

The Communication and European Regional Economic Growth: the Interactive Fixed Effects Approach

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Abstract

Following the frontier framework of the panel data models with the interactive fixed effects, it has been applied to the determinant factors analysis in the European regional economic growth in 268 regions or 4020 observations from 2000 to 2014. The regional communication might provide the supplementary positive effects on the European regional economic growth, where the population and educational attainment level are negative correlated to the regional economic growth. The regional human resources in science and technology remain the domination power as one of the regional economic engines in European Union after the millennium.

Keywords:

growth, panel data, interactive fixed effects, Europe

1. Introduction

There is a long history of the continental economic integration of the European countries. The Treaty establishing the European Coal and Steel Community (1951) created interdependence in coal and steel, which made one country could no longer mobilize its armed forces dependently. The Treaties of Rome (1957) established the European Economic Community (EEC) and the European Atomic Energy Community (EURATOM), which extended the European integration including the general economic cooperation. The Treaty on European Union (Maastricht Treaty, 1992) prepared for European Monetary Union and introduced citizenship, common foreign and internal

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affairs policy, which strengthened the economic and social cohesion without internal frontiers, and ultimately leading to a single currency.

The partial regional factor mobility gradually comes into the reality after the struggling constitutional efforts. Treaty of Amsterdam (1997), Treaty of Nice (2001) and Treaty of Lisbon (2007) amended the founding treaties to make the European Union more efficient and transparent for membership enlargement. In order to preserve the single currency stability, and enhance the Member States convergence of economic, fiscal and labor market policies, the continuous legislative proposals have been recently consolidated and complemented in Economic and Monetary Union since the European sovereign debt crisis.

Regional imbalance actually exists everywhere between EU15 countries and EU28 countries. The factors accumulation persistently facilitates the economic development into the booming prosperity in the center regions, when the refugees are hardly migrating for the better survival standards than their home country. There actually exists the same allocation puzzle of capital (Gourinchas and Jeanne, 2013) in the dispersed regions of the European countries. From the logarithm measurement of the European regions in Figure 1, there is a considerable distance in GDP between Canarias (ES70) and le de France (FR10), the two most popular tourist regions over the last five years. There is the floating differentials drifted in tourist accommodation occupancy between the regions in the similar magnitude of GDP, separating the regions into the higher-popularity tourist regions and lower-attraction tourist regions.

The first contribution of the paper is introducing the empirical inference of the new generation panel data models into endogenous growth framework of the region level of the European Union. The interactive fixed effects is the feasibly smooth semi-parametric methodology to estimate the arbitrary temporal heterogeneity with large number of units and number of time periods. There are 268 regions from the yearly observation from 2000 to 2014 in the estimation procedures to avoid the limitation of the traditional panel data models.

The possible economic explanations of the communication measurement is the second contribution of the empirical framework. The significant positive correlation between the occupancy and regional GDP implies that there exists the complementary effects and substitution effects of the compounding factor mobility after the millennium in the European Union. The regional economic growth is potentially generating from the physical capital, human



Figure 1: Communication Measurement of the European Regional GDP
Sources: the statistical office of the European Union (Eurostat)

resource and innovative technology accompanying with the arrival tourist of the destination regions.

The paper eventually contributes to the new alternative measurement for economic activities in advanced economies. The empirical results highlight quantification of the additional driven power of communication measurement as the European regional economic determinants. There are many existing variables to describe the economic growth, e.g., the night time satellite lights (Pinkovskiy and Sala-I-Martin, 2016) in the emerging market economies, the financial integration (Chakraborty, Hai and Holter, 2017) in Europe, external innovations from small firms (Akcigit and Kerr, 2018) in United States, institutional convergence (Alesina, Tabellini and Trebbi, 2017) as

Lisbon Strategy, and earlier urban agglomeration into cities (Henderson et al., 2018).

There are several strands of literature related to the paper. The first strand is recently studying human resources and economic growth in Europe. Aubry, Burzyński and Docquier (2016) explain the market size effects of the global immigration in OECD countries that the migration affects the aggregate demand for goods and services in the receiving and sending countries with constraint of the firms' entry and exit decisions and number of entrepreneurs, and the amount of consuming goods available. Conti and Sulis (2016) consider the interaction of employment protection legislation (EPL) and TFP growth differentials in manufacturing and service sectors in 14 EU countries. Battisti et al. (2018) explain the labor market competition with the complementarity channel and job creation channel in the separate calibration for 20 OECD countries.

The second strand researches highlights the patent rights and heterogeneous innovation. Akcigit and Kerr (2018) classify the innovation into two types, the external innovation creating for the new products markets, and internal innovation improving for the current products lines. Akcigit, Celik and Greenwood (2016) match up with stylized facts about patent market searching frictions and patent reassignments in United States, shedding light on the firm level ideas licensing or litigation activities and economic growth. Galasso and Schankerman (2015) estimate causal effect of patent protection on cumulative innovation from the decisions of the U.S. Court of Approval for the Federal Circuit.

The remainder of the paper is organized as follows. Section 2 reviews the literature from the growth theories to the econometric methodologies. Section 3 introduces the Eurostat data. Section 4 outlines and discusses the empirical applications of interactive fixed effects. Section 5 checks the robustness. Conclusion is in Section 6. The data and replication codes are organized in the contribution repository (<https://github.com/kautu/ereg>).

2. Literature Review

Theoretically and empirically, the neoclassical growth model has been further developed and broadly extended through tremendous and persistent endeavor by the contemporary economists. It is physical capital, population, human capital and technology that primarily determine the economic growth from the previous classical relevant literature. Durlauf, Johnson and

Temple (2005) summarize 145 variable regressors of the economic growth determinants in their survey in depth and synthesis in detail, as the explanatory variables could be roughly categorized into institutional measurement, demographic characteristics, macroeconomics fundamentals, geography endowments and cultural differences.

Barro (1991) demonstrates that the main economic growth determinants are the education quality of the initial human capital and the initial real per capita GDP in the cross sectional growth approach for 98 countries from 1960 to 1985. Barro and Sala-I-Martin (1992) provide the principal evidence that the poor regions grow faster than the rich ones in cross sectional convergence study across 48 contiguous states in United States from 1963 to 1986. Barro (2012) reexamines the iron law of convergence in the international panels including country fixed effects over 10 five-years intervals from 1960-65 to 2005-09. Mankiw, Romer and Weil (1992) describe the economic growth correlated with the accumulation of physical capital, higher quality of human capital and higher population growth within the endogenous-growth model framework for 121 countries from 1960 to 1985.

Romer (1986) presents the competitive equilibrium model with endogenous technological change, as suggested that the economic growth is primarily driven by both increasing marginal productivity of knowledge and decreasing marginal productivity of physical capital. Romer (1990) explains three basic premises including technological change or improvement, knowledge translation into market practices and non-rivalry and partial excludability of technology. Romer (1987) follows the decentralized dynamic monopolistic competitive equilibrium framework with specialization and variety in production. Aghion and Howitt (1992) introduce the economic growth resulted from industrial innovations and product obsolescence through Schumpeter's process of creative destruction, and Howitt (1999) further analyzes the positive effect of R. & D. subsidies on economic growth.

From government taxation and economic policy analysis, Rebelo (1991) implicates that the lower economic growth was translated from higher income tax rates and poorer property rights enforcement. Recent studies have focused on the taxation effects about international mobility of special talent and migration skill, specifically segmenting on European professional football market by Kleven, Landais and Saez (2010), and particularly highlighting on top superstar patent inventors by Akcigit, Baslandze and Stantcheva (2016). Bosetti, Cattaneo and Verdolini (2015) show that a larger pool of migrants in the skilled professions is associated with higher levels of knowledge creation.

The seminal paper of Sala-I-Martin, Doppelhofer and Miller (2004) first propose the alternative Bayesian Averaging of Classical Estimates (BACE) method for determining the significant cross-sectional growth variables in 88 countries. Using Latent Class Analysis methods, Cuaresma et al. (2016) identify the dependency structures among variables in terms of posterior inclusion probability patterns across the specifications in Dirichlet Process clustering. Rockey and Temple (2015) revisit theoretical arguments on Bayesian Model Averaging, reviewing the empirical approaches in identifying the cross-sectional economic growth determinants.

Econometric methodologically, panel data model has been widely studied and broadly applied in economics literature and social science research. There are plenty of solid improvements and practical contribution to interpret and understand the empirical facts in terms of the delicate alternative structures. Durlauf, Johnson and Temple (2005) thoroughly discuss the economic growth implementation and inevitable limitations of the traditional classical panel data approaches.

The second generation of the panel data is the interactive fixed effects model. Bai (2009) considers the identification, consistency and the limiting distribution of the interactive fixed effects estimator in panel data models with large N (the number of units) and large T (the number of time periods). Kneip, Sickles and Song (2012) propose a semi-parametric method for arbitrary temporal heterogeneity in panel data models without any explicit restrictions on the temporal pattern of individual patterns, as combining smoothing spline techniques with principal component analysis. Following the progressing trends of those evolutionary estimation procedures, Bada and Liebl (2014) publish the compiled R package *phtt* for panel data with general forms of unobservable heterogeneous effects in large dimensions of N and T . Bai and Liao (2017) estimate high-dimensional inverse covariance matrix, with cross-sectional correlations and heteroskedasticity.

There are cumulative amount of simulation literature in determining the number of factors, e.g. the panel criteria and Bayes information criterion by Bai and Ng (2002), eigenvalue ratio and growth ratio by Ahn and Horenstein (2013), and empirical distribution of the sample covariance eigenvalues by Onatski (2010). Thereafter, Moon and Weidner (2015) comment that the limiting distribution of the least squares estimator is independent of the number of factors, when it is assumed to be not underestimated in the interactive fixed effects.

Group effects estimators have been the natural economics implementation

and financial practices. Bester and Hansen (2009) assume that the individual specific parameters are common across the groups at some level when the membership is grouped on the multiple observable variables, but Lin and Ng (2012) create the pseudo threshold variables to partition the panel data into the clustering groups when group membership is unknown. Bonhomme and Manresa (2015) recently exploit the K-Means algorithm for time-varying grouped patterns of unobserved heterogeneity in linear panel data models.

3. Data

The NUTS level 2 regions data are released from the *statistical office of the European Union* (Eurostat), including 268 regions or 4020 observations from 2000 to 2014, primarily for the 28 Member States of the EU, and for the EFTA and candidate countries. The NUTS (*Nomenclature des Units territoriales statistiques*) classification is the geographical nomenclature subdividing the economic territory of the European Union into regions at three different levels, covering NUTS levels 1, 2 and 3, respectively from larger to smaller areas, as is based on Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics. Population of NUTS level 2 regions ranges from 800 thousand to 3 million, and the administrative structures are reserved in priority. More regional data information refers to the Eurostat Regional Yearbook (European Union, 2016).

The regional gross domestic product (GDP) is regional specification of the national accounts in European System of Accounts in the European Union of 2010 (ESA 2010), as the indicator is the primary measurement in the commensurate comparison of the regions economic activities. Both the million euro measurement and the purchasing power standards (PPS) conversion have been considered in our economic performance analysis within the European regional growth. The regional employment thousand hours worked (emhrw) illustrates the regional average balance between work and leisure time in the overall regional productivity standards. The employment working hours describe the total proportional working time allocated to the economic productive activities subject to the social rationality and moral sentiments.

The regional gross fixed capital formation (GFCF) is the regional GDP component of the output approach, which consists of the resident producers' acquisitions, less disposals, of fixed assets during a given period plus certain additions to the value of non produced assets realized by the productive

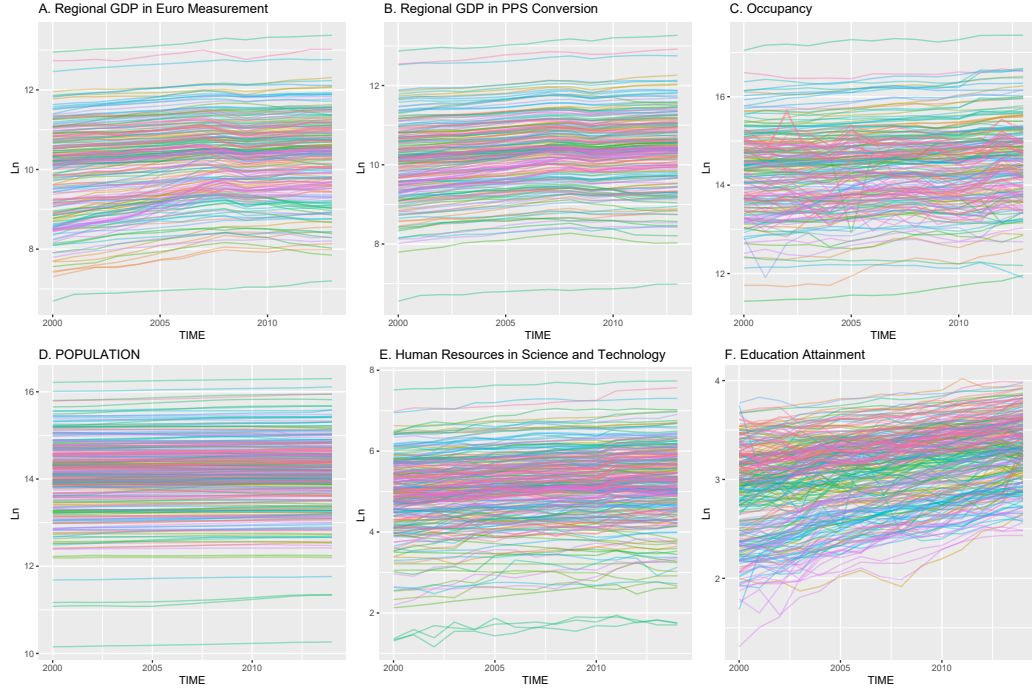


Figure 2: Dependent Variables and Explanatory Variables
Sources: the statistical office of the European Union (Eurostat)

activity of producer or institutional units. The regional variable identifies the production process of both tangible and intangible assets produced as outputs used repeatedly and continuously.

The principal regional communication variable is the tourist arrival accommodation occupancy, measured by the number of the total nights spent of hotels and other short-stay accommodation establishments by residents and non-residents. The tourist accommodation capacity is measured by bedroom occupancy rates in hotels and equivalent accommodation establishments. The tourism consumption patterns are simultaneously composed from the private visitors and business visitors, despite the unavailable regional data to separate the major purposes of the arrival tourists.

The population, high quality human resource and education attainment are the growth determinants in the classical growth studies. The regional population is quantified by the total region residence number with the NUTS 2 level. The human resources in science and technology (hrst) represents for the persons employed in science and technology as the high qualified

personnel capacity of the high-technology manufacturing industries and the knowledge-intensive services. The regional educational attainment level (edat) is the percentage of the individuals aged from 25 to 64 who have successfully completed short-cycle tertiary education (the bachelor, master or doctoral degree) or the equivalent level from the International Standard Classification of Education (ISCED 2010) categories.

4. Empirical Study of Interactive Fixed Effects

4.1. Interactive Fixed Effects of the Growth

Following the spirit of Solow Swan Model, the section empirically studies the economic growth from the constant returns to the scale Cobb-Douglas production function. K is capital, H is stock of human capital, A is technology, L is employment. The Output is given as,

$$Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta} \quad (1)$$

Assume that the physical capital has the free mobility across the regions at least inside the European Union, and the aggregate stock of capital almost remains unchanged in the European Union. The investment is adequate and accessed smoothly without the searching frictions. For the single region i at time t yearly,

$$GDP_{it} = \underbrace{e^{Region_{it}}}_{Unobserved} \cdot \underbrace{Communication_{it}^\eta}_{Mobility} \cdot \underbrace{Population_{it}^\alpha HRST_{it}^\beta EDAT_{it}^\gamma}_{GrowthDeterminants} \quad (2)$$

In decomposition of the output in equation (2), the population, human resources in science and technology, and education attainment are the observed growth determinants in classical growth studies. The communication measurements are the observed variables of the structural mobility for the alternative additional growth. The other regional differences are the unobserved regional variable constituting from the factors of macroeconomic volatility, geography persistence, institutional convergence and cultural heterogeneity. There are the interactive fixed effects and idiosyncratic components in the regional variables.

$$Region_{it} = \underbrace{\lambda'_i \cdot f_t}_{interactive} + \underbrace{u_{it}}_{idiosyncratic} \quad (3)$$

Table 1: COMMUNICATION FACTORS OF EUROPEAN REGIONAL GDP DETERMINANTS

	(1)	(2)	(3)	(4)	(5)	(6)
intercept	9.9800 (0.0959)***	10.0000 (0.0814)***	9.9800 (0.0875)***	10.0000 (0.0766)***	9.9800 (0.0875)***	10.0000 (0.0766)***
ln Arrival	0.1960 (0.0060)**	0.1640 (0.0051)**				
ln Occupancy			0.0206 (0.0059)***	0.0190 (0.0052)**		
ln Capacity					0.0206 (0.0059)***	0.0169 (0.0052)**
interactive	none	two-ways	none	two-ways	none	two-ways
dimensions	4	3	4	3	4	3
observation	2842	2842	2842	2842	2842	2842
R ²	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999

Standard errors of coefficients are presented under the parentheses below. Following the time-varying individual effects of Kneip, Sickles and Song (2012), the regional output is measured with the PPS conversion. The column (1), (3), and (5) omit the interactive fixed effects, and column (2), (4), and (6) implement two ways interactive effects of individual and time effects. The interactive effects are centered around the overall mean. The statistical significance levels: *** less than 0.001, ** 0.001, * 0.05.

Following the new generation procedures by Kneip, Sickles and Song (2012), I estimate the linear panel regression model with cross-sectional dimension N , time-serial dimension T , and interactive fixed effects. Herein, $\lambda_i f_t$ is the time-varying individual fixed effects, λ_i is the unobserved individual loading parameters, f_t is the unobserved common factors, and u_{it} is the idiosyncratic error term. The occupancy is prominent factor in the interplay within the interactive fixed effects model to the endogenous growth framework.

4.2. Communication Factors of European Regional GDP Determinants

The first model quantifies the relationship between the communication factors and European regional economic growth on both sides logarithm of the equation (2) without spelling the traditional determinants. Table 1 describes the similar identical results respectively on tourist nights spent, tourist arrivals and tourist accommodation capacity. The regional communication measurements are statistically significant on the PPS converted European regional GDP. It indicates that communication factors alternatively measure the European regional economic activities, at least from the short time span after the millennium.

There are several possible explanations in the positive correlation of the communication measurement. The first transmission channel is the market size effect of the arrival tourists. The tourist demand for the goods and services expands the aggregate consumption amount in the receiving regions. The market size effect is the contemporary consumption transition of the essential necessity and extraordinary luxuries accompanying by the tourist arrivals. The market size effect of the tourists resembles the aggregate market soaring from the immigration, but differs from arrival purposes. The arrival tourist provides the abundant opportunities of factor mobility. The ongoing continuous migration are transmitted from the structural inequality worldwide.

The second transmission channel is the natural regional persistence.¹ The regional persistence dynamically reflects regional attraction of arrival tourist and transferring immigration. The tourist and migration with special talents smoothly transfers the high quality of human resources into the universal attractive regions. The earlier arrival tourist or immigration of the superstar inventors would be the new innovation creator and the additional high technology inventor. The persistence permanently generates the strategic decisions steadily constrained to business environment and potential facilitation. The additional physical capital constantly flows to the regional investment with the proportional arrival tourists when physical capital is always accompanying with the business decisions on the particular regional investment opportunities from the travelling around entrepreneurs.

The third channel is the amplification effect from transmission channels of regional attraction and geography persistence, selectively sorting the earlier arrivals into the agglomeration of the productive cities (Behrens, Duranton and Robert-Nicoud, 2014), and high skilled workers learning by working in big cities (De la Roca and Puga, 2017). The entrepreneurs gather the composition factors of physical capital, human capital and technology together into the destination regions. The regional priority with the accumulated factors is beneficial to the economic activities in the long run. The mobility of the accumulation factors intensely follows the steps of the arrival tourists.

¹Henderson et al. (2018) Section II.A.2 review the previous literature about persistence of geography characteristics in regional science and urban economics, decomposing the structural transformation of urbanization and agglomeration into the rising agricultural productivity and falling transport costs.

Table 2: ALTERNATIVE FACTORS OF EUROPEAN REGIONAL GDP DETERMINANTS

	(1)	(2)	(3)	(4)
intercept	11.9000 (2.6300)***	7.7800 (1.9700)***	20.6000 (1.9000)***	17.2000 (1.3900)***
ln Population	-0.1480 (0.1860)	0.1630 (0.1400)	-0.7570 (0.1350)***	-0.5040 (0.0984)***
ln HRST	0.0021 (0.0145)	-0.0181 (0.0113)	0.0276 (0.0106)**	0.0113 (0.0082)
ln EDAT	0.0044 (0.0154)	0.0349 (0.0118)**	-0.0329 (0.0112)**	-0.0148 (0.0085)
ln Occupancy	0.0178 (0.0068)**	0.0049 (0.0052)	0.0194 (0.0049)***	0.0126 (0.0038)***
interactive	individual	two-ways	individual	two-ways
dimensions	3	4	3	4
observation	4020	4020	4020	4020
R ²	0.9990	0.9999	0.9999	0.9999

Standard errors of coefficients are presented under the parentheses below. Following the time-varying individual effects of Kneip, Sickles and Song (2012), the regional output is the euro measurement in column (1) and (3) and measured with the PPS conversion in column(2) and (4). The column (1) and (3) consider the individual effects, and column (2) and (4) implement two ways interactive effects of individual and time effects. The interactive effects are centered around the overall mean. The statistical significance levels: *** less than 0.001, ** 0.001, * 0.05.

4.3. Compounding Power of the Determinants

The following interactive fixed model of equation (2) studies the structural mobility interacted with the traditional growth determinants in Figure 2. There is almost no explanation power of the traditional determinant indicators for economic growth from the euro measurement in column (1) and (2). Obviously, there is the negative driven power from the population, and the positive driven effects from the regional communication indicator in the PPS conversion of column (3) and (4). The human resources in science and technology is positive correlated to the regional economic growth, and the educational attainment level is negative correlated to the regional economic growth, only allowing the individual effects in the interactive fixed effects in column (3).

The regional communication is partially considered as the alternative sup-

plementary driven stress as the economic growth determinant in European Union. The regional population has occasionally proceeded to be the social expenditure burden on regional level. The structural population is greatly diminishing the explanation power to the contemporary economic development after the millennium in Europe than in the other emerging market countries.

The human resources in science and technology actually interprets the high quality personnel and special talent techniques in labor market, and represents for the high quality science and technology in manufacturing industry and knowledge sectors. The empirical results are consistent with the policy assessment in Bosetti, Cattaneo and Verdolini (2015), attracting and employing high skilled migrants in skilled professions, efficiently fosters EU competitiveness in innovation.

It indicates that the high quality human resources are associated with the free mobility across the integrating European regions, even in the scope of the globalization. The high quality employment plays an important role more than the education attainment level in European regional economic growth. The regional education might have been gradually progressing to some saturation point after the millennium in Europe, making the entire working age population adequately educated with the high skills and special techniques to basically satisfy the regional labor demands across regions.

4.4. *Decomposition with the Regional Population*

Rewriting the equation (2) in the decomposition of the regional population according to the previous results, there is the calculated transformation of the estimated indexes $\theta_1, \theta_2, \dots, \theta_5$. The regional output is composed from the several transformed multiplier factors as follows,

$$GDP_{it} = \left(\frac{HRST}{Population}\right)^{\theta_1} \cdot \left(\frac{Occupancy}{Population}\right)^{\theta_2} \cdot \left(\frac{e^{Region}}{Population}\right)^{\theta_3} \cdot \left(\frac{1}{Population \cdot EDAT}\right)^{\theta_4} \cdot \left(\frac{1}{Population}\right)^{\theta_4}$$

The regional national accounts are constitutionally influenced by the multiplier factors such as the proportion of the high qualified employment to the population, the proportion of tourist occupancy to the population, the unobserved heterogeneity relative to the population, the high quality educated population, and the entire regional population. Moreover, the first three multipliers factors have the positive explanation power, accompanying with the negative effects from the last two lagging denominator estimators.

Meaningfully, the first multiplier factor is the knowledge mobility from the high qualified labor market, the second multiplier factor represents for the capital mobility generated from the business tourists, the third multiplier factor denotes the supplementary mobility of the observable heterogeneity,

the fourth multiple factor has been considered as the interactive obstacles and institutional barriers from the expenditure reallocation for high quality education surplus, and the last multiple factor defines the potential aggregate demand for goods and services.

The mobility smoothness would facilitate the regional communication through the regional factor integration, as it seems to be the general insights from the European regional economic growth. The population would be the constraints and limitation of the aggregate demand for goods and services across European regions, as the entire economic activities would be market powerless because of the shrinkage demand of the market size. The meaningful argument of the decomposition is consistent with the second phase of European integration of the single currency from the late 1990s until 2008 (Alesina, Tabellini and Trebbi, 2017).

5. Robustness Analysis

5.1. *K-Means Clustering of the Regional GDP*

Following the spirit of the grouping panel data patterns in Bonhomme and Manresa (2015), the subsection applies the K-Means partitioning the regional GDP into the nearest means groups. The separated estimated parameters figure out the regional differentials from group panel data in interactive fixed effects. Comparing with the main results, the grouped interactive fixed effects estimators provide the alternative interaction perspective of the growth determinants.

Filtering K-Means algorithm to 7 diverged groups, the first grouped regions with the ceiling regions have been omitted in the interactive fixed effects estimation. The first group membership of the ceiling regions are actually the regional center cities and European economic engines with the maximum agglomeration power. There is the biased estimator for the interactive fixed effects for the limited regions coverage in the limited membership group, and there are 6 remaining groups comparatively for the following group approach.

The population remains the negative correlation in the grouped regional economic growth with the statistical significance except for the first two richer grouped regions. The smaller GDP regions are much more suffering from the stagnating population growth than the geography persistence of the larger regions. The geography persistence remains the economic explanation of the grouped differentials. There are much more engine power for the richer group regions than for the poorer group regions.

Table 3: Filtering K-Means Algorithm (K = 7) of Regional GDP

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
intercept	10.5000 (9.5400)	18.0000 (6.0100)**	26.7000 (6.2400)***	23.6000 (7.1300)***	19.0000 (2.8200)***	16.8000 (4.1700)***
ln Population	-0.1250 (0.6040)	-0.5470 (0.3940)	-1.1100 (0.4260)**	-0.9460 (0.4990).	-0.6750 (0.2010)***	-0.5880 (0.3170).
ln HRST	0.1380 (0.0884)	0.0253 (0.0495)	0.0346 (0.0257)	0.0061 (0.0201)	0.0401 (0.0240).	0.0222 (0.0194)
ln EDAT	-0.0016 (0.0999)	-0.1150 (0.0632).	-0.0304 (0.0305)	0.0228 (0.0203)	-0.0391 (0.0270)	-0.0509 (0.0194)**
ln Occupancy	0.1470 (0.0470)**	0.1180 (0.0347)***	0.0277 (0.0107)**	0.0190 (0.0097)*	0.0249 (0.0097)*	0.0042 (0.0100)
Panel B						
intercept	9.5100 (0.7940)***	9.6100 (0.5600)***	24.9000 (6.3800)***	23.5000 (2.8400)***	18.9000 (4.3100)***	17.0000 (0.1480)***
ln Population			-0.9790 (0.4350)*	-0.9340 (0.4960).	-0.6620 (0.2030)**	-0.6030 (0.3280).
ln Occupancy	0.1430 (0.0462)**	0.1130 (0.0342)***	0.0264 (0.0106)*	0.0186 (0.0096).	0.0227 (0.0097)*	
observation	150	285	660	915	990	975

The first cluster of the ceiling regions has been omitted in the following group interactive fixed effect estimation. The average regional GDP is diminishing from the column (1) to (6). In 2014, the average GDP of group in column (2) is 45.24% of column (1), the group in column (3) is 27.87% of column (1), the group in column (4) is 16.95% of column (1), the group in column (5) is 11.08% of column (1), and the group in column (6) is 4.62% of column (1). Panel A empirically checks the compounding power between occupancy and traditional growth determinants. Panel B implements the interactive fixed effects model for complementary effects and substitution effects of the communication measurement interacted with population. The statistical significance levels: *** less than 0.001, ** 0.001, * 0.05, . 0.1.

The human resources in science and technology is the positive determinants of the regional economic growth without the statistical significance. The insignificant explanation power provides the complex interplay with the other determinants. The education attainment almost remains the negative relationship with the regional economic growth, but only the last group of the poorer regions is statistically significant in dragging economic power. There is the exclusive inefficient education in the regional imbalances.

The occupancy is the prominent economic growth determinants in all groups implementation of interactive fixed effects. Contrary to traditional growth determinants, there are the great significant power in explaining the regional growth in the majority of the European regions. The occupancy simultaneously generates economic development in higher developed regions and lower developing regions. The first two richer regions are much more beneficial from the occupancy than the other four remaining groups regions.

The possible explanation is that human resource from periphery regions in Europe and outside Europe are willingly inclined to migrate to the core regions in Europe. The remote periphery regions is the supportive resource foundation for the core developed regions.

5.2. Classification And Regression Tree (CART)

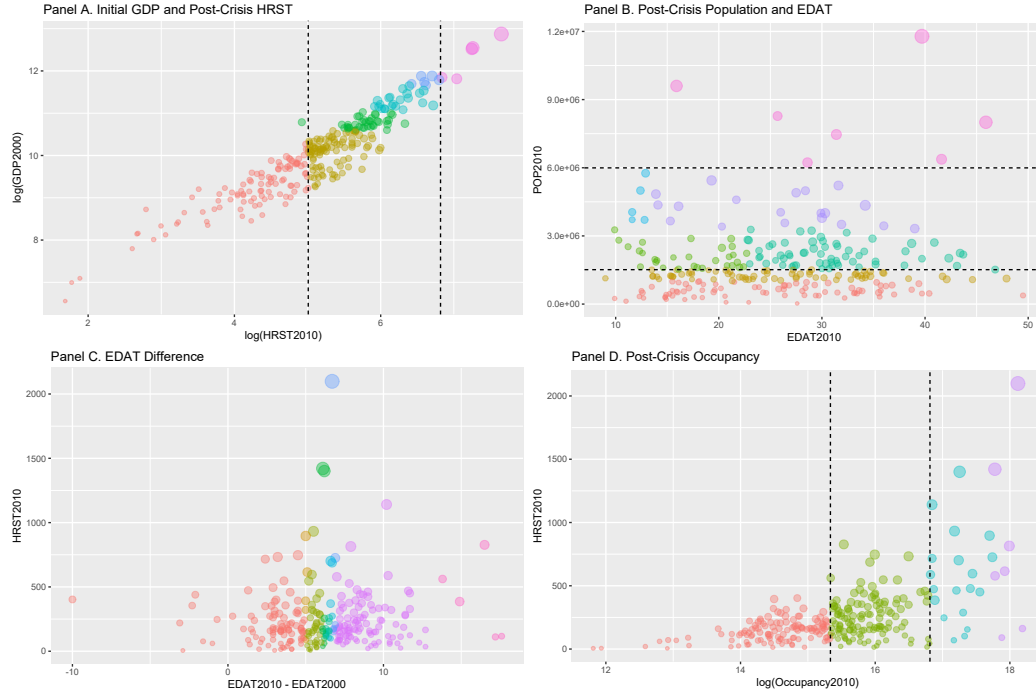


Figure 3: Regional GDP Partitioning Branches

There are four separated CART clustering applications in the diversity segmenting scenarios. The different composition of the variables selections shape the identified clustering patterns of the regional GDP. Panel A checks the relationship between the initial GDP level and post crisis high quality human resources. Panel B illustrates the population categories interacted with education after crisis. Panel C presents the education attainment differences between 2000 and 2010. Panel D provides the upper bound of the occupancy comparing with the high quality human resources after the crisis. The dashed lines are the major splitting nodes of the regression trees. The size of the points represents for the regional GDP level. The different colours are the different clusters from CART.

Inspired from the examination procedures of the Middle-Income Trap Hypothesis with Conditional Inference Regression Tree (Han and Wei, 2017), the subsection presents the regional segmentation with the tree based methods. Applying the classification and regression trees (CART) in the regions clustering, initially innovated from machine learning community (James et

al., 2017) to shape the regional economic growth patterns in the diversity scenarios. There are four diverse separated clusters in dimensional variables in Figure 3.

Panel A checks the linear correlation between the initial economic development level and high-skilled human resource after the crisis. There is the strong positive relationship in virtually all the European regions, and the smaller regions in GDP are more dispersed than the larger regions in GDP. The initial natural persistence is highly consistent with the empirical results in the benchmark models.

Panel B separates the population into three categories by the dashed horizontal lines, illustrating the education in the complicated interplay. In the middle-level population regions, there is the subtle economic driven effects from the education differentials after the crisis. The population is statically the elementary foundation for the economic activities.

In panel C, the most efficient generation powers of education progress is close to the improved education quality of the engine star regions in high-skilled human resources. The upper bound of high quality human resources approximates the quadratic function of education attainment differentials. The ordinary regions in GDP are equally accumulated on both downward sides of the highest differential, and the universal education investment is not the direct cause of the booming prosperity in Europe after the millennium.

In panel D, the upper bound of the human resources is the exponential function of occupancy in the logarithm measurement. There are three occupancy categories of region attraction separated by two vertical dashed lines. It is demonstrated that the technology hubs and knowledge centers are much more attractive for the factor mobility measured by tourist accommodation establishments. The occupancy is the alternative growth determinant in the persistent agglomeration regions, and the decreasing explanation power fades in the tourist paradise regions.

6. Conclusion

The mobility factors are more accumulated within some regions than the others through bidirectional communication. The regional GDP are sharply distributed into the imbalanced structured of the economic activities. The positive effects of tourist accommodation occupancy is statistically significant as the European regional GDP determinant in the interactive fixed effects model. There is the suggestive evidence that the communication factors are

the alternative measurement of the European regional economic activities, at least in the integrating European Union in the short time span after the millennium. The occupancy of the communication measurement does not belong to the previous growth determinants categorized in the Table A.4 of Appendix.

There is the diminishing fading driven power of classical growth determinants in the feasible interactive fixed effects approaches. When population and education have dragged the European regional economic activities in the poorer regions, the regional communication additionally provides the substantial driven power for European regional economic growth in the richer regions. The extensive education expenditure is not the unique catalyst of the economic prosperity in Europe.

Human resource in science and technology remains to be the considerable twofold explanation power in interactive fixed effects estimation. The high technology manufacturing industries and knowledge intensive services are one of the major economic engines in European Union after the millennium. The high quality employment is compelling energetic for the regional GDP in European Union with the integration convergence process.

The future researches should avoid the limitation of the time length of the data sample. The longer time horizon will provide more identified details of the regional GDP development paths when the specific sample data becomes available. As Table A.4 in Appendix illustrates that the European integration in the single currency is the short fraction of the rapid growth following the Great Moderation. The micro level of the European tourists data is the explicit bridges to examine the possible transmission channels to the macro economic growth.

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Appendix A. Categorization and Longer Sample Comparison

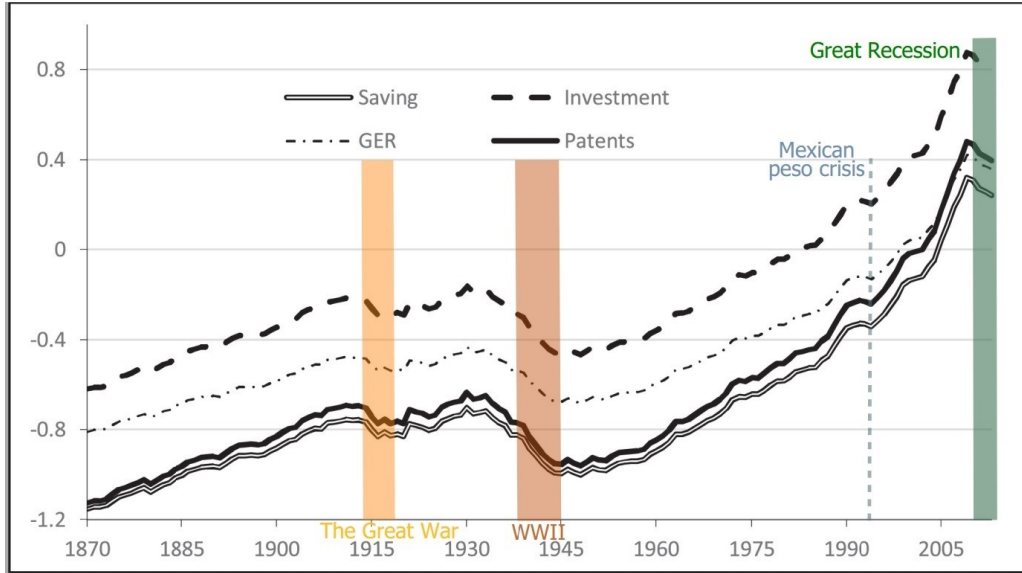


Figure A.4: Long Time Sample of Economic Growth of 21 OECD Countries from 1870-2011. Revised from Figure 3 in Madsen, Islam and Doucouliagos (2018).

The first two yellow shadow areas are the World War I and World War II. The dashed line represents for the Mexico peso crisis, and the last green shadow area is the recent Great Recession. The original chart and calculation are sourced from the empirical growth study in the longer time horizon by Madsen, Islam and Doucouliagos (2018). The four indexes are the semi elasticities of outcome variables with inequality.

Table A.4: The Categorized Classical Growth Variables

Macroeconomics	Institutional	Geography	Demographic	Cultural
Investment Price	Years Open 1950-94	Tropical Area	Primary Schooling	East Asian
GDP in 1960 (log)	Openness 1965-74	African Dummy	Popu Density Coastal	Confucian
Fraction GDP in Mining	Political Rights	Latin American	Malaria Prevalence	Muslim
Gov. Consumption Share	European Dummy	Spanish Colony	Life Expectancy	Buddhist
Real Exchange Rate Distortions	Outward Orientation	Population In Tropics	Population Density	Ethnolinguistic
Government Share of GDP	Civil Liberties	Air Distance to Big Cities	Higher Education	Foreign Language
Primary Exports 1970	Revolutions and Coups	Absolute Latitude	Fraction Hindus	Protestants
Public Investment Share	British Colony Dummy	Landlocked Country	Population under 15	Catholic
Nominal Government GDP Share	Defense Spending Share	Land Navigable Water	Fertility in 1960s	Colony
Hydrocarbon Deposits in 1993	Socialist Dummy	Land Area	Population Over 65	Religion
Terms of Trade Growth	English Speaking Population	Tropical Climate Zone	Population in 1960	Orthodox
Public Education Spending Share	Oil Producing Country		Population Growth	
Size of Economy	Timing of Independence		Interior Density	
Average Inflation 1960-90	Spent in War 1960-90			
Square of Inflation 1960-90	Capitalism			
Terms of Trade Ranking	War Participation 1960-90			

Source: There are 67 variables in the econometric interpretation by Sala-I-Martin, Doppelhofer and Miller (2004).

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