviano, 1999; Fujita and Thisse, 2002). A 1% increase in agglomeration (*URBAN*) leads to a 3.192 % increase in economic growth.

We expect that schooling (*SCHOOL*) has a positive impact on the economic growth. The estimate is according to Carkovic and Levine (2002), and Wijeweera et al. (2010). The result indicates that human capital promotes the economic growth. An increase of 1% of schooling would generate 0.042 % increased in growth.

The variable labour (*LogLABOUR*) finds a positive sign, as we expected, and corresponds to the results of Jonhson (2006) and Wijeweera et al. (2010).

According to empirical literature (Carkovic and Levine 2002; Jallab et al. 2008; Wijeweera et al. 2010), the coefficient of international trade would have a positive impact on the economic growth. Our result indicates that international trade is an important vehicle to expand the economic growth.

The variable surface area (*AREA*) finds a positive sign, as we expected, and corresponds to the theoretical paradigm (Martin and Ottaviano, 1999; Fujita and Thisse, 2002). The panel data of Brulhart and Sbergami (2009) applied to European countries found a positive correlation between population density and economic growth.

The table 4 reports the estimative using Tobit model. All explanatory variables are significant a 1% level.

In table 4 we can observe the relationship between agglomeration and economic growth using Tobit model. All variables are significant at 1% level (*LogURBAN, LogSCHOOL, LogLABOUR, LogTRADE, LogAREA*).

The agglomeration (*URBAN*)presents a positive sign, this result is according to the hypothesis formulated. A positive effect of schooling (*SCHOOL*) on economic growth was expected and the results confirm this. The coefficient of labour force (*LABOUR*) is positive with significance. The variables bilateral trade (*TRADE*) and surface (*AREA*) have also the expected signs.

Table 4: Agglomeration and growth: Tobit Model

Variables	**Coefficient**	**t-Statistics**	**Expected Sign**
LogURBAN	1.185	(6.144)***	(+;-)
LogSCHOOL	0.370	(8.118)***	(+)
LogLABOUR	8.544	(6.216)***	(+)
LogTRADE	1.316	(4.063)***	(+)
LogAREA	-0.311	(-3.549)***	(+)
C	-4.158	(-2.954)***	
SIGMA	0.658	(21.633)***	
Observations	234		
Log likelihood	-234.394		

T- Statistics (heteroskedasticity corrected) are in brackets.
***/- statistically significant at 1% .

Table 5 reports on the GMM-System output with orthogonal transformation of data. The equation presents consistent estimates, with no problems with the validity of Ar(2). The Sargan test shows that there are no problems with validity of instruments used. We used the criterion of Windmeijer (2005) to small sample correction. The instruments in levels used are LogGDP (3,7), LogURBAN (3,7), and LogTRADE (3,7) for first differences. For levels equations, the instruments are used first differences all variables lagged t-2. As show in table 5, all explanatory variables are significant ($LogGDP_{it-1}$, at 1%, LogURBAN at 5%, LogSCHOOL at 10%, LogLABOUR, at 5%,LogTRADE at1%, and LogAREA at 5% level significant).

As expected the lagged dependent variable ($LogGDP_{it-1}$) has a significant and positive effect. The agglomeration (LogURBAN) has a negative sign, our result validates the hypothesis of the growth will be influenced by urban agglomeration. The coefficient of human capital (LogSCHOOL) presents a positive sign. The variable labour force (LogLABOUR) presents a positive sign, which confirms that labour force enhances economic growth. For the proxy LogTRADE the expected sign is positive, and this is confirmed by the estimation.

Table 5: Agglomeration and growth: GMM-System

Variables	GMM-SYS	*t*-statistics	Expected Sign
$LogGDP_{it-1}$	0.950	(4.35)***	(+)
LogURBAN	0.834	(2.24)**	(+;-)
LogSCHOOL	0.013	(1.68)*	(+)
LogLABOUR	1.001	(2.63)**	(+)
LogTRADE	0.115	(1.82)*	(+)
LogAREA	0.041	(2.56)**	(+)
Observations	234		
Arellano-Bond test for Ar(2) (P-value)	0.47		
Sargan test (P-value)	1.00		

The null hypothesis that each coefficient is equal to zero is tested using one-step robust standard error. T-statistics (heteroskedasticity corrected) are in round brackets. P-values are in square brackets; ***/**/*- statistically significant at the 1%, 5%, and 10% levels. M2 is tests for first-order and second–order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null hypothesis of no serial correlation (based on the efficient two-step GMM estimator). Sargan is a test of the over-identifying restrictions, asymptotically distributed as under the null of instruments' validity (with two-step estimator).

CONCLUSIONS

This research adds significant contribution to the economics because as noted by Brulhart and Sbergami (2009), little academic attention has been devoted to the influence of urban agglomeration on economic growth. In order to properly evaluate this paradigm we introduce variables typically seek models of exogenous and endogenous economic growth. The selected explanatory variables (urban agglomeration, international trade, human capital and workforce) were based on empirical studies conducted in the area

The study investigates the connections between urban agglomeration and economic growth. Our results provide empirical value for the validity of hypothesis formulated. All of the independent variables are robust with the static and dynamic panel data. Generally, these estimates are in line with the results of previous empirical studies. From our results we can infer the following: i) the urban agglomeration promotes economic growth, which is validated by several studies (Martin and Ottaviano, 1999, Fujita and Thisse, 2002, Baldwin and Martin, 2004), ii) the result obtained for a coefficient of schooling is according to Carkovic and Levine 2002, and Jallab et al. 2008; iii) International trade and labor force are consistent with the literature.

This research need to extend as other factors have influence on the economic growth such as life expectancy, government consumption, the price level of investment expenditure.

REFERENCES

Ades, A., Glaeser L. (1995) Trade and Circuses: Explaining Urban Giants, *Quarterly Journal of Economics*, 110(1): 195-227.

Arellano, M , Bond S.(1991) Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations, *Review of Economic Studies*, 58(2): 277-297.

Arellano, M, Bover O. (1995) Another Look at the Instrumental Variable Estimation of Error-Components Models, *Journal of Econometrics*, 68(1): 29-52.

Bertinelli, L., Black D. (2004) Urbanization and Growth, *Journal of Urban Economics*, 56(1): 80-96.

Blundell, Richard and Stephen Bond (1998) Initial conditions and moment restrictions in dynamic panel data models, *Journal of Econometrics*, 87(1): 115-143.

Brullhart M. and Sbergani F (2009) Agglomeration and Growth: Cross-Countries Evidence, *Journal of Urban Economics*, 65(5): 48-63.

Baldwin, E., Martin P (2004) Agglomeration and Regional Growth in: Henderson, J. Vernon and Jacques-François Thisse (eds.) Handbook of Regional and Urban Economics, Volume 4: *Cities and Geography*, Elsevier North-Holland.

Bairoch, P (1993) *Economics and World History: Myths and Paradoxes*. Chicago University Press.

Carkovic M., Levine, R. (2002) Does Foreign Direct Investment Accelerate Economic Growth? W/P nº2, Department of Business Finance, University of Minnesota.

Crozet, M., Koenig P. (2007) The Cohesion Vs Growth Trade: Evidence from EU Regions, Mimeo, University of Paris 1.

Fujita, M, Krugman, P, and Venables, A (1999) *The Spatial Economy*, MIT Press, Cambridge, Massachussets.

Fujita, M, Thisse J. (2002) *Economics of Agglomeration: Cites, Industrial Location, and Regional Growth*, Cambridge University Press.

Henderson, J. Vernon, Z., and Venables A. (2001) Geography and Development. *Journal of Economic Geography*, 1(1): 81-105.

Henderson, J. Vernon, Z. (2003) The Urbanization Process and Economic Growth: The So-What Question, *Journal of Economic Growth*, 8(1): 47-71.

Hohenberg, P, and Lynn H. L. (1985) *The Making of Urban Europe,* Harvard University Press.

Hohenberg, P (2004) The Historical Geography of European Cites: An Interpretative Essay, in: Henderson, J. Vernon and Jacques – François Thisse (eds) *Handbook of Regional and Urban Economics*, Volume 4: Cities and Geography, Elsevier North-Holland.

Johnson, A (2006) The Effects of FDI Inflows on Host Country Economic Growth, CESIS, W/P nº58, Royal Institute of Technology, Sweden.

Jallab M, Gakou M, and Sandretto R. (2008) Foreign Direct Investment Macroeconomic Instability and Economic Growth in MENA Countries, W/P, GATE, UMR 5824 du CNRS.

Krugman, P. (1991) *Geography and Trade*, MIT Press, Cambridge, Massachussets.

Krugman, P., Livas R. (1996) Trade Policy and the Third World Metropolis, *Journal of Development Economics*, 49 (1): 137-150.

Martin, P, Ottaviano, G. (1999) Growing Localizations: Industry Localization in a Model of Endogenous Growth, *European Economic Review* 43(2): 281-302.

Leitão,N. C. (2011) United States' Intra-Industry Trade, *Ekonomska Istrazivanja - Economic Research*, 24(2):68-76.

Romer, M. (1990) Growth Based on Increasing Returns Due to Specialization, *Journal of Political Economy* 94(5): 71-102.

Wijeweera A, Villano R, and Dollery B. (2010) Economic growth and FDI Inflows: A Stochastic Frontier Analysis, W7P, University of New England, Australia.

Williamson, J.G. (1965) Regional Inequality and Process of National Development, *Journal of Economic Literature*, 37 (1):112-156.

Windmeijer, F (2005) A Finite Sample Correction for the Variance of Linear Efficient Two-Step GMM Estimators, *Journal of Econometrics*, 126(1): 25-51.

Sala-i-M, Xavier, D, and Miller, R (2004) Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach, *American Economic Review,* 94 (4):813-835.