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The Contribution of Regions to Aggregate Growth

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The contribution of Regions to Aggregate Growth

by

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Abstract:

This paper investigates the contribution of regional performance to aggregate growth in the OECD. We find a great degree of heterogeneity in the performance of large (TL2) and small (TL3) OECD regions and among types (urban intermediate and rural) of regions suggesting possibilities for growth performance exist everywhere. We find that distribution in GDP and GDP per capita growth rates follow an approximately normal distribution among large regions, but the symmetry appears to break down among small regions. Distribution of each region's contribution to aggregate growth is not symmetric. This implies that average values loose meaning and may not be the most adequate policy target for maximizing aggregate output. On the contrary, we find evidence of a power law and its scale free properties among regional contributions to aggregate growth, implying that a very small number of regions contributes disproportionately to aggregate growth whereas the most of individual regions contribute only marginally. Nevertheless, because there is a very large number of these small regions, their cumulated contribution has a major impact on aggregate growth. For the period 1995-2005, 4% of the large regions contribute to 33% of aggregate OECD growth and the remaining 96% to 67%. Confirming the scale-free properties of the distribution, only 2.4% of small regions contribute to 27% of OECD GDP growth and the remaining 97.6% to 73%. Using these properties, we then estimate an econometric model explaining growth at the regional level by several policy variables and controls, under different scenarios, and compute the derived aggregate growth. We find that a 10% increase in policy variables -- infrastructure, educational attainments, and employment growth -- increases aggregate GDP growth annually during the period 2005-2015 by 0.22 percentage points relative to the BaU scenario. An increase in policy variables by 10% in only lagging regions will entail a similar effect on aggregate output, as well as an increase in the same policies in only leading regions. The policy variable having the largest increase on aggregate growth is an improvement in human capital (measured by education attainment) at the regional level.

Non-Technical Summary:

This paper investigates the links between the regional and the aggregate dimension in three main sections. The first section analyzes trends in the performance of OECD regions and their link to aggregate output. The second section estimates a model of regional growth capable of forecasting annual average growth rates and by extension aggregate output. The third section carries out several simulation scenarios allowing us to better understand the links between the regional and the aggregate dimension. The main findings of section one are:

1. Economic performance in OECD regions -- measured by growth rates in GDP, GDP per capita and productivity -- is very **heterogeneous**, even among regions from within the same country.

2. Despite the observed heterogeneity, distributions of growth rates in GDP and in GDP per capita resemble a **normal distribution** among larger OECD Territorial Level (TL) 2 regions. At a smaller scale (TL3 regions) the symmetry appears to break down. Examining distribution of each region's **contribution to aggregate growth**, we find no symmetry meaning average values loose meaning and may not be the most adequate tool for maximising aggregate output. We find evidence of a **power law** and its scale free properties in the following:

- Distributions of **region's contributions to OECD aggregate GDP** growth follow a **power law** both at the level of TL2 (large) and TL3 (small) regions.
- Power laws in the distributions of *contributions to aggregate growth* appear at different scales and among different groups of regions confirming scale free properties:
 - At a larger scale, **countries' contributions to OECD GDP growth follow a power law**,
 - At a smaller scale, **regions' contributions to national GDP growth** also follow a power law in a wide range of OECD countries.
 - Within **predominantly urban, intermediate and predominantly rural regions**, the distributions of region's **contribution to aggregate growth** follow a **power law** within each type of region.

3. Power laws reveal the existence of a small number of regions disproportionately contributing very strongly to aggregate growth. At the same time the bulk of regions albeit each contributes individually marginally to aggregate growth, their summed contribution is quite significant. The following magnitudes appear in the data during the period 1995-2005:

- Among large regions only **4%** of TL2 regions contribute to **33% of aggregate growth** and the remaining **96% of** regions contribute to **67%**. The top 10% of TL2 regions contribute to aggregate growth in the same proportion as the remaining 90% of regions.
- Among TL3 regions only **2.4%** contribute to almost **one third (i.e. 27%) of OECD GDP** growth and the remaining **97.6%** sum up to approximately three-fourths (**i.e. 73%**) of aggregate growth.

4. Examining the contributions to aggregate growth by categories and groups of regions during 1995-2005 we find:

- Capital TL2 regions which represent less than **1%** of the sample contribute to **16%** of aggregate GDP growth
- **Lagging regions** -- defined by lower GDP per capita than national averages -- contribute to **44%** of the overall OECD growth, almost as large as the contribution by leading regions (**56%**).
- In **40%** of OECD countries **lagging regions** contribute **more** to national GDP growth than **leading regions**.
- Urban regions contribute to **60%** of overall growth, **intermediate** regions to **26%** and **predominantly rural** regions to **15%**.

5. Section two estimates an econometric model of regional growth during the same period 1995-2005 capable of predicting regional per capita growth rates and by extension GDP growth and aggregate growth. The findings of our model are consistent with previous studies. We find **infrastructure** and **human capital** positively contribute to regional growth and gains in the **employment rate** also have a positive influence on growth.

6. We employ our regional model to improve our understanding between regional dynamics and aggregate output rather than trying to predict accurate aggregate values at the national and OECD level, which depend on many additional factors not included in our model. For this task section three carries out simulations exercises examining several scenarios at the regional level and their impact on aggregate growth. The simulations reveal:

- A 10% increase in policy variables -- infrastructure, educational attainments, and employment growth -- increases aggregate GDP growth annually during the period 2005-2015 by 0.22 percentage points relative to the benchmark model (*e.g.* no increases in the policy variables).
- Increasing policy variables in only **lagging regions** by 10% will impact aggregate growth **similarly** as an increase the same policies in **only leading regions** by the same proportion.
- Increasing our each policy variable separately by the same proportion reveals the largest impact on aggregate growth when reducing the labour force attaining only **primary and lower secondary education** accounting for more than half of the GDP gains. The second most relevant policy variable is when increasing the labour force with **tertiary education** and accounts for almost 40% of the GDP increase. Finally increasing infrastructure density accounts for 8.1% of the overall gain and employment rate growth with 0.6%.

7. In sum power laws carry important policy implications suggesting policy makers should ensure the few regions with the strongest contribution to aggregate growth continue to be competitive. At the same time opportunities for growth at the aggregate level are possible when **all** remaining regions improving their performance.

8. Place based policies defined by the new regional paradigm (*Regions Matter, OECD 2009*) are best suited for this task. Moreover given that possibilities for growth exists in all types of region this policy option is not only feasible but also worthwhile pursuing in the interest of aggregate growth. This means improving the performance of periphery and even lagging regions can be justified not only on redistributive and social equity grounds but for improving aggregate growth.

Introduction

Nations are characterised by very heterogeneous social and economic policies, different educational backgrounds, legal systems and history, therefore it is not surprising to observe marked differences in the economic performance across countries. Nonetheless, within any given individual country -- where policies, institutions and history tend to be more homogeneous -- per capita incomes should be more similar than across countries.

In fact, OECD (2009) shows persistent differences in income level among regions from a given country over long periods of time. This suggests that cumulative factors operate at the regional level yield significant differences in productivity and consequently income levels among regions, as opposed to the view suggesting that income differences will eventually even out as corrective market forces will induce firms to move to areas where labour is cheaper, or labour to move to areas where wages are higher. Understanding how this heterogeneity at the regional level relates to aggregate output can therefore be a key tool for improving regional policies and their contribution to aggregate growth.

This paper precisely aims at better understanding the links between the regional and aggregate growth. It is structured around three main sections. The first section analyses the heterogeneity in productivity, GDP and GDP per capita growth rates in 335 regions (OECD TL2 level, see Appendix1) and in 1687 regions (OECD TL3 level) measured over the period 1995-2005. It also estimates the distributions of GDP and GDP per capita growth rates and distributions of regional contributions to OECD and national GDP growth. The section also examines the impact on aggregate growth by different types of regions (*e.g.* urban, intermediate and rural) and by regions from different groups, using regional performance taxonomy.

The second section estimates econometrically a regional GDP per capita growth model, which incorporates the initial levels of income, human capital, infrastructure, and labour market outcomes. This reduced form model is consistent with specifications used in previous OECD research based on neo-classical theory, the endogenous growth and the new economic geography.

The final section projects GDP per capita growth rates for the year 2015 using the coefficient estimated in the econometric model under several policy scenarios permitting to better understand the links between the regional and aggregate growth.

1. Distribution of growth performance across regions and its impact on aggregate growth

1.1. The large heterogeneity of regional growth rates

Regional growth rates are very heterogeneous; differences are not only visible across regions and regions (Table 1), but also when comparing regions within countries (Table 2). Comparing the spread of growth in GDP, GDP per capita and productivity among all OECD TL2 and TL3 regions with the national spread over the period 1995-2005 reveal a larger spread of growth -- by a factor of three -- at regional level than at national level (Table 1). This larger degree of heterogeneity could be due to a statistical phenomenon driven by the larger sample size of regions -- than of countries -- and therefore a larger spread between the endpoints. Nonetheless, heterogeneity is also very marked between regions within the same country. The spread of growth rates among regions within countries exceeds the spread of growth among OECD countries by a factor of two (Table 2).

Table 1. Dispersion of growth rates of GDP, GDP *per capita* and Labour productivity across OECD countries, TL2 and TL3 regions, 1995-2005

		Change in Real GDP	Change in Real GDP per capita	Change in GDP per worker (Labour Productivity)
Countries	Min	1.1% (Japan)	1.0% (Japan)	-0.4%(Spain)
	Max	7.7% (Ireland)	6.0% (Ireland)	4.8% Poland)
	Range	6.3 pp	5.0 pp	5.2 pp
TL2	Min	-1.7% (Berlin, DEU)	-1.8% (Adana, TUR)	-3.8%(Champaigne-Ardenne, FRA)
	Max	8.5% (Southern and Eastern, IRL)	7.1% (Southern and Eastern, IRL)	7.1% (Podlaskie, POL)
	Range	10.2 pp	8.9 pp	10.9 pp
TL3	Min	-7.8% (Kilis)	-6.2% (Kilis)	-5.4% (L'Aquila)
	Max	9.4% (South-West, IRL)	8.7% (South-West, IRL)	11.1% (Südthüringen, DEU)
	Range	17.2 pp	14.9 pp	16.5 pp

*pp refers to percentage points

Note: GDP data for Turkey are only available for 1995-2001, and for the United States for 1997-2005. TL3 data are not available for Australia, Canada, the United States and Mexico.

Source: How Regions Grow: Trends and Analysis, OECD 2009

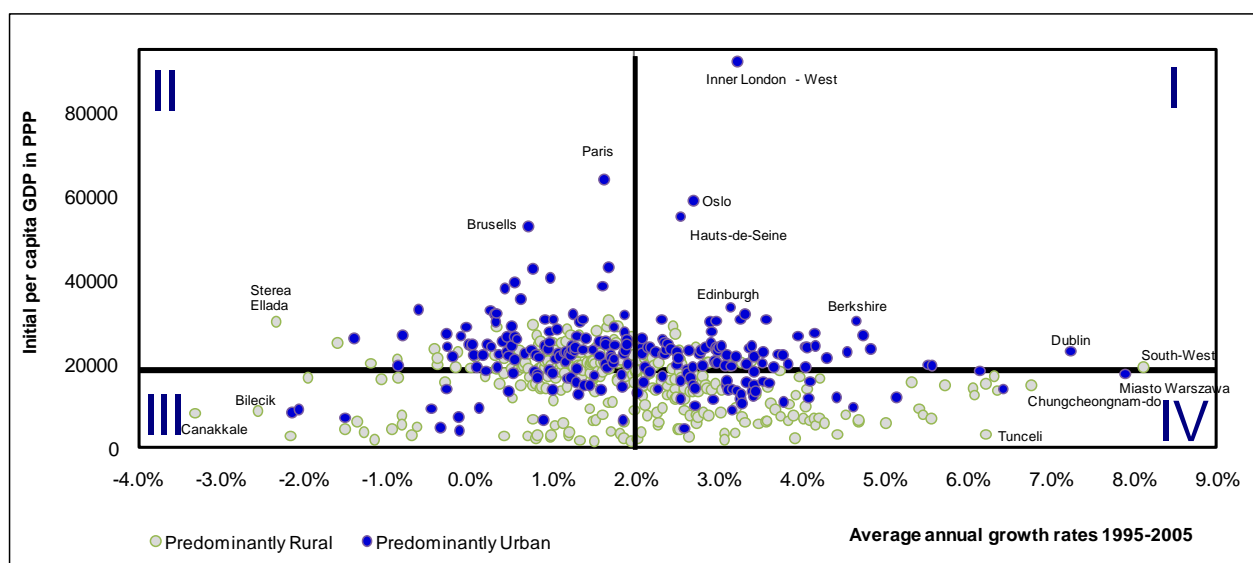
Table 2. Growth rate variations for GDP, GDP per capita and productivity within countries, TL2 and TL3 regions, 1995-2005

		Real GDP	Real GDP per capita	Productivity
TL2	Min	-0.9% (Balıkesir)	-1.8% (Adana)	-3.8%(Champaigne-Ardenne)
	Max	4.5% (Zonguldak)	5.6% (Zonguldak)	6.2% (Corse)
	Range	5.4 pp (Turkey)	7.4 pp (Turkey)	10 pp (France)
TL3	Min	-7.8% (Kilis)	-6.2% (Kilis)	-1.4% (Südheide)
	Max	7.6% (Batman)	6.7% (Tunceli)	11.1% (Südthüringen)
	Range	15.4 pp (Turkey)	12.9 pp (Turkey)	12.5 pp (Germany)

Source: How Regions Grow: Trends and Analysis, OECD 2009

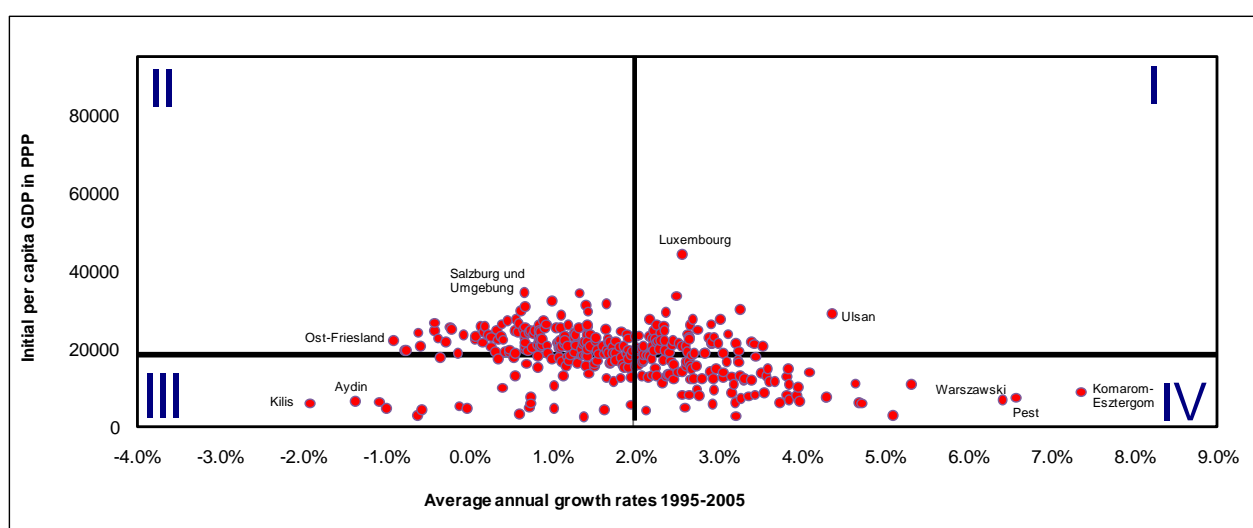
Heterogeneity is also observable when comparing growth rates in GDP per capita among different types of OECD TL3 regions (*e.g.* predominantly urban, intermediate and predominantly rural). Figure 1 reveals a significant number of urban regions growing faster than rural ones, but also a significant number of rural regions out-performing urban regions in terms of GDP per capita growth rates over the past decade. Similarly intermediate regions vary significantly (Figure 2). This means patterns for sustainable growth rates are not unique -- appearing only in particular types of regions -- nor linear; rather opportunities for growth can exist in all types of OECD regions.

Figure 1. Initial GDP per capita and annual average growth rates in GDP per capita among predominantly urban and rural OECD TL3 regions, 1995-2005



Source: How Regions Growth Trends and a Analysis, OECD 2009

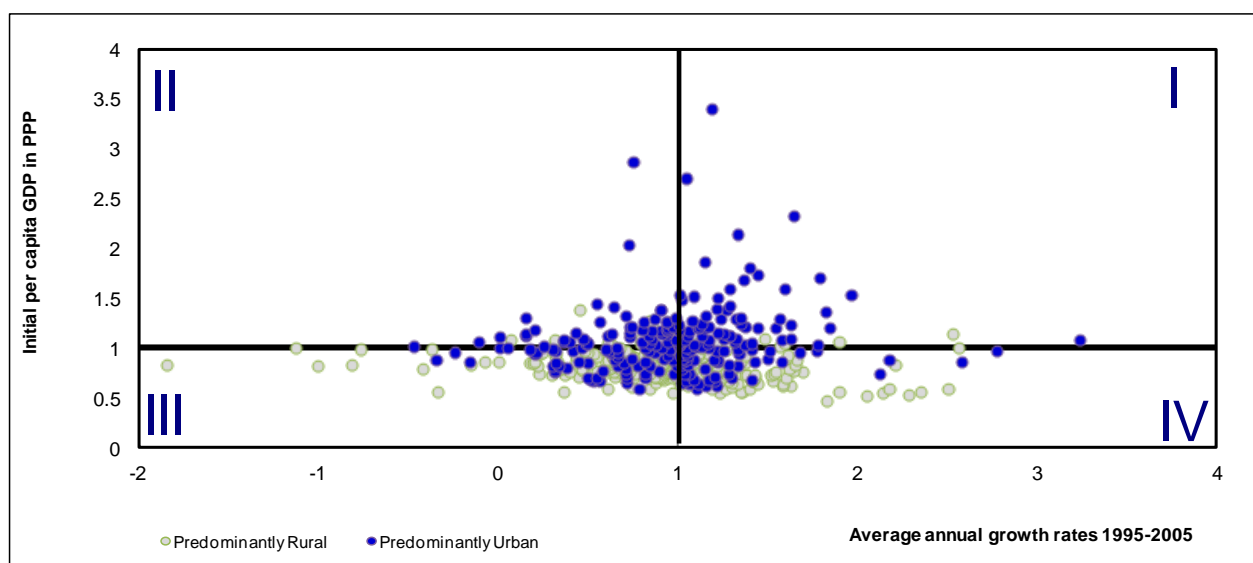
Figure 2. Initial GDP per capita and annual average growth rates in GDP per capita among intermediate OECD TL3 regions, 1995-2005



Source: How Regions Growth Trends and a Analysis, OECD 2009

A large heterogeneity by types of regions is also observable when controlling by national factors. Figure 3 displays the performance of urban and rural regions relative to their respective national values. Again we observe there are a significant number of urban regions outperforming rural ones and vice versa.

Figure 3. Initial GDP per capita and annual average growth rates in GDP per capita among predominantly urban and rural OECD TL3 regions normalised by national values, 1995-2005



Note: The value 1 represents the national value.

Source: Own computations using data from the OECD 2010 Regional Database

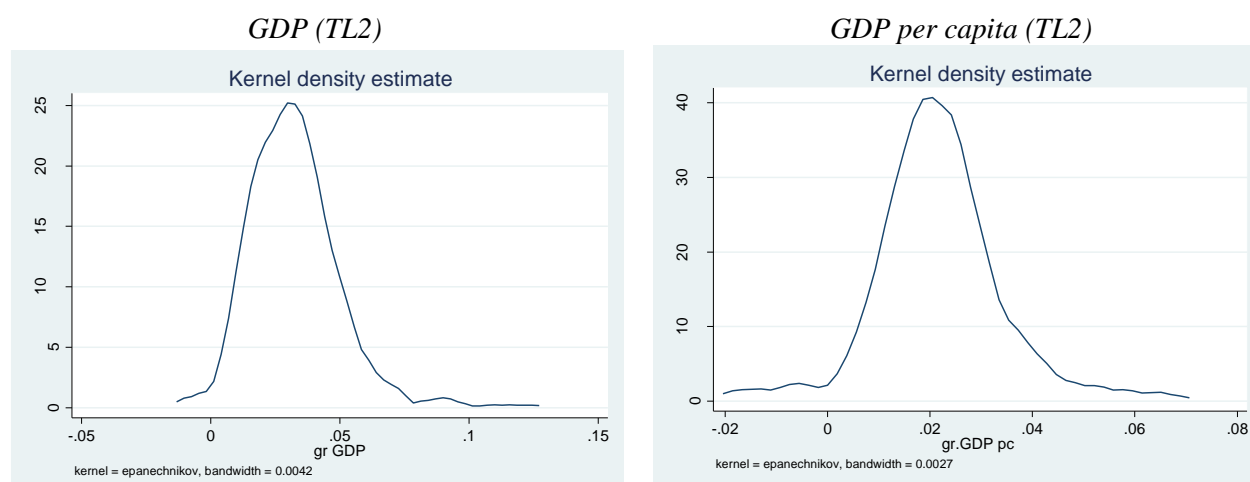
1.2 Implications of heterogeneity for overall performance

The significant degree of regional heterogeneity has important implications for aggregate performance. Understanding the distribution of regional growth rates and their contributions to aggregate output can help the design of appropriate policies, target regional characteristics. Moreover, it also helps to better understand important macroeconomic phenomena such as why some national economies are able to sustain longer periods of high growth relative to other economies, why some national economies are more resilient than others or why economies behave differently over cyclical patterns.

One could envisage two polar cases. If a country's economic activity is mainly concentrated in few regions, and in addition these regions outperform the rest of regions, a sensible policy for maximising national growth would be to continue targeting growth in these regions at least until signs of deceleration become visible. In contrast, if the national economy is approximately proportionately distributed among all regions (each contributing equally to national output), and all regions display a similar performance, a sensible approach would be targeting the growth potential of all regions for maximizing national growth. In reality the picture is more complex, especially when accounting for the evolving economic performance of regions over time.

We first map the distributions – estimated through kernel densities -- of annual average growth rates in GDP and GDP per capita over the period 1995-2005 for 324 and 816 OECD TL2 and TL3 regions where data are available (Figures 4 and 5). The shapes of the distributions – of GDP and GDP per capita – resemble a normal (symmetric) distribution (Figure 4) for TL2 regions centred around a mean of 3% for GDP and 2% for GDP per capita.

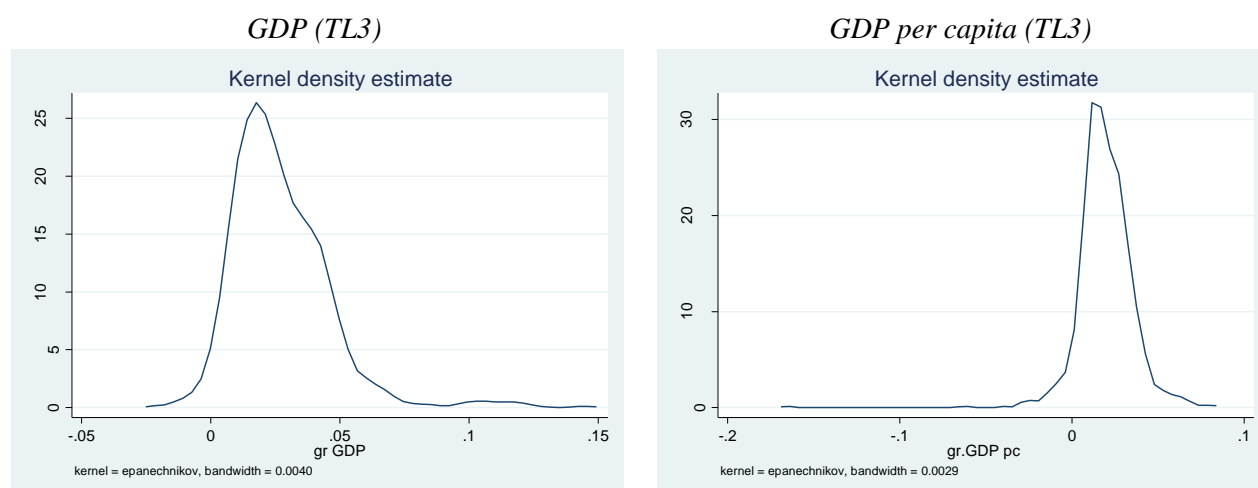
Figure 4 Distributions in growth rates in GDP and GDP per capita among OECD TL2 regions, 1995-2005



Source: Own computations using data from the OECD 2010 Regional Database

However, at a smaller scale (*i.e.* TL3), the **symmetry** of distribution around the mean value appears to **break down** with some regions displaying very high GDP growth rates, while some other display very negative rates of GDP per capita growth. Nevertheless, apart for the tail, these distributions still largely resemble that of a normal curve (Figure 5).

Figure 5 Distributions in growth rates in GDP and GDP per capita among OECD TL3 regions, 1995-2005



Regions are missing from XXX

Source: Own computations using data from the OECD 2010 Regional Database

From a policy perspective perhaps a more relevant distribution is each region's contribution to aggregate growth. If we think of an economy as an engine where each region represents the cylinders of the engine, a region's contribution to aggregate growth depends on the size of the cylinders and how fast the pistons are moving. Formally these two elements translate into:

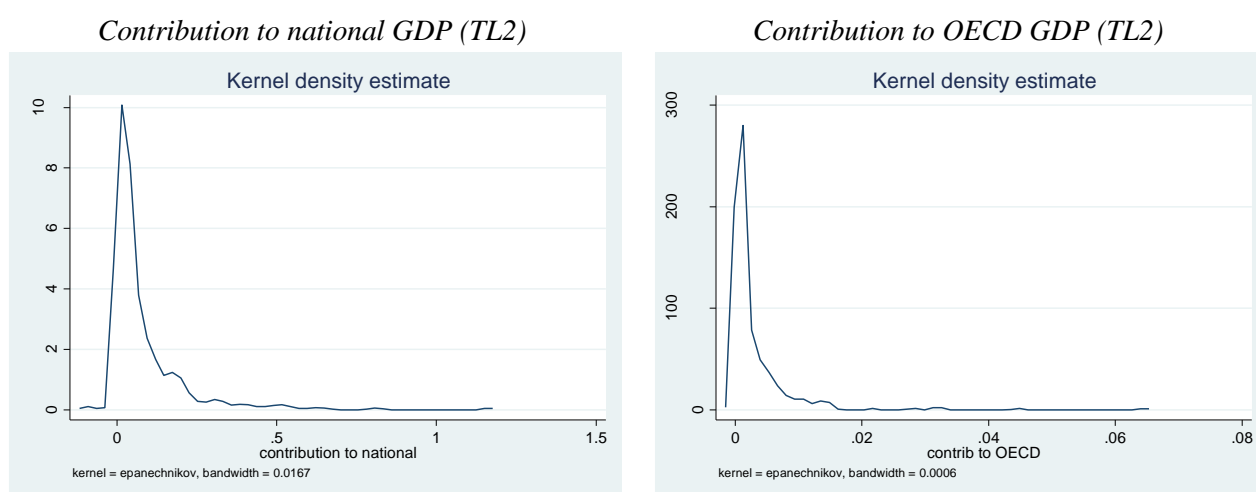
1. The growth rate of a the region over a given period of time, and

2. the size of the region represented by its share in aggregate GDP.

Therefore large regions with fast growth rates will have the largest impact to aggregate growth, while small regions with low rates will have the lowest impact. The impact of a large region displaying very low growth rates could potentially be as large as the impact of a small region displaying very fast growth rates. It will depend on each of these two elements. We estimated the distributions of ‘contributions to national and OECD growth’ by TL2 and TL3 regions using kernel density estimates for the period 1995-2005 in Figures 6 and 7.

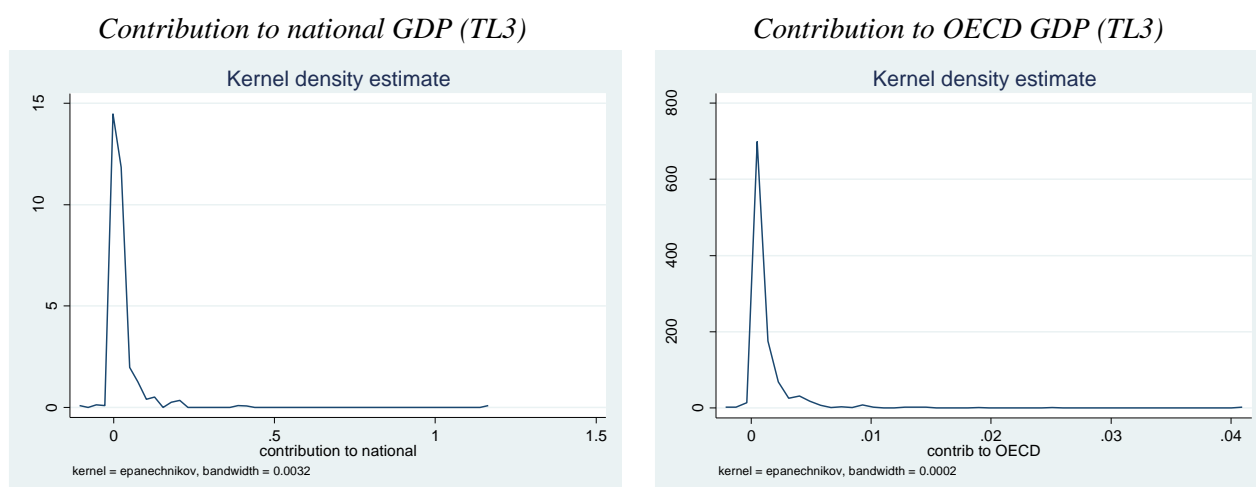
The striking feature is that the shape of the distributions does not resemble a normal curve anymore in all four cases; rather they appear to follow the shape of a, so-called, power law distribution.

Figure 6. Contributions to national and OECD GDP growth, TL2 regions 1995-2005



Source: Own computations using data from the OECD 2010 Regional Database

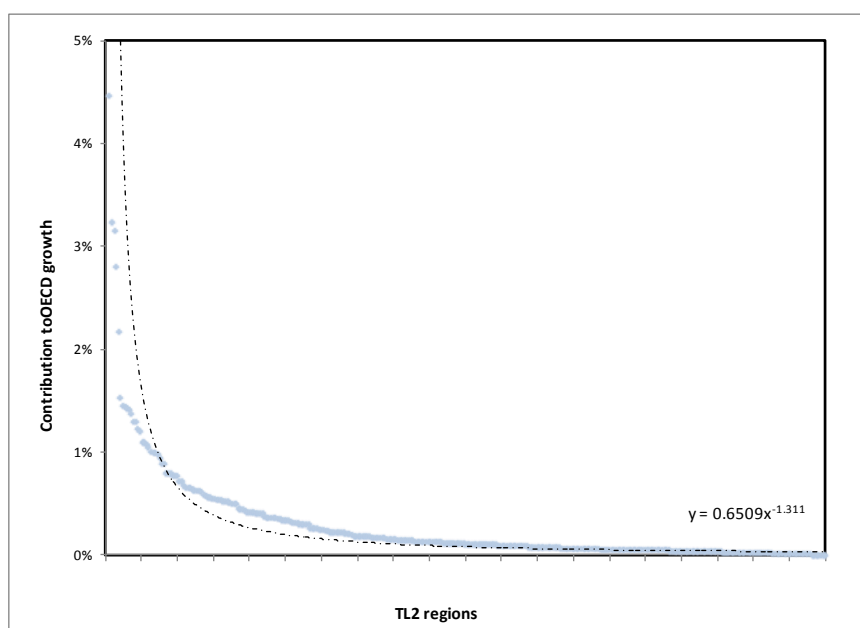
Figure 7. Contributions to national and OECD GDP growth, TL3 regions 1995-2005



Source: Own computations using data from the OECD 2010 Regional Database

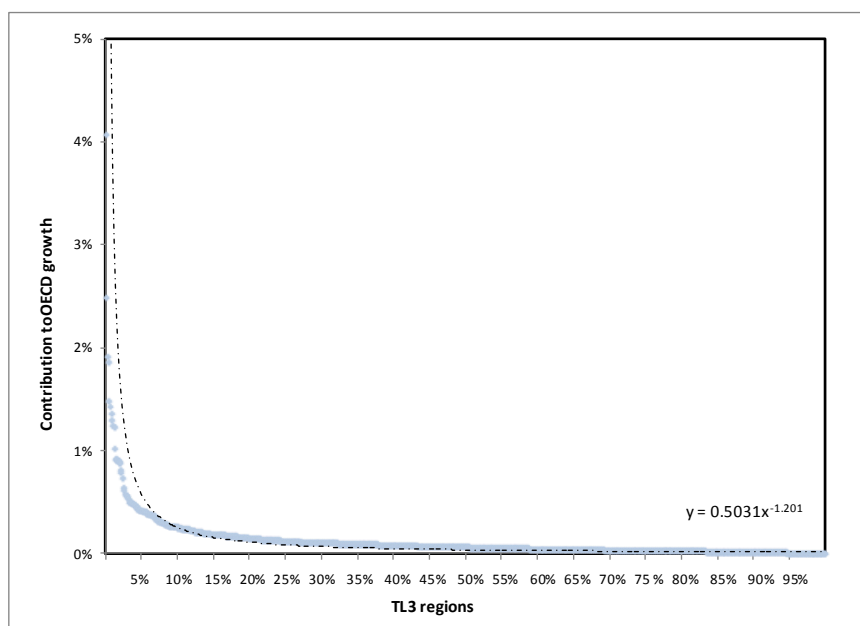
A **power law** is a special type of mathematical relationship between two quantities. If one quantity is a *frequency of an event*, and the other is the *size of the event* then the relationship has a power-law distribution (see Appendix 2). Defining regions as the *frequency of an event* and their contribution to overall GDP growth as the *size of an event*, we obtain a power-law distribution. Figures 8 and 9 estimates the coefficient of power laws using a fitted line specified as non-linear power-law.

Figure 8. Power laws in TL2 region's contributions to OECD GDP growth, 1995-2005



Source: Own computations using data from the OECD 2010 Regional Database

Figure 9. Power laws in TL2 region's contributions to OECD GDP growth, 1995-2005



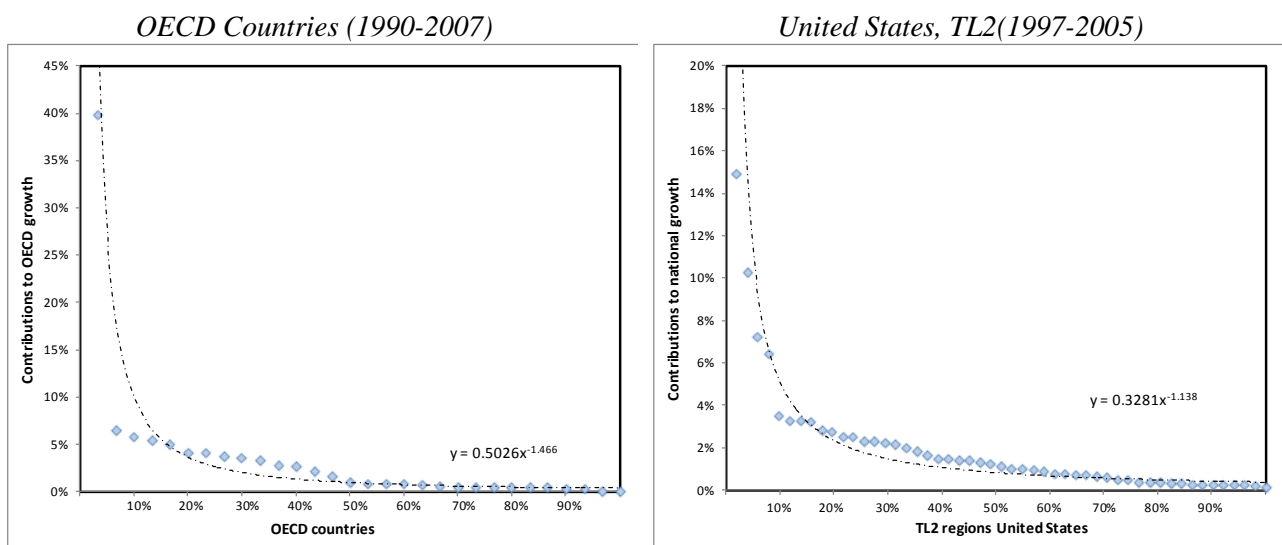
Source: Own computations using data from the OECD 2010 Regional Database

This particular shape (*e.g.* a power law) carries important policy implications essentially revealing there are very few regions with disproportionately large contributions to aggregate growth and the majority of regions each contributes individually low to aggregate growth, nevertheless their aggregate sum is quite significant. From a policy maker's point of view, ensuring these few regions with the strongest contribution to aggregate growth continue to be competitive becomes essential. At the same time opportunities for growth at the aggregate level are possible when **all** remaining regions improving their performance.

Place based policies defined by the new regional paradigm (Regions Matter, OECD 2009) are best suited for this task. Moreover given that possibilities for growth exists in all types of regions (How Regions Grow: Trends and Analysis, OECD 2009) this policy option is not only feasible but also worthwhile pursuing in the interest of aggregate growth. In essence improving the performance of periphery and even lagging regions can be justified not only on redistributive and social equity grounds but rather for maximizing aggregate growth. We argue these two do not necessarily go counter rather they complement each other.

Power laws have **scale free properties**, meaning this particular shape tends to self-replicate at smaller and larger scales or within sub-samples of the distribution. Figure 10 depicts power laws in contributions to aggregate OECD growth at different scales: at the country level, and at the regional level within OECD countries. Appendix 3 displays regional contributions to national growth for the remaining OECD countries. Figure 15 in Section 1.3 displays contributions to aggregate growth within types of regions (*e.g.* predominantly urban, intermediate and predominantly rural).

Figure 10. Contributions of countries to OECD GDP growth and of regions to national growth in the US



Source: Own computations using data from the OECD 2010 Regional Database

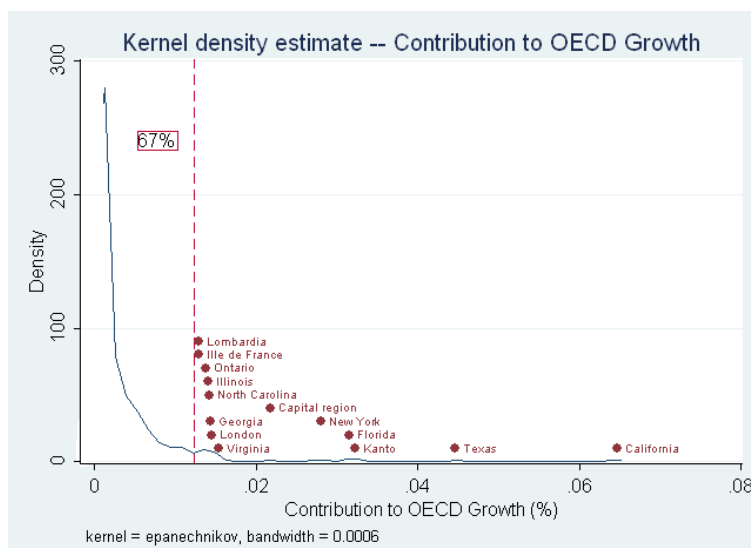
The fact that the shape of the distribution is quite similar at different scales (*e.g.* contribution of countries to aggregate growth) confirms the **scale free properties** of power laws.

Measuring contributions to aggregate growth using power laws

Figure 11 displays the top 14 TL2 regions (or 4% of them) with the largest contribution to OECD GDP growth over the period 1995-2005. California carries the highest contribution (6.5%), followed by

Texas (4.5%), Kanto (3.2%) and Florida (3.16%). The magnitude of the 14 regions is very significant: these **4% of regions contribute to 33% of the aggregate OECD growth**, while the remaining 96% of regions (left to the red dashed line in Figure XX) contribute to remaining 67% of aggregate growth.

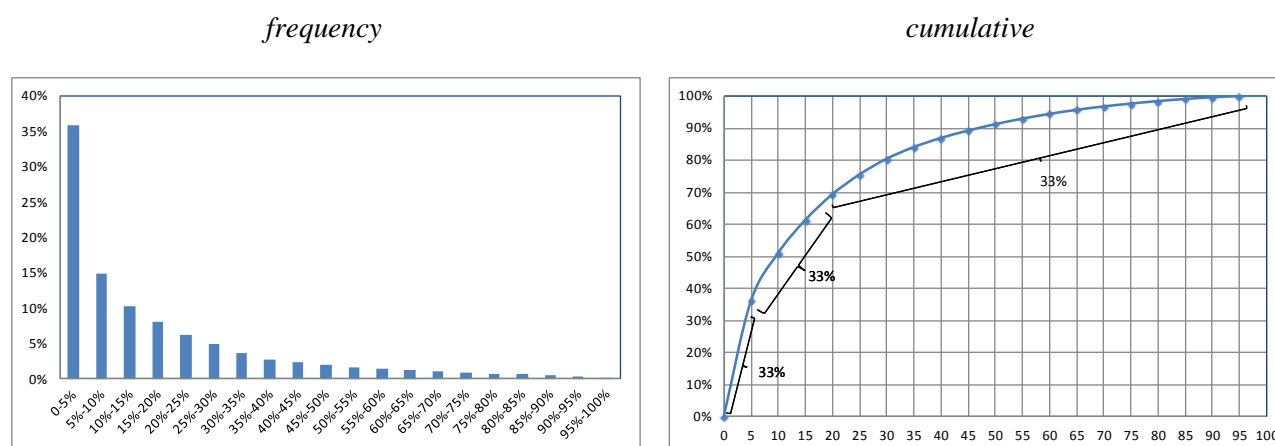
Figure 11. Contributions to OECD GDP growth, TL2 regions 1995-2005



Source: Own computations using data from the OECD 2010 Regional Database

The disproportionately large impact of few regions is further examined in Figure 12 revealing just **4 %** (or 14) of TL2 regions contributes to the same amount to aggregate growth (33%) as **13% (or 44)** of them and 83% of TL2 regions. In other words just 4% of regions have an equivalent impact on aggregate growth as **83%**. The top 10% of TL2 regions contributes to approximately the same proportion as the remaining 90% of regions to aggregate growth.

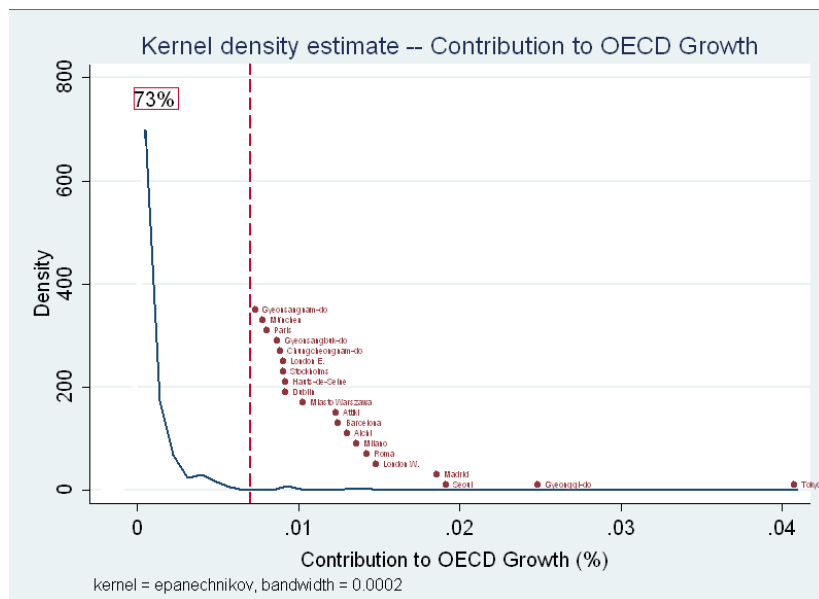
Figure 12. Frequency and cumulative distribution of contributions to OECD GDP growth, TL2 regions 1995-2005



Source: Own computations using data from the OECD 2010 Regional Database

Among TL3 regions for which data are available¹, Tokyo recorded the highest (4.1%) contribution to OECD GDP growth followed by Gyeonggi-do (2.5%), Seoul and Madrid (1.9%). The top 20 TL3 contributors to aggregate growth represent only **2.4% of the regions** and yet **contributed to almost one third (i.e. 27%) of OECD GDP** growth during the period 1995-2005. In the remaining 97.6% of regions, no region individually contributed more than 0.7% of GDP growth, however their contribution summed up to approximately three-fourths (i.e. 73%) of aggregate growth.

Figure 13. Contributions to OECD GDP growth, TL3 regions 1995-2005



Note: GDP data are missing for TL3 regions from Australia, Canada, Mexico and the United States

Source: Own computations using data from the OECD 2010 Regional Database

These results reveal the magnitude few regions have on aggregate output. As previously mentioned policies and policy-makers should ensure these engines of growth remain competitive and continue to add to aggregate growth disproportionately. At the same time the potential to further boost aggregate growth is possible by mobilising assets and resources in **all** remaining regions, even if it is only marginally as long as the number of regions improving their relative position includes as many as possible the impact aggregate output will be non-trivial.

1.3 Contributions to aggregate growth by categories and type of regions

We next compute the impact to overall growth by different categories and types of regions. For TL2 regions we first disentangle the effects of capital and no-capital regions. Then we categorise regions into **six distinct groups** according their level of initial average income (e.g. GDP per capita) and their growth rates in GDP per capita over the period 1995-2005. TL3 regions are classified into **predominantly urban, intermediate and predominantly rural regions** applying the OECD taxonomy by types of regions (Appendix 1). The contribution to growth by these different groups of regions assists in helping understand the dynamics and importance of particular groups of regions to aggregate values instead of relying on an

1. Note at TL3 GDP data are missing from Australia, Canada, Mexico and the United States

average values and by extension assuming there is symmetry in the distributions of regional contributions to aggregate growth, which we find this is not the case in the previous section.

Contribution to growth TL2 regions:

Results derived by the New Economic Geography imply that the growing population and the wealth of major urban areas are driven by benefit of agglomerations operating mainly through economies of scale, labour market pooling and spillover effects. Consequently more densely populated regions support higher productivity and income levels respect to the lesser densely populated regions. Table 3 show the top-ranked region of a country supports a double than higher GDP per capita level with respect to that of the lowest-ranked region, and sometimes far more than that. In many countries, the region with the highest GDP per capita corresponds to region hosting the capital with the exceptions in the EU of Germany, where the Hamburg region records a higher value than the Berlin region; and Italy, where the Milan region has a higher GDP per capital than in Rome

Table 3. Ratios of per capital GDP by region, 2005

Country	Ratio of highest to lowest	Ratio of second highest to lowest
Australia	1.57	1.52
Austria	2	1.52
Belgium	2.75	1.37
Canada	2.39	2.21
Czech Republic	2.69	1.18
Denmark	1.63	1.23
Finland	1.56	1.19
France	1.95	1.2
Germany	2.58	2.01
Greece	1.76	1.11
Hungary	2.57	1.56
Italy	2.04	2.04
Japan	1.71	1.71
Korea	1.28	1.24
Mexico*	6.24	4.49
Netherlands	1.31	1.15
Norway	1.87	1.26
Poland	2.32	1.57
Portugal	1.7	1.33
Slovak Republic	3.43	1.32
Spain	1.91	1.85
Sweden	1.66	1.13
UK	2.01	1.41
USA	5.17	2.46
National GDP, EU15	2.92	1.8
National GDP, EU27	4.27	2.63
National GDP, OECD	7.46	4.6

* 2004

Source: Regions Matter, OECD 2009

The contribution to aggregate growth by capital regions is disproportionately high. Although OECD TL2 capital regions represent less than 1% of the sample of TL2 regions, their contribution to aggregate growth is **around 16%** over the period 1995-2005. The remaining 84% of aggregate growth is produced by non-capital regions.

Using a taxonomy measuring the performance of regions relative to their countries we measure the contribution to growth by each of the 6 groups defined in the taxonomy. This taxonomy benchmarks the performance of TL2 regions to national standards using initial levels of GDP per capita (e.g. 1995) and annual average growth rates in GDP per capita over 1995-2005. The initial level of GDP per capita determines the first dimension of the categories lagging, quasi-lagging or leading according to the following rule:

(i) Lagging -- when a region's initial level of GDP per capita is below 75% of the national average.² The threshold of 75% is selected in line with the European Commission's choice for defining lagging regions below this threshold.

(ii) Quasi-lagging -- when a region's initial level of GDP per capita is below the national average and above 75% of the national average.

(iii) Leading -- when region's initial level of GDP per capita is above national average.

The second dimension of the category growing or underperforming is defined by regions growing at a faster or slower annual average GDP per capita growth rate than the national average respectively. The two dimensions defining categories give rise to 6 groups: (1) *lagging growing*, (2) *lagging-underperforming*, (3) *quasi-lagging growing*, (4) *quasi-lagging underperforming*, (5) *leading growing* and (6) *leading underperforming*. This simple taxonomy allows us to determine the significance of each of these groups and the contribution to growth by *leading* and by *lagging* TL2 regions, defined by those regions with a higher GDP per capita value than their respective countries and a below average value respectively.

Using this framework we find lagging regions to be quite important contributors to aggregate growth. Over the period 1995-2005 **lagging regions** contributed to **44%** of the overall OECD growth, almost as large as the contribution by leading regions (**56%**). Moreover in 40% of OECD countries (9 of 23 considered) lagging regions contributed in fact **more** to national GDP growth than leading regions (Table 4).

Table 4. Annual average contribution to national GDP growth, 1995-2005

	# of TL2 regions	lagging growing	lagging underperforming	quasi-lagging growing	quasi-lagging underperforming	lagging	leading growing	leading underperforming	leading
Australia	8	0%	0%	22%	7%	29%	49%	22%	71%
Austria	9	3%	0%	38%	12%	53%	17%	30%	47%
Canada	12	2%	0%	5%	18%	26%	28%	46%	74%
Czech Republic	8	0%	0%	14%	48%	62%	38%	0%	38%
Finland	5	0%	0%	0%	35%	35%	65%	1%	65%
France	22	1%	0%	39%	29%	68%	30%	2%	32%
Germany	16	14%	0%	1%	12%	27%	43%	30%	73%
Greece	4	0%	0%	0%	-16%	-16%	116%	0%	116%
Hungary	7	0%	14%	11%	9%	34%	56%	9%	66%
Italy	21	16%	5%	0%	6%	26%	30%	43%	74%
Japan	10	1%	0%	23%	4%	27%	65%	8%	73%
Korea	7	0%	0%	20%	3%	23%	31%	47%	77%
Mexico	32	16%	8%	9%	11%	44%	39%	17%	56%
Netherlands	4	0%	0%	22%	27%	49%	51%	0%	51%
Norway	7	0%	0%	30%	32%	61%	39%	0%	39%
Poland	16	0%	0%	17%	27%	44%	30%	26%	56%
Portugal	7	0%	0%	34%	20%	54%	46%	0%	46%
Slovak Republic	4	0%	0%	0%	67%	67%	33%	0%	33%
Spain	19	17%	0%	10%	22%	48%	6%	46%	52%
Sweden	8	0%	0%	0%	58%	58%	42%	0%	42%
Turkey	26	32%	4%	6%	5%	47%	20%	33%	53%
United Kingdom	12	0%	0%	11%	46%	57%	43%	0%	43%
United States	51	0%	1%	31%	19%	51%	36%	13%	49%
average unweighted		4%	2%	16%	22%	43%	42%	15%	57%
average weighted		4%	1%	21%	17%	43%	39%	17%	56%

2. The national average is un-weighted meaning it is computed by summing the GDP of all regions and dividing it to the sum of the national population aggregated from the regional data.

For the definitions of the 6 groups see Box XX

Countries with fewer than four TL2 regions (Belgium, Denmark, Iceland, Ireland, New Zealand and Luxembourg) are not included. For Switzerland GDP data at TL2 are not available

Source: Calculations based on OECD Regional Database (2009).

Among the different groups, the largest contributor to aggregate growth is the *leading growing* group producing 39% of total GDP with just 26% of the population share in only 17% of regions followed by the *quasi-lagging growing* group (21%). The *quasi-lagging underperforming* and the *leading underperforming* each produced 17% of the aggregate growth. It is interesting to note that the *quasi-lagging underperforming* group, which includes the most number of TL2 regions (103) and is home to one fourth of OECD population only contributes to 17% of OECD growth in comparison to the *quasi-lagging growing* group which contributes to 4 more percentage points (e.g. 21%) with almost half of the amount of regions and only 18% of population share. Improving the performance of *quasi-lagging underperforming* regions can bring important overall GDP gains by virtue of their large size.

Table 5. Contributions to OECD growth by TL2 regions by six categories, 1995-2005

	growing	underperforming
lagging	37 regions or 11% population share = 8% contributions to growth = 4%	15 regions or 5% population share = 3% contributions to growth = 1%
quasi-lagging	61 regions or 19% population share = 18% contributions to growth = 21%	103 regions or 32% population share = 24% contributions to growth = 17%
leading	54 regions or 17% population share = 26% contributions to growth = 39%	55 regions or 17% population share = 20% contributions to growth = 17%

Source: Calculations based on OECD Regional Database (2009).

In sum, regions from different categories at the level of TL2 contribute very differently to aggregate growth: capital regions and regions from the *leading growing* group contribute disproportionately more to aggregate growth. In contrast the contribution to aggregate growth from remaining regions -- although individually may not be significant -- is quite substantial. This is the case of **lagging regions** which overall added **almost half of overall GDP growth**, and in **40% of OECD countries lagging regions contributed more to national growth than leading regions**.

Contribution to Growth TL3 regions

The smaller regional scale allows us to apply the OECD regional taxonomy defining predominantly urban, intermediate and predominantly rural regions among TL3 regions. Section one already finds a large degree of heterogeneity in the performance in urban, intermediate and rural regions suggesting sustainable high growth paths do not necessarily follow a liner path. We now measure the contributions to growth by these three types of regions.

By virtue of the OECD definition urban regions are associated with higher density of population and therefore naturally will also have a larger population size. Consequently we expect their share of GDP and their contribution to aggregate growth as a group to be larger than intermediate and rural regions.

Predominantly urban regions are home to half of the OECD population in regions where TL3 data are available³. The average population size in urban regions is double the size of intermediate regions and more than three times larger than in rural regions. As expected their contribution to overall growth is also larger, around **60% over the period 1995-2005**. Intermediate regions contributed to the remaining **26%** and rural regions to **15%**. These numbers should be taken with caution given missing data observations under-represent the true size of rural regions.

Table 6. Contributions to OECD growth by TL3 regions by six categories, 1995-2005

typology	count	count data	av population size	GDP pc (PPP) av.	density av.	population share	GDP (PPP)	GDP pc (PPP)	contribution to OECD growth
PU	361	243	1,314,481	28,616	1531	50%	58%	2.14%	59%
IN	446	300	673,737	22,870	160	32%	28%	2.00%	26%
PR	893	300	373,687	21,052	62	18%	14%	2.43%	15%

Source: Calculations based on OECD Regional Database (2009).

It is interesting to observe the higher annual average GDP per capital growth rates recorded by predominantly rural regions in comparison to the rates by intermediate and urban regions displaying rural regions need not to be a drain on national economies, as commonly argued. In fact Figure 14 maps growth rates in GDP per capita and contributions to OECD growth by the three types of regions. The heterogeneity in the performance of regions within each regional type, highlighted in Figure 1.1 and 1.2 at the outset of this section are also visible in this graph.

Figure 14. GDP per capita growth rates and contributions to OECD growth by TL3 regions, 1995-2005



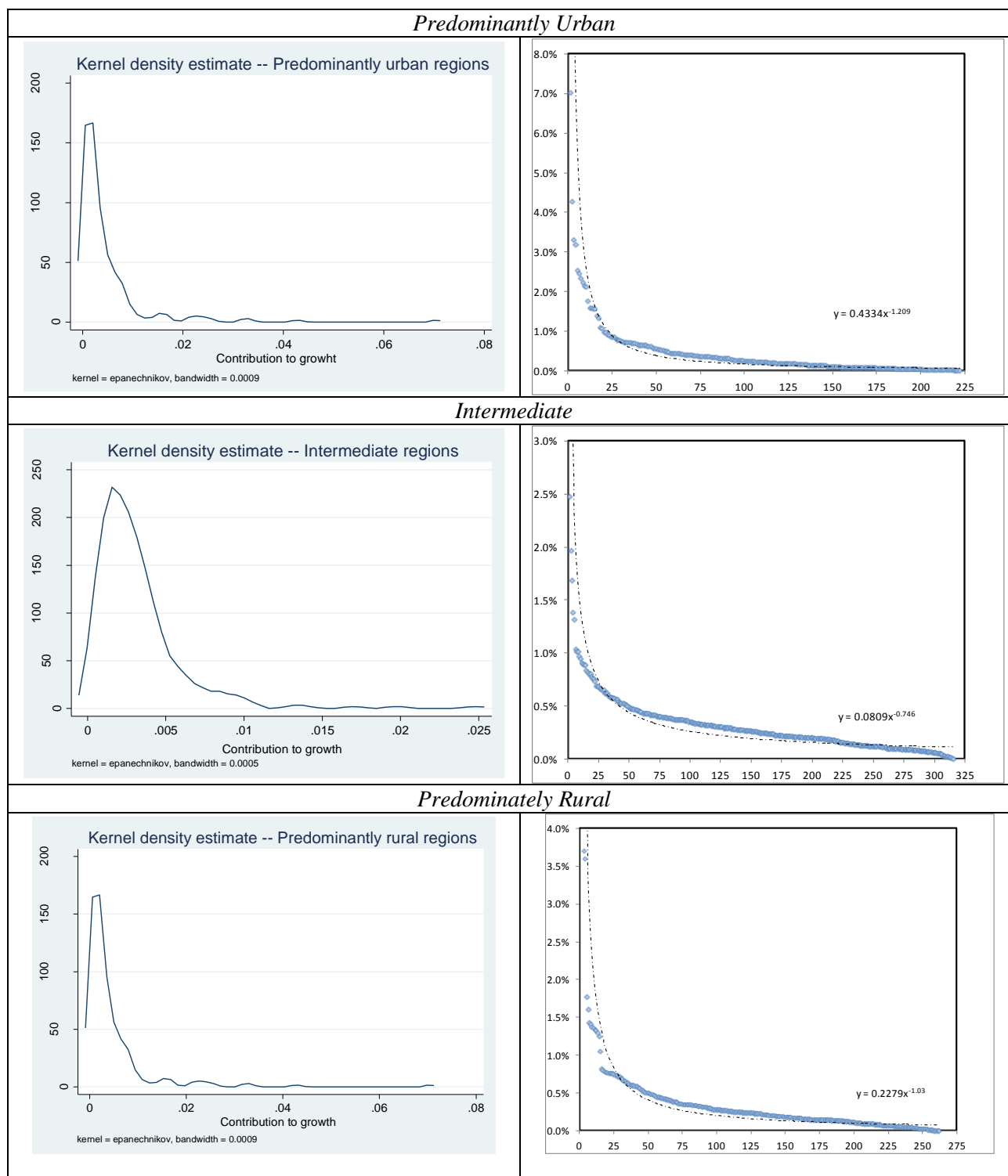
Source: Calculations based on OECD Regional Database (2009).

The kernel density estimates display the distributions of regional contributions to growth within each of the three types of regions. The shape of the distributions also resembles a power law (Figure 15)

- There is a bias in our sample of regions where data are available under-representing rural regions. Given that GDP data for TL3 regions are missing for the United States, Canada, Australia, Mexico, Switzerland and New Zealand the number of rural regions is significantly reduced – from 893 to 300 – from the true size of rural regions.

revealing there are a small number of regions disproportionately contributing much more to aggregate growth. Among the three types of regions, urban and rural regions display the strongest relationship. In contrast the shape of the power law is a bit weaker among intermediate regions.

Figure 15. Contributions to growth by predominantly urban, intermediate and rural TL3 regions, 1995-2005



Source: Calculations based on OECD Regional Database (2009).

2. The Drivers of Growth at the Regional Level

The wide variation in economic performance among types of OECD regions reflects the regions' great heterogeneity in levels of income, rates of employment, mixes of high and low productivity activities, endogenous and exogenous assets, comparative advantages, stages of development and public policies. Therefore growth at the regional level results from a complex set of interconnected factors. Despite the complexity behind regional growth we can pinpoint and measure the structural factors of growth using an econometric model based on a theoretical framework already developed in previous studies (How Regions Grow: Trends and Analysis, OECD 2009). This model can help connect the regional with the national dimension allowing us to simulate and measure contributions to national growth from different groups and types of regions in Section 3.

Estimating GDP per capita growth among OECD TL2 regions

The theoretical framework⁴ considers elements from the neoclassical literature, the endogenous growth theory and the new economic geography. We estimate regional GDP per capita growth using a cross sectional two way fixed effects model with the following reduced functional form:

$$\ln\left(\frac{GDPpc_{i,t}}{GDPpci_{t-1}}\right) = \alpha + \beta_1 \ln(Initial Y_{i,t-1}) + \beta_2 \ln(Infrast_{i,t-1}) + \beta_3 \ln(Prim Ed_{i,t-1}) + \beta_4 \ln(Tert Ed_{i,t-1}) + \beta_5 (Emp Rate_{i,t-1}) + \beta_6 \ln\left(\frac{EmpRate_{i,t}}{EmpRate_{t-1}}\right) + \gamma_j CD_j + \phi_t TD_t + u_i + e_{i,t} \quad (1)$$

Where yearly regional growth of GDP per capita is regressed on:

- $Initial Y_i$ = initial GDP per capita
- $Infrast_i$ = motorway density defined by kilometres of motorway to population
- $Prim Edu_i$ = stock of labour force with only primary educational attainment
- $Tert Edu_i$ = stock of the labour force with tertiary educational attainment
- $Empl Rate_i$ = initial year employment rates
- CD_j = country dummies for j countries
- TD_t = time dummies, for t periods (e.g. 1995-2005)

The panel model can be specified with fixed effects and random effects. One potential consequence of the fixed effect panel is that disturbances may be correlated within groups (*i.e.* countries). The random

4. For an in depth theoretical review of the literature influencing growth, see: "How Regions Grow: Trends and Analysis".

effects account for this correlation and therefore the random effects estimator should be selected, when possible, over the fixed effects estimator if it is statistically justifiable to do so since it offers more efficient estimates. A Hausman test can determine whether it is statistically justifiable to use random effects. We apply a Hausman test our model and therefore employ a random effects (re) instead of fixed effects (fe) in our panel estimation.

Table 7. Panel results for regional economic growth in OECD TL2 regions, 1995-2005

Random-effects GLS regression			Number of obs = 1311			
Group variable: ctry_num			Number of groups = 23			
R-sq: within = 0.0582			Obs per group: min = 5			
between = 0.3966			avg = 57.0			
overall = 0.1288			max = 255			
Random effects u_i ~ Gaussian			wald chi2(6) = 94.56			
corr(u_i, X) = 0 (assumed)			Prob > chi2 = 0.0000			
gr_gdp_pc	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
gdp	-.002106	.0028829	-0.73	0.465	-.0077563	.0035442
transport	.0085531	.002478	3.45	0.001	.0036962	.0134099
ln_ed_02	-.0111997	.0017041	-6.57	0.000	-.0145396	-.0078597
ln_ed_56	.0084355	.0016315	5.17	0.000	.0052378	.0116332
er	-.0589233	.0118553	-4.97	0.000	-.0821592	-.0356875
grer	.0334903	.0205067	1.63	0.102	-.0067021	.0736828
_cons	.1128597	.0281309	4.01	0.000	.0577242	.1679951
sigma_u	.00971649					
sigma_e	.022897					
rho	.15259881	(fraction of variance due to u_i)				

Source: Calculations based on OECD Regional Database (2010).

The regression results provided in Table 7 are fairly consistent with estimates obtained in previous studies finding **infrastructure** and **human capital** positively influence GDP per capita growth rates at the regional level. In addition this specification adds *employment growth*, a flow variable in addition to the stock variable employment rate which acts in the similar manner as the initial level of GDP per capita, meaning the rate of employment captures the potential regions have for adding workers into productive activities. The lower the rate the more room regions have to generating growth by adding employers into the workforce. This result is confirmed by the positive and significant sign of employment rate growth.

Linking regional GDP per capita growth with aggregate output

The model estimates growth rates in GDP per capita. Nevertheless we can establish the link to aggregate growth using regional data on population and GDP per capita. Given that our forecast is an estimate of an annual average growth rate over a 10 year period, we can estimate aggregate growth over this time horizon – from 2005 to 2015.

Through equation (1) we can forecast an *annual average growth rate in GDP per capita* for each TL2 region using the estimated beta coefficients values – give in Figure XX -- and the values of the explanatory variables (e.g. infrastructure, initial GDP per capita, primary and tertiary attainment rate, employment rate and growth of employment rate) for each TL2 region in the year 2005. This forecast allows us to *estimate regional GDP* in 2015 and consequently estimate contributions to aggregate growth by each region in 2015 using the following procedure:

- Step 1: multiply each region's estimated *annual average growth rate in GDP per capita* to their GDP per capita value of 2005 repeatedly for deriving an *estimated GDP per capita* for the year 2015.
- Step 2: estimate *population* for the year 2015 in each TL2 region by interpolating the growth rate of population from 1995-2005 forward.
- Step 3: multiply the *population estimate* of 2015 (step 2) times the *GDP per capita estimate* of 2015 (step 1) for obtaining an *estimate of GDP* for 2015.
- Step 4: Using the *GDP estimate* of 2015 we compute a GDP growth rate (from the period 2005-2015) and we multiply it by each region's share of GDP in 2005 to estimate each region's *contributions to growth* over the period 2005-2015.

The purpose of deriving aggregate forecasts is by no means trying to attain an accurate aggregate future growth forecast, especially after the unprecedented shock of the global financial crisis in OECD economies; rather our purpose is trying to better understand of how internal distributions influence aggregate growth in different ways. We proceed in this task by simulating various scenarios in Section 3.

3. Simulating the Impact of Regional Policies on Aggregate Growth

Before simulating different scenarios, we develop a benchmark scenario forecasting GDP in the OECD for the year 2015 by applying the four step procedure described in the previous section. The benchmark scenario predicts OECD GDP to grow annual on average by **2.83%** in the OECD. In the benchmark scenario lagging regions -- defined by a lower level of GDP per capita than their respective national average in 1995 -- contribute to **47%** of aggregate growth and leading regions to **53%**. This ratio is off by three percentage points to the actual contribution of lagging and leading regions in the period 1995-2005. This difference can be due to missing data (for some explanatory variables) in several regions. Nonetheless given the small difference between the predicted contributions to growth with the actually values the predicted results from our model are fairly robust.

Contributions to growth by lagging and leading regions

The first simulation increases policy variables in the model -- infrastructure, educational attainments, and employment growth -- in all regions by 10% over the period 2005-2015. It then replicates the exercise increasing the policy variables by 10% in **only** lagging regions and in **only** leading regions.

The results of the simulation, given in Table 8, suggest that an increase in all policy variables by 10% would increase aggregate GDP growth annually on average by **3.05%**, or 0.22 percentage points relative to the benchmark model. It is interesting to note that **an increase in only lagging regions will impact aggregate growth similarly as an increase in only leading regions** by 10%. In the former case aggregate GDP growth will increase annually on average by 2.937% (or 0.107 percentage points more than the benchmark) and in the latter it will increase by 2.942%.

Table 8. Simulations increases in leading and lagging regions, 1995-2005

	benchmark	increase policy variables by 10%		
		all regions	only leading	only lagging
aggregate growth annually	2.829%	3.049%	2.942%	2.937%
percentage point change relate to benchmark	0	0.219	0.113	0.107

Source: Calculations based on OECD Regional Database (2009).

Our next simulation increases the value of each control variable by 10% in all regions first, then in leading regions only and finally only in lagging regions. This allows us to measure the effects of each control or policy variable separately when increased by 10% and secondly whether the increasing of each policy variable has a larger effect in leading or in lagging regions.

If we simulate a change by 10% in our four policy variable separately, the largest impact on aggregate growth occurs when reducing the labour force with only **primary and lower secondary attainment rates** (into upper secondary and tertiary education). This change accounts for more than half of the GDP gain when increasing all policy variables by 10%. The second most relevant policy variable is when increasing the labour force with **tertiary education** by 10% and accounts for almost 40% of the GDP increase. Finally increasing infrastructure density accounts for 8.1% of the overall gain and employment rate growth with 0.6%.

Table 9. Simulations increasing each policy variable by 10% separately, 1995-2005

increase by 10%	all regions	only leading	only lagging
only infrastructure	8.1%	3.4%	4.7%
only primary education	54.4%	28.3%	26.2%
only tertiary education	37.0%	19.3%	17.8%
only employment rate growth	0.6%	0.4%	0.2%
sum	100%	51%	49%

Note: an increase of all policy variables by 10% will increase OECD GDP annual growth by 0.219 percentage points to 3.049% relative to the benchmark. The figures in table are expressed in percentages of the 0.219 percentage point change.

Source: Calculations based on OECD Regional Database (2009).

It is interesting to note the larger gains in these simulations in leading regions except for the case of infrastructure where it is larger in lagging regions. This result is consistent with previous OECD research indicating lagging regions or regions far from their production possibility frontier could especially gain from infrastructure projects. These gains will be larger when human capital in the region is also improved

APPENDIX 1: REGIONAL GRIDS

In any analytical study conducted at sub-national level, defining the territorial unit is of prime importance, as the word *region* can mean very different things both within and among countries. In order to have a measure that is comparable, the OECD has developed a regional typology for classifying regions within each member country.

The classification is based on two territorial levels. The higher level (Territorial Level 2 – TL2) consists of 335 large regions, while the lower level (Territorial Level 3 – TL3) is composed of 1 679 small regions. All the regions are defined within national borders and in most cases correspond to administrative regions. Each TL3 region is contained within a TL2 region.

This classification – which, for European countries, is largely consistent with the Eurostat classification – helps to compare regions at the same territorial level. Indeed these two levels, which are officially established and relatively stable in all member countries, are used as a framework for implementing regional policies in most countries

APPENDIX 2: POWER LAWS

A **power law** is a special type of mathematical relationship between two quantities. If one quantity is the frequency of an event, and the other is the size of the event, then the relationship has a power-law distribution when the frequency of the event decreases at a greater rate than the size increases (Figure A.2.1).

Technically A power law is any polynomial relationship that exhibits the property of scale invariance. The most common power laws relate two variables in the following functional form:

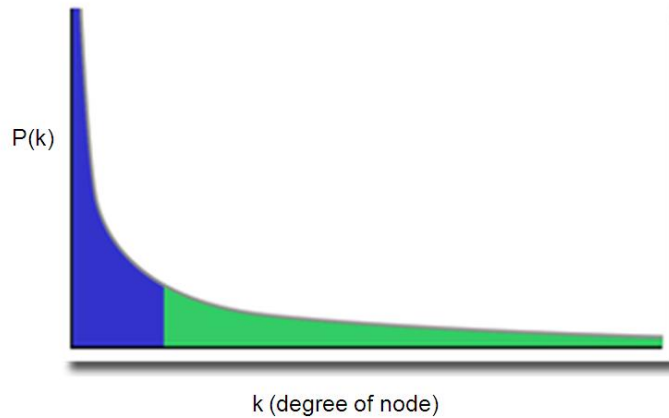
$$f(x) = a x^k + o(x^k) \quad (\text{A1})$$

- where a and k are constants
- $o(x^k)$ is an asymptotically small function of x^k
- k is called the scaling exponent where the word scaling denotes the fact that a power law satisfies:

$$f(cx) = a c^k x^k \sim f(x) \quad (\text{A2})$$

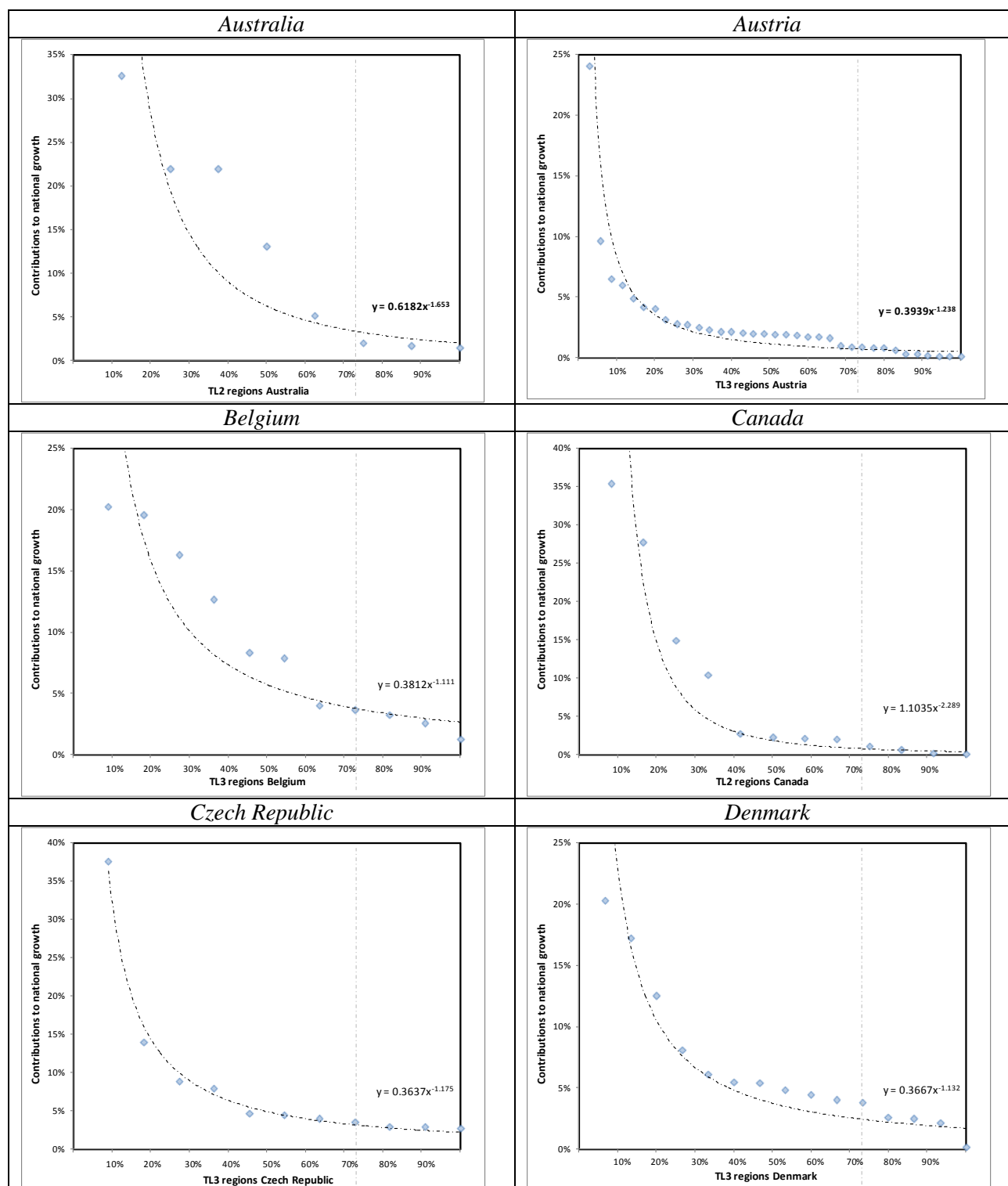
Taking logarithms of (A1) reveals a linear relationship with slope k . Rescaling the argument produces a linear shift of the function up or down but leaves both basic form and the slope k unchanged.

Figure A.2.1. Power Laws

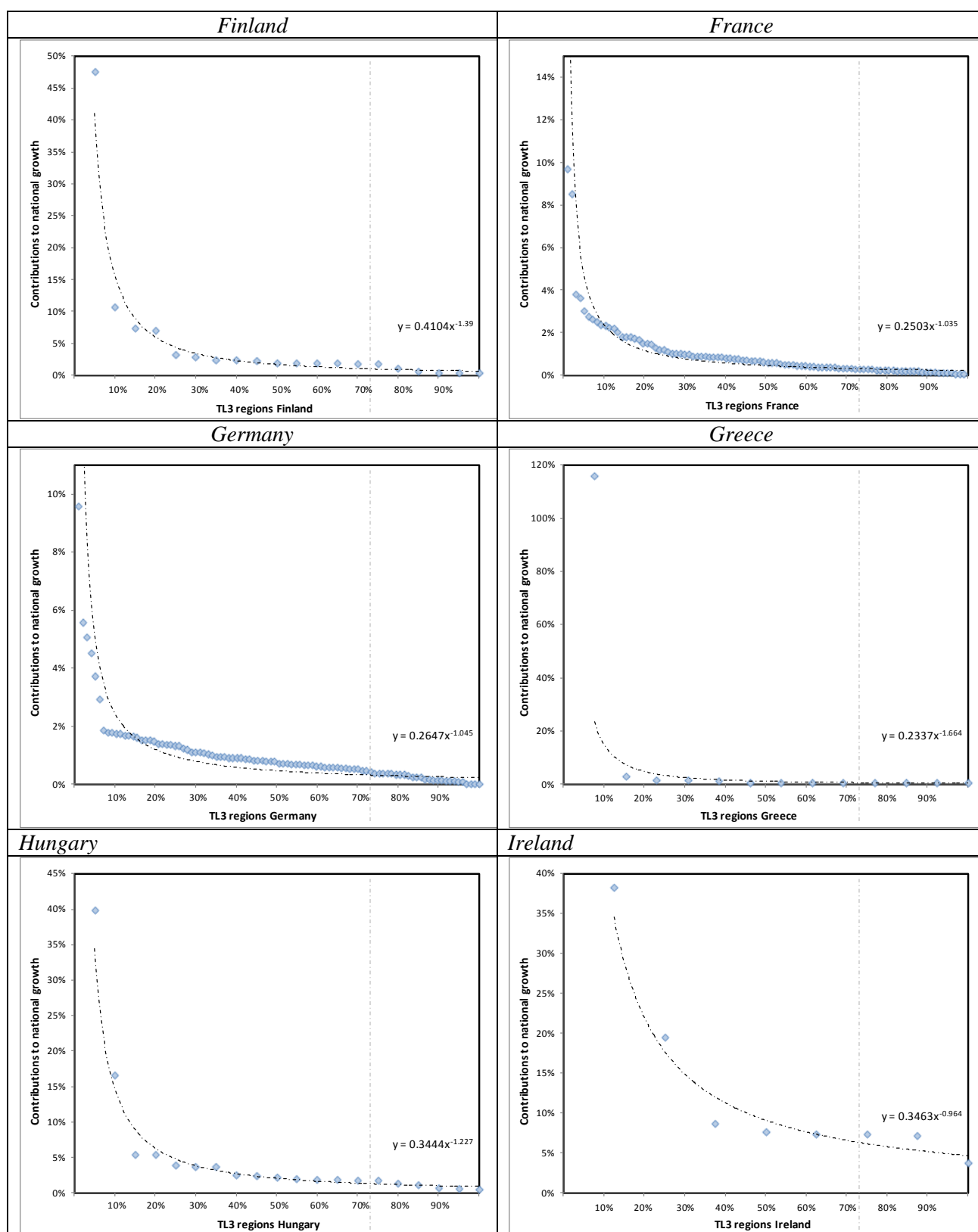


APPENDIX 3: CONTRIBUTIONS TO NATIONAL GROWTH BY TL2 AND TL3 REGIONS

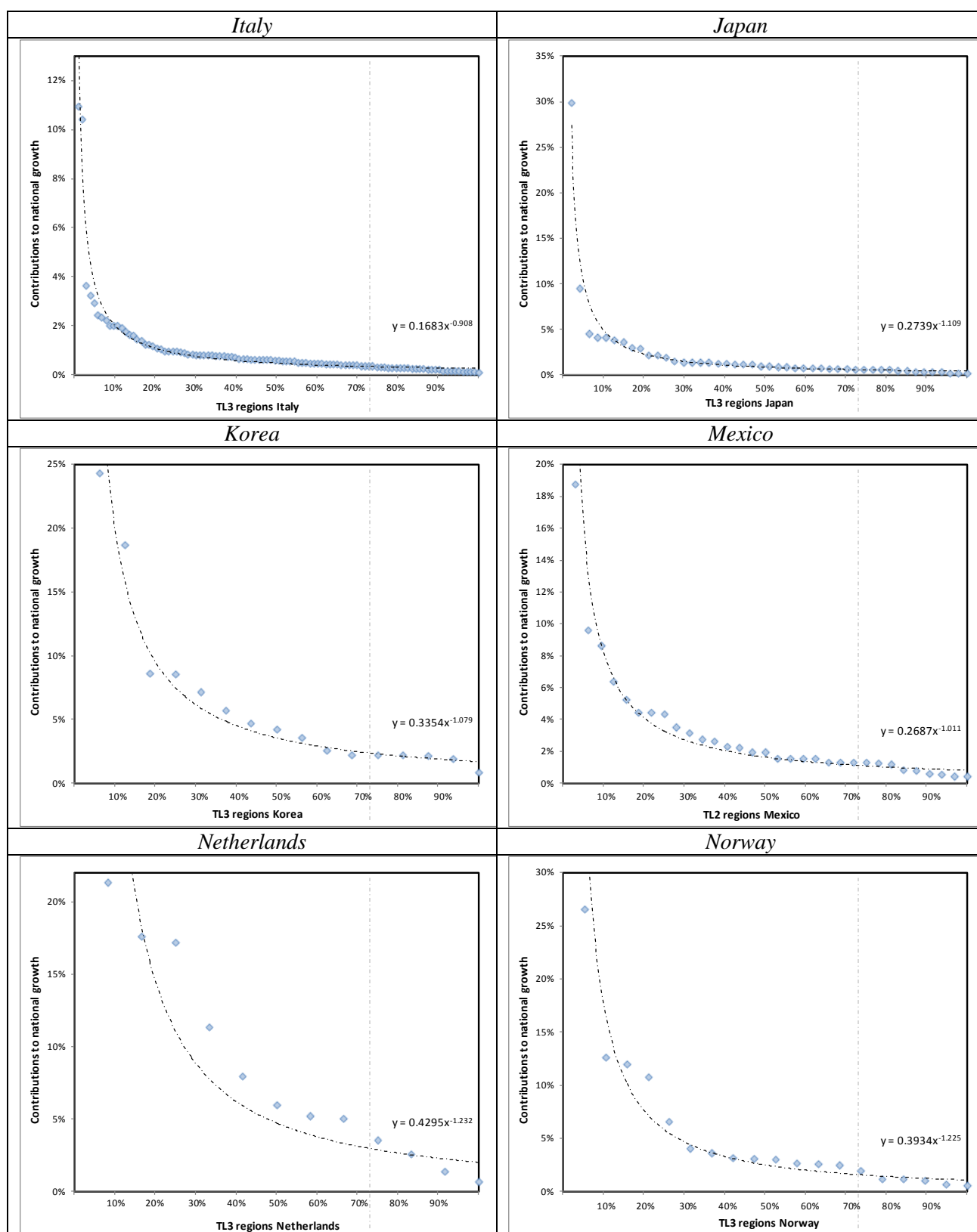
Figure A.3. Contributions to national growth by TL2 and TL3 regions, 1995-2005



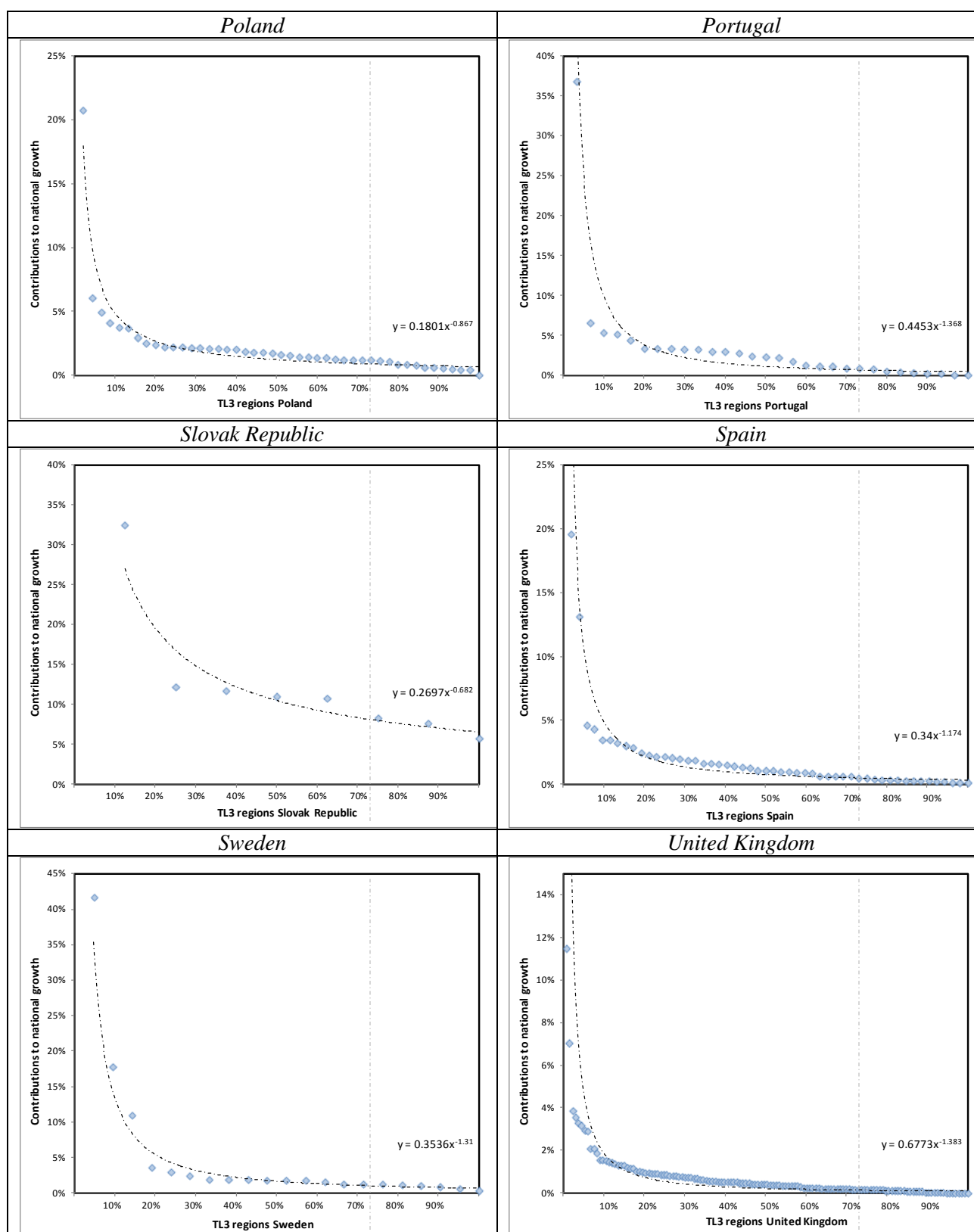
Source: Calculations based on OECD Regional Database (2009).



Source: Calculations based on OECD Regional Database (2009).



Source: Calculations based on OECD Regional Database (2009).



Source: Calculations based on OECD Regional Database (2009).