How Much Land Does it Take To Support Each Person? The Ecological Footprint and the Sustainability

July 2012

Maria Carmen Papaleo[1]

Abstract

This paper investigates the Ecological Footprint indicator by focusing on a sustainable development and then a carrying capacity of land. The impact of man on nature is a theme explored in order to conduct an empirical analysis on the growth rate of population, the percentage of urban and rural population, in Europe. It 's an ongoing study the impact of CO_2 emissions on the environment, especially following the growth of urban population. Thanks to an indicator, it's possible to compare the level of CO_2 emissions per inhabitant in the EU with levels in developing countries and, through a sectoral approach, we can see the total CO_2 emissions per capita from fuel combustion, from electricity and heat production, from manufacturing industries and construction, from transport, etc.

Keywords: ecological footprint, sustainable development, carrying capacity, growth rate of population, urban population, rural population, CO_2 emissions.

1 Ph. D. Student in Economics of the Public Sector at University of Salerno. Department of Economics and Statistics.

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1 INTRODUCTION

Sustainable development is "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Bruntland Report, 1987). The possibilities for future generations to meet their own needs depends on: *i)* the availability of a composite capital, as used by the present generation; *ii)* a degree of substitutability of factors; *iii)* by a certain minimum level of critical natural capital, that it's necessary for the reproducibility of the biological system; *iv)* the carrying capacity of the system, i.e. the amount of pollution and waste that the planet is able to withstand.

The concepts of sustainable development that require a strong or very strong sustainability are based on assumptions increasingly pessimistic about the carrying capacity of land, and then on the closeness level of critical natural capital and on the substitutability factors. Connected to the notion of sustainable development is that of intergenerational equity, which is the concern to ensure equal opportunities for subsequent generations. To get an economy truly "sustainable" in relation to the regenerative and assimilative capacities of natural systems that allow us to live, you must rely on the principle of equity. It's possible to prevent the continued social and economic iniquity of which is so abundant in today's world and to manage our progress to sustainability through the attribution of value of what we measure rather than measuring what we value (Wackernagel *et al.*, 2000).

In summary, to monitor progress towards sustainable development, you must be able not only to define, but also to measure the various aspects of sustainability: the limits that nature imposes, our impact on it and our quality of life. The measurability is not the only problem, but progress towards that greatly help progress towards sustainability. The indicators (environmental, social, economic, aggregates, etc) allow today to provide timely, accessible and reliable information, very useful to make decisions. Among the sustainability indicators of aggregate type, they are cited: *i) TMR*, Total Material Requirements, summary of flows of matter and energy in the economy; *ii)LPI*, Living Planet Index (average of indexes related to biodiversity); *iii) HDI*, Human Development Index (average of longevity, aspects cultural and income); *iv) GPI*, Genuine Progress Index, supplemented by factors such as GDP taking into account the quality of life, pollution and consumption of non-renewable resources; *v)*

ESI, Environmental Sustainability Index, which measures the progress towards environmental sustainability based on a set of twenty indicators, each of which sums up to eight variables.

2 ECOLOGICAL FOOTPRINT

An indicator for evaluating sustainability is the Ecological Footprint (EF hereafter). The EF method has been developed at the turn of the eighties and nineties by ecologist William Rees of the University of British Columbia's School of Community and Regional Planning in Canada and his colleagues, first of all, then Ph.D. student Mathis Wackernagel. The method has undergone continual refinement over the last decade and, still, it's the subject of further analysis and research to improve its effectiveness. The analysis of the EF aims to overcome some problems related to the evaluation of carrying capacity used in the ecology of the human species, completely inverting the traditional question: instead of asking "how many people can the Earth support?", the EF method asks "how much land does it take to support each person?". In other words, the footprint does not focus on the number of heads, but the size of the feet (Wackernagel *et al*., 2000). Therefore, it becomes crucial not only the number of people but also the types of production technologies and consumption patterns. The EF is then defined as the total area of terrestrial and aquatic ecosystems required to produce the resources that a given human population (an individual, family, community, region, nation, etc) consumes and to assimilate waste that the same population produces. The calculations are based on EF chance to estimate the resources we consume, the waste we produce and the possibility that these flows of resources and waste can be converted to an equivalent area of biologically productive land, necessary to ensure these functions. If the bioproductive space required is greater than what is available, we can reasonably say the rate of consumption is not sustainable.

The EF of a person is the sum of six different components: *i)* the surface of cultivated land needed to produce the foods and natural resources; *ii)* the grazing area necessary for the breeding and to produce animal products; *iii)* the surface of forest necessary for harvest timber and paper; *iv)* the sea surface required to produce fish and seafood; *v)* the area of land required to accommodate housing and infrastructure; *vi)* and the area of forest needed to absorb emissions of carbon dioxide resulting from the energy consumption of the individual taken into account. It's measured in global hectares: a global hectare is equivalent to one hectare of bioproductive space in relation to the average global productivity.

Table 1. Ecological Footprint and Biocapacity (2008)

Country/region	Population (millions)	Income Group	Cropland Footprint	Grazing Footprint	Forest Footprint	Fish Footprint	Carbon Footprint	Built up land	Total Ecological Footprint	Cropland	Grazing land	Forest land	Fishing ground	Built up land	Total biocapacity	Biocapacity (Deficit) or Reserve
			Ecological Footprint 2008 (global hectares per person)							Biocapacity 2008 (global hectares per person)						
World	6739,6		0,6	0,2	0,3	0,1	1,5	0,1	2,7	0,6	0,2	0,8	0,2	0,1	1,8	(0,9)
Belgium	10,6	HI	1,8	1,0	0,5	0,2	3,3	0,4	7,1	0,5	0,1	0,3	0,0	0,4	1,3	(5,8)
Bulgaria	7,6	UM	1,0	0,2	0,5	0,0	1,7	0,2	3,6	1,2	0,2	1,0	0,1	0,2	2,6	(0,9)
Czech Republic	10,4	HI	1,2	0,2	0,8	0,0	2,9	0,2	5,3	1,2	0,1	1,2	0,0	0,2	2,7	(2,6)
Denmark	5,5	HI	2,8	0,7	1,2	0,8	2,5	0,3	8,3	2,4	0,0	0,3	1,9	0,3	4,8	(3,4)
Estonia	1,3	HI	0,8	0,1	1,6	0,2	1,9	0,2	4,7	0,8	0,4	3,3	4,1	0,2	8,7	4,0
Finland	5,3	HI	1,1	0,2	0,4	0,3	4,2	0,1	6,2	0,9	0,0	8,6	2,5	0,1	12,2	6,0
France	62,1	HI	1,2	0,4	0,6	0,2	2,2	0,2	4,9	1,5	0,2	0,9	0,2	0,2	3,0	(1,9)
Germany	82,5	HI	1,2	0,3	0,4	0,0	2,5	0,2	4,6	0,9	0,1	0,6	0,1	0,2	2,0	(2,6)
Greece	11,3	HI	1,3	0,5	0,4	0,1	2,5	0,1	4,9	1,0	0,1	0,1	0,2	0,1	1,6	(3,3)
Hungary	10,0	HI	1,3	0,0	0,4	0,0	1,6	0,2	3,6	1,8	0,1	0,6	0,0	0,2	2,7	(0,9)
Ireland	4,4	HI	1,3	0,5	0,5	0,0	3,7	0,2	6,2	0,6	0,8	0,2	1,6	0,2	3,4	(2,8)
Italy	59,9	HI	1,0	0,4	0,5	0,1	2,4	0,1	4,5	0,6	0,1	0,3	0,1	0,1	1,1	(3,4)
Latvia	2,3	UM	0,8	0,1	1,2	0,3	1,5	0,1	4,0	1,0	0,7	3,0	1,9	0,1	6,6	2,7
Lithuania	3,4	UM	1,0	0,1	1,0	0,4	1,6	0,2	4,4	1,4	0,8	1,7	0,3	0,2	4,3	(0,1)
Netherlands	16,5	HI	1,3	1,1	0,5	0,1	3,1	0,2	6,3	0,3	0,1	0,1	0,4	0,2	1,0	(5,3)
Poland	38,2	UM	1,0	0,0	0,7	0,1	2,0	0,1	3,9	1,0	0,1	0,7	0,1	0,1	2,0	(1,9)
Portugal	10,6	HI	1,0	0,0	0,1	1,0	2,0	0,1	4,1	0,3	0,2	0,6	0,1	0,1	1,3	(2,8)
Romania	21,6	UM	0,9	0,1	0,4	0,0	1,2	0,2	2,8	0,9	0,2	1,0	0,1	0,2	2,3	(0,5)
Slovakia	5,4	HI	1,1	0,3	0,9	0,0	2,3	0,2	4,7	1,0	0,1	1,6	0,0	0,2	2,9	(1,8)
Slovenia	2,0	HI	0,9	0,3	0,6	0,0	3,2	0,2	5,2	0,4	0,2	1,8	0,0	0,2	2,6	(2,6)
Spain	45,1	HI	1,3	0,3	0,3	0,4	2,4	0,1	4,7	1,0	0,1	0,2	0,1	0,1	1,5	(3,3)
Sweden	9,2	HI	1,0	0,5	1,0	0,2	3,0	0,1	5,7	0,6	0,0	6,4	2,4	0,1	9,5	3,8
United Kingdom	61,5	HI	0,9	0,4	0,5	0,1	2,6	0,1	4,7	0,5	0,1	0,1	0,5	0,1	1,3	(3,4)

Source: Global Footprint Network

The footprint can be compared with the biological ability of which locally has; it's represents the total of the biologically production areas of a country or region, giving rise to an ecological deficit or surplus. Calculations of this type, as far easier if referring to the entire world or nations, it's possible to implement even for smaller entities. In particular, in recent years, increasingly estimates are made for determine the EF of cities and towns or groups of municipalities, provinces or regions. It's shown that in most cases the cities "consume" much more soil than they would have if there were no phenomena of "transfer" of natural capital. A distinction between the different measurement systems for sustainability based on the level of concentration of information that the nature of the indicator aggregated or not.

3 METHODOLOGY

There are two complementary approaches to calculate the EF: compound and component method. The compound method is most extensive and robust if we consider as the unit of analysis nation, since it refers to trade flows and energy data. The calculation is divided into three parts: *i)* the first part consists in the consumption of the population, taking into account more than fifty food items and not. The consumption is calculated adding to domestic production, imports and subtracting exports; *ii)* the second part of the calculation determines the energy balance, considering both energy generated locally and those incorporated in the products sold. Once the fuel used, it's converted to carbon content. This part is used to calculate the energy footprint, i.e. the amount of area forest needed to absorb CO_2; *iii)* the third section summarizes the calculation of EF in six types of land and provides the total per capita. Multiplying the value per capita for the population under consideration is obtained by the total footprint.

In the component method is pre-calculated values of EF of some activities, using the characteristic data for the region or country concerned. Any set of data based on the life cycle of products can be combined and transformed to determine the footprint of the products consumed. The purpose is to compute the majority of consumption through a series of analyses of the components that form the products, for considering the possible impacts of human activities. Furthermore, depending on the level of specificity required, some components may be divided or omitted in the case the information is non-existent.

In both methods, data sources are rarely congruent, the estimates are based on assumptions, methods and different samples. The two methods, using different information sources, have different sensitivity analysis in the determination of quantitative values.

Through the use of conversion factors or productivity defined by Wackernagel, we can express the result in terms of world biologically productive land on average. This makes the result comparable with the values obtained from different studies on the footprint of other populations. In addition, to the conversion factors Wackernagel has also introduced the equivalence factors which assign different types of land by a percentage proportionate to their productivity. The total should then be compared with biocapacity of the country or region surveyed. In biologically productive land must be subtracted 12% for the sustenance of biodiversity, the remaining 88% is considered as an area available.

The analysis is further based on the European data collection about growth rate of population, urban and rural population, CO_2 emissions. The main sources are the World Bank and Eurostat websites, and the International Energy Agency (IEA) and the European Energy Agency (EEA). The graphs are plotted with Gretl, a software package for econometric tasks and statistical analysis of time series.

4 CARRYNG CAPACITY AND GROWTH RATE OF POPULATION

The analysis of the EF is a calculation tool that allows you to estimate the resource consumption and waste assimilation required by a given human population or a certain economy and to express these quantities in terms of corresponding surface area production. The EF is among the aggregate indicators and it measures human impact on the Earth in an unambiguous and comprehensive quantitative pattern. From a theoretical point of view, there is no difficulty in conceptually defining the impact of man on nature and it's calculated as

$$I = P \cdot A \cdot T$$

where I is human impact on the biosphere, P is people on the planet, A is affluence (average consumption of each person), and T is technology, i.e. a measure of the technical quality of the produced goods.

The carrying capacity is defined as the ability of an habitat and its resources to support a number of individuals without cracking the productivity habitat itself. The ecological weight is equally dependent on cultural factors and ecological productivity: in fact, the total ecological weight of any population varies when some factors change as average income per person, the expectations of consumption, energy and materials efficiency. Moreover, the global economy allows to everyone to have access to resources around the world (Wackernagel and Rees, 2000). Now the question is: how much does the population (P in the EF equation) grow each year? In the matter of that, we analyse the growth rate of European population. The growth rate of human population measures as it changes the relative abundance of populations over time. The units of measurement of the growth rate of population are the existing individuals at a given historical moment. The population size can be changed only by four factors: *i)* the number of births, that adds new individuals in a population, *ii)* the dead, that removes individuals from a population, *iii)* immigration, adding new individuals in a population *iv)* emigration, that removes individuals in a population. The growth rate of population is positive when in a population other individuals are add, it's negative when removed individuals are more than added individuals, equal to zero when an equal number of individuals is added and removed. The population size is known as a carrying capacity of the terrestrial globe and it's the size beyond which a significant increase can not occur due to limitations such as lack of food, water, space, etc.

5 DATA ANALYSIS IN EUROPE

5.1 GROWTH RATE OF POPULATION

We can verify empirically the growth rate of the population of all European countries in the fifty years 1961-2011. The analysed data are extrapolated from the site of the World Bank and they are related to the growth rate of human population for the following countries: *i)* Austria; *ii)* Belgium; *iii)* Bulgaria; *iv)* Cyprus; *v)* Denmark; *vi)* Estonia; *vii)* Finland; *viii)* France; *ix)* Germany; *x)* Great Britain; *xi)* Greece; *xii)* Ireland; *xiii)* Iceland; *xiv)* Italy; *xv)* Latvia; *xvi)* Liechtenstein; *xvii)* Lithuania; *xviii)* Luxembourg; *xix)* Malta; *xx)* Norway; *xxi)* Netherlands; *xxii)* Poland; *xxiii)* Portugal; *xxiv)* Czech Republic; *xxv)* Romania; *xxvi)* Slovakia; *xxvii)* Slovenia; *xxviii)* Spain; *xxix)* Sweden; *xxx)* Switzerland; *xxxi)* Turkey; *xxxii)* Hungary. As it can be seen from the list, the data on the growth rate of world population have been modified in order to obtain a table containing only European states, and only for those years (eliminating, therefore, the data relating to 1960).

Table 2. Growth rate of European population (A-La).

Country Name	Austria	Belgium	Bulgaria	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia
1961	0,54847	0,33221	0,95816	0,60411	-0,160042501	0,698142	1,17759	0,70571	1,31495	0,76985	0,7929	0,45324	1,94872	-0,1485	0,66838	1,48363
1962	0,6129	0,39805	0,87526	0,22508	0,395694491	0,778455	1,26428	0,68	1,39359	0,87943	0,59578	0,32266	1,85337	0,41248	0,67662	1,33381
1963	0,64236	0,74761	0,81038	0,03876	0,477058972	0,787727	1,2485	0,70698	1,40236	0,92588	0,37089	0,26018	1,77979	0,58532	0,72955	1,33561
1964	0,66655	0,94648	0,81609	0,12415	0,58890324	0,799213	1,2331	0,55632	1,32204	0,80514	0,36261	0,3156	1,77777	0,48727	0,82262	1,33457
1965	0,64973	0,90814	0,73191	0,40456	0,528566073	0,77924	1,09423	0,33337	1,1824	0,85319	0,46779	0,27729	1,73268	0,37502	0,84211	1,12265
1966	0,7014	0,67546	0,6547	0,74482	0,425318535	0,803006	1,0479	0,3748	1,01812	0,83456	0,7378	0,30224	1,69345	0,39968	0,7773	0,7605
1967	0,74743	0,55665	0,62975	1,01939	0,323870353	0,78842	1,12044	0,54155	0,87584	0,45721	0,81441	0,37216	1,61344	0,47251	0,72378	0,7854
1968	0,51925	0,39339	0,71196	1,2091	0,237687869	0,608832	1,10802	0,44897	0,77882	0,44472	0,65053	0,38306	1,3677	0,45134	0,63174	0,96865
1969	0,34533	0,28317	0,76851	1,26693	0,204663762	0,552993	1,09514	-0,058	0,74811	0,79298	0,36542	0,4175	0,92922	0,58651	0,56606	0,83801
1970	0,34922	0,09861	0,65473	1,23137	-0,389873238	0,751423	1	-0,3787	0,76295	0,33266	0,2282	0,37978	0,52427	0,83883	0,52888	0,68013
1971	0,44625	0,18225	0,55	1,17469	-0,317563701	0,694896	1,07038	0,1262	0,79349	0,18348	0,43384	0,28618	0,8087	1,17677	0,46645	0,72748
1972	0,58119	0,39159	0,46521	1,14529	0,41450322	0,571991	1,12391	0,5952	0,80496	0,47848	0,65004	0,2981	1,46378	1,4973	0,56771	0,80825
1973	0,55404	0,31466	0,52063	1,12729	0,552141692	0,604488	0,96003	0,56791	0,78607	0,31494	0,45413	0,32228	1,50909	1,61681	0,67819	0,83737
1974	0,17021	0,31463	0,66797	1,13247	0,664900388	0,465594	0,86527	0,52354	0,72317	0,03897	0,36818	0,44633	1,35292	1,67047	0,65439	0,88057
1975	-0,2653	0,28898	0,48274	1,14856	0,699965182	0,288269	0,78546	0,44386	0,63235	-0,37285	0,93866	0,58808	1,27891	1,65896	0,59725	0,77428
1976	-0,1767	0,17867	0,43316	1,18799	0,667037111	0,251351	0,71274	0,30145	0,53291	-0,42877	1,55321	0,55018	0,99286	1,52059	0,49885	0,60315
1977	0,03839	0,12348	0,5191	1,2077	0,598799763	0,311446	0,73604	0,27974	0,45318	-0,22638	1,30111	0,46458	0,74443	1,36347	0,42472	0,56836
1978	-0,081	0,0933	0,1118	1,15157	0,541813438	0,310596	0,68561	0,28712	0,40823	-0,08703	1,2966	0,34492	0,78054	1,42892	0,35631	0,51568
1979	-0,1705	0,08988	0,13501	0,99652	0,489354496	0,24563	0,55625	0,25558	0,41134	0,04421	1,2467	0,18075	0,97848	1,3412	0,28915	0,32103
1980	0,00011	0,11021	0,40249	0,78791	0,115087338	0,121604	0,60335	0,31108	0,44885	0,20743	0,98222	0,06509	1,0589	1,15747	0,206	0,22911
1981	0,25502	-0,0026	0,33327	0,54627	-0,034962755	-0,02841	0,70472	0,42652	0,49613	0,15231	0,89662	0,00678	1,14058	1,17792	0,12005	0,30689
1982	0,07172	-0,0272	0,29581	0,36595	0,138100551	-0,07348	0,71988	0,56029	0,53359	-0,09511	0,61646	-0,059	1,33661	0,9499	0,07408	0,4617
1983	-0,1616	-0,0079	0,24955	0,3397	0,087505593	-0,06867	0,6871	0,59599	0,56143	-0,26215	0,58172	-0,1502	1,32404	0,71146	0,03629	0,58817
1984	-0,0063	-0,0015	0,23397	0,52244	0,06155688	-0,05238	0,65219	0,53434	0,57255	-0,34567	0,49816	-0,2001	1,06363	0,62163	0,02235	0,62787
1985	0,04695	0,02979	-0,0015	0,85193	0,066820435	0,040527	0,66706	0,41707	0,57062	-0,22349	0,38829	-0,1818	0,78767	0,1602	0,0289	0,65459
1986	0,06355	0,03565	-0,0265	1,22079	0,049411624	0,133728	0,74351	0,32479	0,56983	0,04577	0,33076	-0,1706	0,73259	0,04545	0,00545	0,81174
1987	0,06328	0,08525	0,14711	1,53754	0,049213263	0,126664	0,7781	0,28363	0,5712	0,15362	0,33436	-0,1678	1,09563	0,01037	0,01021	1,02139
1988	0,14157	0,31793	0,11237	1,7942	0,076879259	0,048593	0,62162	0,29069	0,56174	0,39068	0,3632	-0,1533	1,56622	-0,4268	0,04832	1,01709
1989	0,45051	0,36325	-1,17	1,95875	0,055917204	0,059988	0,39814	0,36102	0,53894	0,77334	0,52185	-1,089	1,2384	-0,3955	0,07501	0,50827
1990	0,762	0,29824	-1,8038	2,05085	-0,267830773	0,162456	0,06649	0,44338	0,50752	0,86197	0,66584	-1,0331	0,77766	0,08445	0,08371	-0,1427
1991	0,99842	0,37159	-0,9904	2,13267	-0,240064842	0,259518	-0,5022	0,54617	0,47456	0,72861	0,97379	-0,0057	1,15915	0,57658	0,06923	-0,4731
1992	1,10055	0,40571	-1,0739	2,2121	0,102241165	0,330671	-1,8242	0,56191	0,44659	0,76035	1,10127	-0,0391	1,25663	0,68459	0,06792	-1,3768
1993	0,82463	0,39064	-0,7977	2,24156	0,103947042	0,333166	-2,5743	0,48385	0,42538	0,65739	0,91827	-0,114	1,01681	0,50109	0,06114	-1,9719
1994	0,38487	0,3082	-0,3396	2,21583	0,036121766	0,337707	-2,1386	0,43105	0,41403	0,34686	0,83267	-0,1369	0,86684	0,39497	0,02037	-1,6738
1995	0,15311	0,20944	-0,4454	2,15283	-0,061314063	0,520962	-1,7854	0,38166	0,41188	0,2939	0,76791	-0,1392	0,54247	0,51401	0,00159	-1,4258
1996	0,13502	0,19539	-0,5157	2,06555	-0,116381299	0,565926	-1,4754	0,32804	0,40748	0,28947	0,7008	-0,1718	0,53991	0,79441	0,0281	-1,1264
1997	0,11332	0,24199	-0,6088	1,982	-0,107762749	0,415565	-1,1409	0,29738	0,40657	0,14631	0,62675	-0,2015	0,8192	1,00786	0,05291	-0,9968
1998	0,10973	0,21353	-0,6673	1,92366	-0,094744752	0,363163	-0,9606	0,26547	0,42698	0,01514	0,54024	-0,2327	1,07086	1,04854	0,02877	-0,9429
1999	0,19456	0,22919	-0,5606	1,90291	-0,102175934	0,330886	-0,7605	0,23212	0,32487	0,06463	0,43928	-0,2833	1,20924	1,13368	0,01682	-0,814
2000	0,24047	0,24252	-0,4939	1,90396	-0,112258212	0,334234	-0,4473	0,20761	0,68458	0,13543	0,3202	-0,2598	1,36919	1,34197	0,0453	-0,7346
2001	0,3828	0,34395	-1,8516	1,90978	-0,34942087	0,358316	-0,3961	0,22769	0,72733	0,16823	0,29702	-0,2294	1,3293	1,60489	0,06164	-0,7603
2002	0,49198	0,44827	-1,911	1,89481	-0,309549365	0,319487	-0,4008	0,24238	0,72668	0,16813	0,34266	-0,2848	0,8926	1,69943	0,31575	-0,6983
2003	0,48713	0,41864	-0,5724	1,84635	0,024583319	0,27201	-0,3751	0,23846	0,70817	0,05536	0,32685	-0,2864	0,6925	1,64229	0,77945	-0,5696
2004	0,62041	0,43279	-0,5434	1,75501	0,084746025	0,258432	-0,3157	0,29035	0,7357	-0,02171	0,34582	-0,2214	0,87794	1,84513	0,98576	-0,54
2005	0,68127	0,55006	-0,5317	1,63607	0,193742982	0,275482	-0,2369	0,34225	0,75321	-0,05678	0,38135	-0,1989	1,58289	2,20261	0,73938	-0,5335
2006	0,4948	0,65956	-0,5296	1,51	0,32485824	0,328645	-0,1896	0,38378	0,69662	-0,1128	0,39991	-0,1557	2,34742	2,38548	0,56905	-0,5476
2007	0,38803	0,73433	-0,5112	1,39774	0,63122155	0,443466	-0,1397	0,42543	0,61817	-0,13372	0,3966	-0,1549	2,53009	2,24187	0,73327	-0,5192
2008	0,43441	0,78998	-0,4759	1,30598	0,868815999	0,587548	-0,0743	0,46555	0,55843	-0,19014	0,39529	-0,1751	1,85957	1,56567	0,76655	-0,4406
2009	0,33946	0,8046	-0,5032	1,24312	0,601029549	0,535079	-0,0301	0,47825	0,54182	-0,25338	0,40556	-0,1549	0,34124	0,74869	0,60074	-0,4981
2010	0,2924	0,91547	-0,6725	1,20086	0,310506715	0,444197	-0,0082	0,45749	0,54753	-0,1532	0,28983	-0,226	-0,1439	0,34509	0,48176	-0,7043
2011	0,34778	1,02463	-0,7767	1,1636	0,248820586	0,473257	-0,012	0,43995	0,55318	-0,0623	-0,1018	-0,2907	0,30108	0,28219	0,47275	-0,8526

Source: World Bank

Table 3. Growth rate of European population (Li-U)

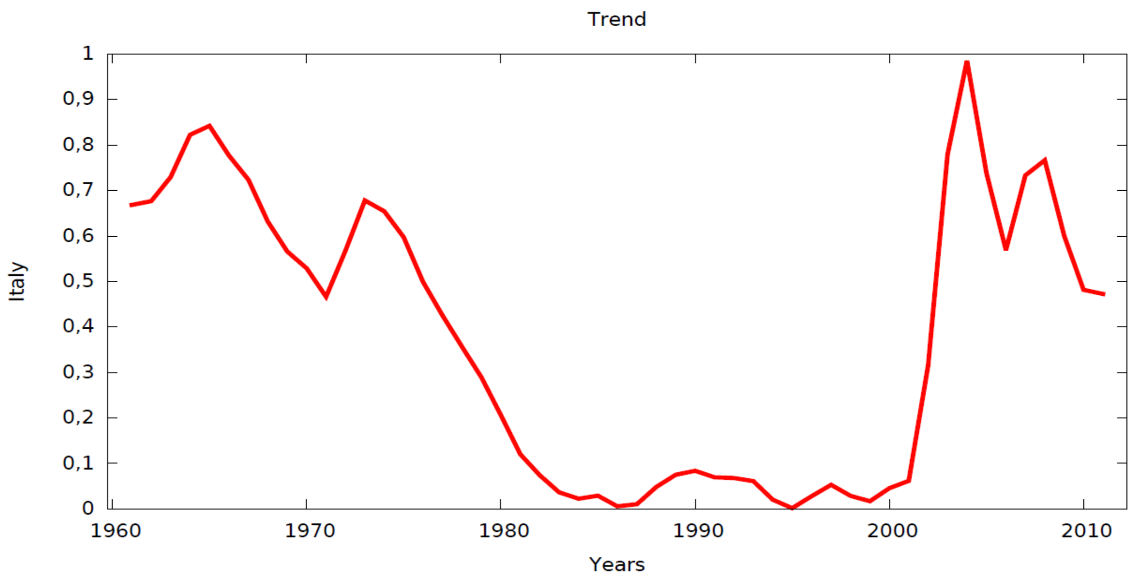
Country Name	Liechtenstein	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovak Rep.	Slovenia	Spain	Sweden	Switzerland	Turkey	U.K.
1961	2,357121988	1,606575	0,91152554	-0,4	1,31529459	0,794354	1,09579	0,80509	0,80269	2,99236759	0,5921	0,929	0,47108	1,97861506	2,57236	0,76
1962	2,366215648	1,399731	1,22493082	-0,42	1,42447507	0,803402	1,14315	0,72162	0,6516	1,10373126	0,59529	0,92	0,55153	2,53501254	2,52619	0,849
1963	2,407149543	1,235633	1,03901067	-0,42	1,34849197	0,756124	1,32253	0,40357	0,64738	1,02883409	0,8273	0,877	0,56363	2,13766282	2,46764	0,748
1964	2,498741886	1,242699	1,11990125	-0,4	1,33778133	0,755403	1,3822	0,05546	0,64309	1,05291054	0,93215	0,994	0,74712	1,65425825	2,39386	0,65
1965	2,608937754	1,227446	1,1376687	-0,77	1,37266111	0,777327	0,97629	-0,4078	0,59261	1,0034661	1,039	1,086	0,94185	1,15484251	2,3137	0,642
1966	2,735132162	1,224198	0,71987627	-1,14	1,30517073	0,79838	0,74787	-0,7541	0,96151	0,92644693	1,25007	1,024	0,95157	1,04515174	2,23102	0,551
1967	2,79889099	1,201181	0,32890341	-1,16	1,13314407	0,836537	0,96173	-0,6343	1,64543	0,8509443	1,16825	1,231	0,76723	1,23904725	2,16252	0,539
1968	2,757110604	1,125231	0,25490254	-1,18	1,03854696	0,840602	0,95673	-0,4276	1,35045	0,77347099	0,88496	1,308	0,562	1,25925635	2,12392	0,487
1969	2,582542439	0,920479	0,49008786	-1,18	1,15796911	0,814728	0,78234	-0,8974	1,05158	0,77072118	0,54575	0,985	0,70275	1,12542046	2,12263	0,416
1970	2,3257413	1,036281	0,49388947	-0,54	1,23893266	0,726516	0,35576	-0,8863	1,19852	0,43317652	0,64076	1,111	0,93348	0,72240383	2,14622	0,399
1971	2,043772043	1,245583	0,95365692	0,017	1,18913354	0,701293	0,36426	-0,4234	1,03739	0,42275114	0,77639	1,109	0,6881	0,52479184	2,17987	0,418
1972	1,804799528	1,081907	1,21304031	-0,08	1,01117285	0,764803	0,82672	-0,1543	0,95522	0,85586487	0,79632	0,906	0,2955	0,76247999	2,20585	0,339
1973	1,639930405	0,95435	1,10466657	-0,08	0,82733102	0,699505	0,90811	0,03093	0,85664	0,97040543	0,82207	0,907	0,17236	0,73822553	2,2171	0,193
1974	1,578575156	0,903796	1,30405817	-0,07	0,78367225	0,620349	0,95979	1,39488	0,92559	1,03264553	0,53263	0,964	0,29016	0,53852083	2,20721	0,063
1975	1,584105837	0,844285	1,09244784	0,734	0,89138996	0,551889	0,9936	3,80041	1,24829	1,04961039	0,97762	1,065	0,39728	-0,043738	2,1847	-0,01
1976	1,605895691	0,814807	0,49494252	0,509	0,78499339	0,469014	0,9978	2,8441	1,20459	1,05791841	1,47591	1,144	0,36369	-0,5715958	2,15148	-0,02
1977	1,605466965	0,789148	0,17366285	0,39	0,594626	0,422661	0,96387	1,06175	0,94424	1,05907444	1,20833	1,191	0,35516	-0,3390109	2,12712	-0,03
1978	1,600562178	0,726941	0,1794392	1,041	0,61526458	0,381789	0,79406	1,07896	0,89398	1,01996378	1,08889	1,372	0,29115	0,00897881	2,13102	0,005
1979	1,579375514	0,540861	0,23425127	1,014	0,69028225	0,340566	0,80219	1,07199	0,63133	0,99395493	1,07078	0,887	0,21822	0,20080949	2,17121	0,09
1980	1,550852459	0,451033	0,35598093	1,049	0,79133181	0,321226	0,92327	1,08143	0,68646	0,82353269	0,98925	0,637	0,203	0,39707442	2,22987	0,12
1981	1,523261697	0,576822	0,29477314	0,735	0,6860468	0,34408	0,90787	0,86708	0,77262	0,72609944	0,27396	0,802	0,11992	0,54706491	2,29693	0,035
1982	1,511949717	0,703386	0,08210743	2,145	0,45855986	0,367278	0,92028	0,61133	0,44611	0,77437007	0,19927	0,534	0,05719	0,58429168	2,33897	-0,04
1983	1,478056965	0,80702	0,02653365	1,409	0,3792226	0,33106	0,93769	0,46397	0,32547	0,72675486	0,62552	0,472	0,04527	0,42878792	2,32715	0,034
1984	1,445318546	0,829019	0,10278561	0,021	0,39693319	0,282203	0,90459	0,38455	0,29683	0,68746266	0,51021	0,409	0,09087	0,35911165	2,24785	0,158
1985	1,406305064	0,859591	0,19325682	1,757	0,46632652	0,299472	0,80359	0,27354	0,43816	0,67395444	0,4898	0,366	0,16517	0,44144267	2,12559	0,227
1986	1,357727029	0,965016	0,448671	1,671	0,55495773	0,356689	0,68107	0,09095	0,4553	0,61937665	1,24492	0,304	0,23257	0,52039161	1,992	0,232
1987	1,325192261	1,041053	0,64808339	0,689	0,63452688	0,46805	0,5642	-0,0269	0,39364	0,55683923	1,20394	0,247	0,33368	0,62811576	1,87855	0,213
1988	1,300779197	1,063957	0,72561458	0,821	0,64609623	0,537923	0,41446	-0,104	0,4705	0,53002787	0,27202	0,22	0,4596	0,73494306	1,79367	0,222
1989	1,294561999	0,795883	0,97262775	0,973	0,59990721	0,412808	0,36166	-0,1459	0,44915	0,48156477	0,05787	0,195	0,66718	0,80853606	1,74883	0,26
1990	1,302169554	0,367999	1,25174571	0,978	0,68860382	0,344151	0,3924	-0,2179	0,17418	0,4396171	0,09062	0,152	0,7726	1,02687307	1,732	0,299
1991	1,316079041	0,170117	1,33968317	0,999	0,78803104	0,476504	0,35468	-0,1538	-0,8687	0,07747244	0,06344	0,228	0,68164	1,24982602	1,71913	0,309
1992	1,319146475	-0,10859	1,32834757	0,983	0,75605659	0,57718	0,30668	0,02081	-0,9035	0,03246512	-0,1467	0,33	0,58653	1,10252107	1,69831	0,27
1993	1,315237439	-0,47411	1,34238703	0,949	0,69699133	0,595229	0,25445	0,12668	-0,1361	0,38171989	-0,2383	0,311	0,58084	0,91071557	1,67812	0,24
1994	1,30143675	-0,694	1,36184014	0,884	0,60293847	0,569388	0,21101	0,21504	-0,1454	0,39405443	-0,1157	0,269	0,71071	0,79715841	1,6563	0,255
1995	1,275021339	-0,76973	1,40474246	0,675	0,49392737	0,519126	0,13572	0,2625	-0,2023	0,29263221	0,02156	0,234	0,5247	0,66824233	1,63287	0,265
1996	1,24301011	-0,76034	1,36114394	0,607	0,46139575	0,506882	0,07607	0,27364	-0,2881	0,2116744	-0,0625	0,231	0,15915	0,44163641	1,61324	0,255
1997	1,21198222	-0,73783	1,25350248	0,682	0,514767	0,54222	0,06546	0,33013	-0,2879	0,18462999	-0,1345	0,264	0,05726	0,24089121	1,59406	0,258
1998	1,191236657	-0,72444	1,2438708	0,606	0,61664053	0,59541	0,03575	0,37754	-0,207	0,1341216	-0,2181	0,35	0,05551	0,29713577	1,56616	0,291
1999	1,177213099	-0,70949	1,35062129	0,487	0,66549319	0,684759	-0,0083	0,42026	-0,157	0,10205316	0,07143	0,515	0,07793	0,47691993	1,52683	0,333
2000	1,172647885	-0,70339	1,344083	0,527	0,71477036	0,649045	-0,5356	0,52836	-0,1294	-0,1353765	0,29607	0,84	0,16058	0,56195462	1,48078	0,357
2001	1,168082034	-0,52269	1,19045635	3,013	0,75484006	0,506047	-0,5363	0,65465	-1,3954	-0,1830123	0,1575	1,129	0,26847	0,63277124	1,43099	0,365
2002	1,157569196	-0,35169	1,04766082	0,746	0,63829167	0,539291	-0,0463	0,72991	-1,497	0,00351369	0,12392	1,447	0,32544	0,75646915	1,38666	0,368
2003	1,123740238	-0,42942	1,21520088	0,658	0,4718144	0,586533	-0,0675	0,69845	-0,2807	0,01024291	0,0603	1,658	0,37209	0,7419196	1,35566	0,404
2004	1,050162494	-0,54034	1,42133257	0,672	0,34747541	0,590931	-0,0585	0,58153	-0,2631	0,05261082	0,06407	1,623	0,3933	0,68742596	1,34232	0,505
2005	0,958580196	-0,62153	1,53005466	0,638	0,23366315	0,681073	-0,0439	0,45084	-0,2332	0,0847398	0,17321	1,641	0,39994	0,64060154	1,34034	0,594
2006	0,858078761	-0,59403	1,59505192	0,635	0,16061367	0,805393	-0,0634	0,33047	-0,2161	0,08179315	0,31911	1,642	0,56248	0,62755847	1,34158	0,615
2007	0,771413284	-0,54549	1,54438685	0,648	0,2175216	1,034735	-0,0543	0,22641	-0,1891	0,10954028	0,55921	1,714	0,74155	0,89369098	1,33648	0,643
2008	0,72047439	-0,51986	1,78749663	0,706	0,38929246	1,246333	0,01364	0,13262	-0,1544	0,17230749	0,15814	1,497	0,77903	1,27061807	1,32134	0,665
2009	0,70413936	-0,55719	1,85177523	0,494	0,51428455	1,261127	0,06776	0,09475	-0,1545	0,22103956	0,90388	0,772	0,8519	1,24948463	1,29228	0,678
2010	0,724196803	-1,58874	1,8254058	0,483	0,5129231	1,245666	0,08405	0,04574	-0,1976	0,21217318	0,43608	0,353	0,85252	1,05745474	1,2533	0,678
2011	0,752049552	-2,58327	1,96245774	0,72	0,48395547	1,275221	0,0846	-0,0033	-0,2242	0,1821695	0,16666	0,355	0,79522	1,02773693	1,2122	0,656

Source: World Bank

By way of an example, the reported analysis concerns only the growth rate of Italian, Portuguese and Lithuanian population: the first for reasons of nationality of the author and curiosity of study, the second because it's the European country in the fifty years under review with the highest growth rate of population, and finally the third because it's the European country in the fifty years under review with the lowest growth rate of population.

The time series is used to order the variables with respect to the time factor and it's possible to express its dynamics graphically. It's considered the growth rate of Italian population as variable.

Figure 1. Time series Growth rate of Population: Italy (1961-2011).

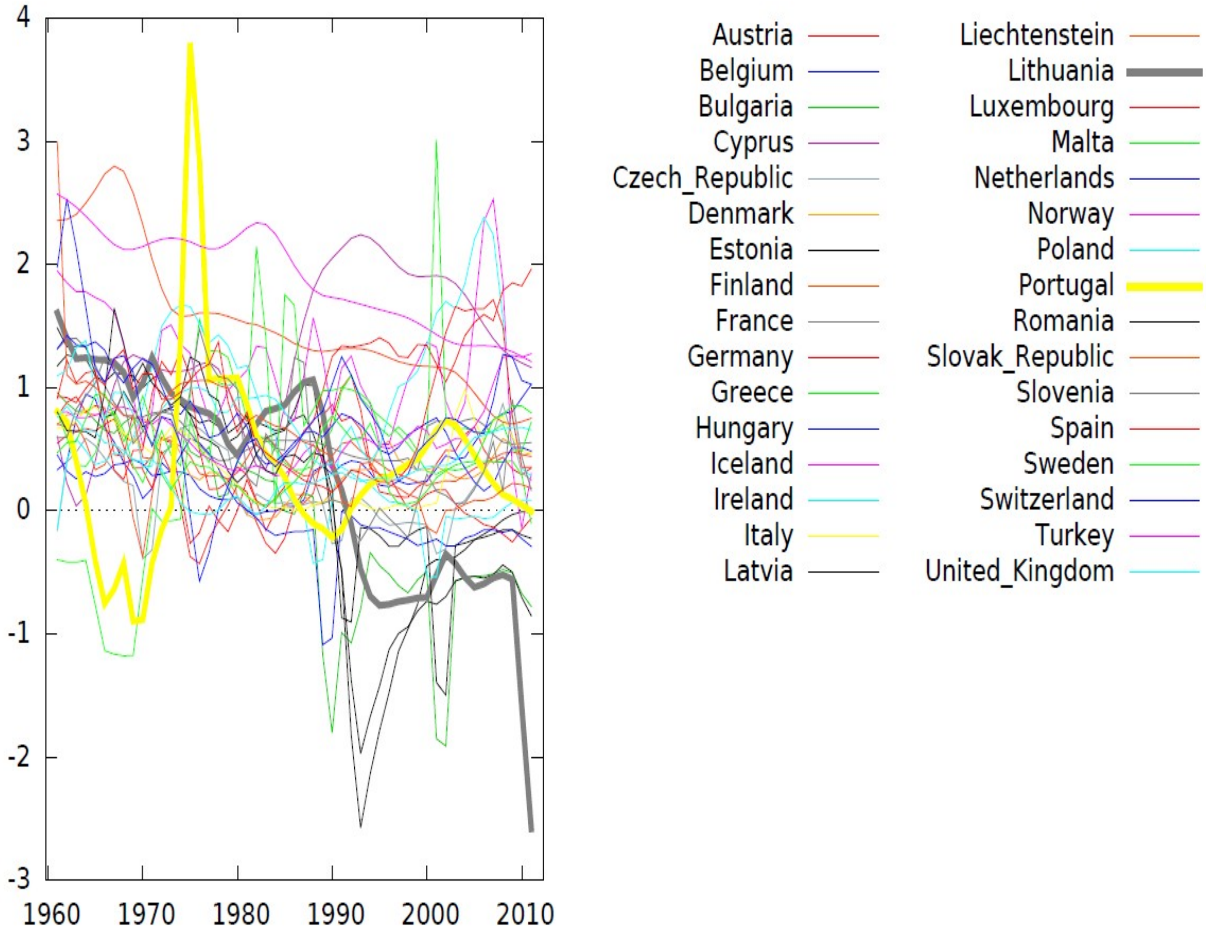


Source: World Bank

The data analysis covers the period from 1961 to 2011 and it has an annual frequency. The initial value is 0.668383 percentage points, while the final value is 0.472755 percentage points: the variation of considered time horizon is given, then, by subtraction between the initial and final value which corresponds, in the case of the growth rate of population is equal to - 0.195628 percentage points. The growth rate of population varies within a range of values starting from the minimum value of 0.0015886 percentage points in 1995, and then arrive at the maximum value of 0.98576 percentage points in 2004. Therefore the width of the variation interval is of 0.9841714 percentage points. The dynamic is monotonically decreasing until 1999, after which there is a continuous and steady growth until 2004.

As a demonstration, we propose a graph (Figure 2) that includes all European countries, highlighting through a thicker line those in which the growth rate of population has been particularly high (Portugal) or particularly low (Lithuania), along the considered span of time, and then we analyse them jointly through a graphical representation (Figure 3).

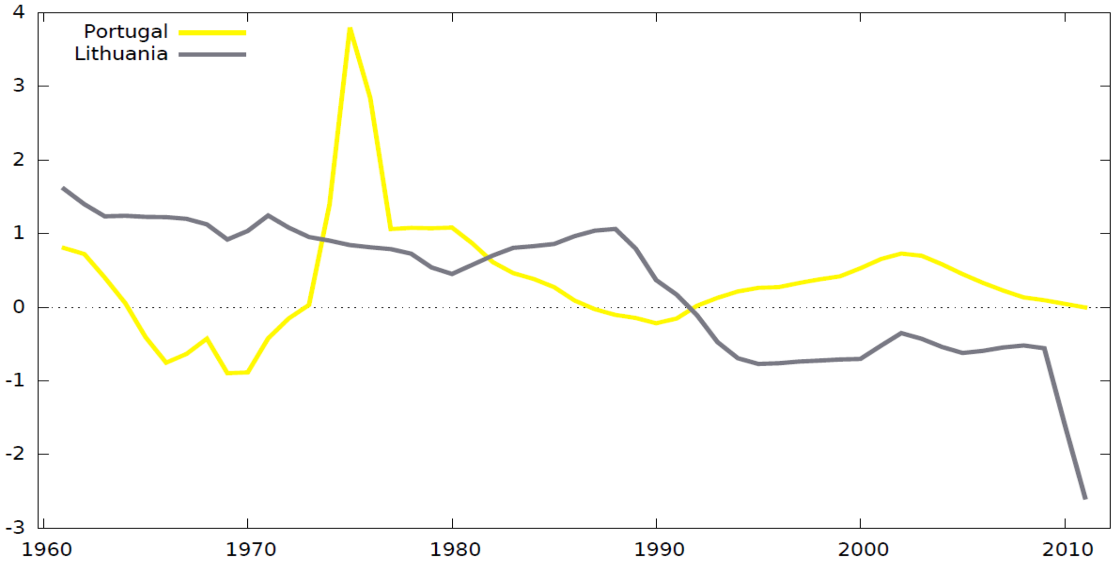
Figure 2. Growth rate of European Population.



Source: World Bank

The empirical analysis allows us to understand the growth rate trend of European population, which is a decreasing trend in most cases.

Figure 3. Time series Growth Rate of Population: Portugal and Lithuania (1961-2011).

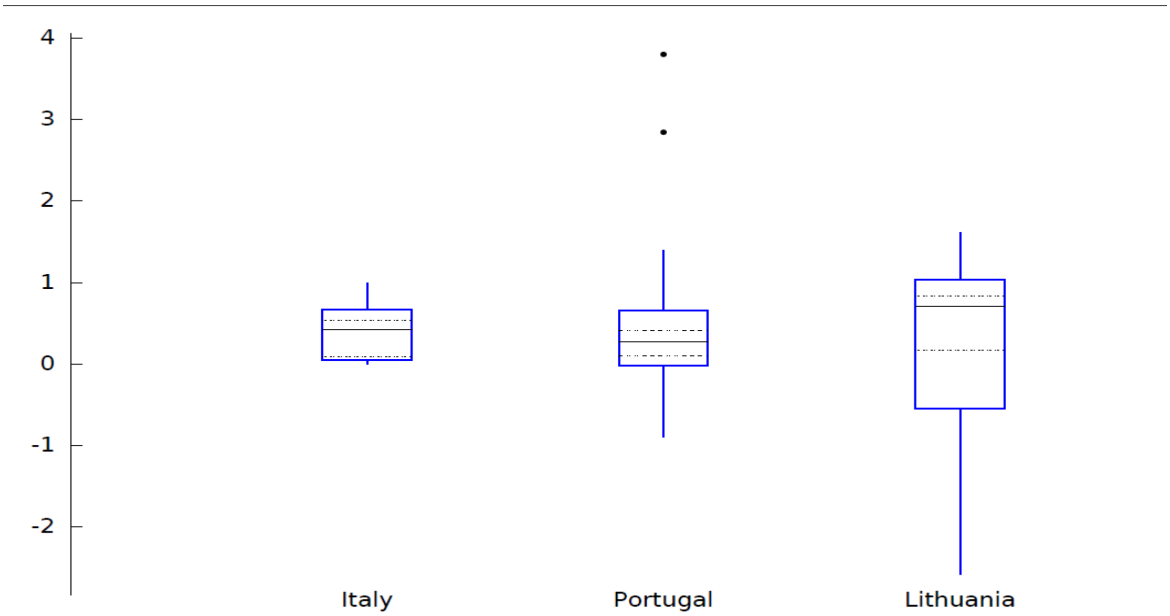


Source: World Bank

Figure 3 shows, through time series, the growth trend of the population simultaneously in Portugal and Lithuania: if in this last State, during the fifty years, the trend is monotonically decreasing, in the first country it places particular emphasis on a fluctuation between the mid-'70s and the '80s.

The measure of central tendency attempts to identify the more central portions of the data: the mean of all European States corresponds to a growth rate of 0.57%, value very close to the median value (the middle number, less sensitive to outliers: 0.54%). Therefore, on average the growth rate of European population is positive, slightly higher than 0, although the trend is decreasing in almost all European countries. The mean of the growth rate of Italian population is 0.37%; the mean of the growth rate of Portuguese population is 0.36%; the mean of the growth rate of Lithuanian population is 0.28%. The construction of box-plots can visually represent some key features of a statistical distribution: the degree of dispersion of data, the symmetry and the presence of outliers. The centre line of the box represents the median of the distribution, the horizontal lines of the box represent the first and third quartiles. The interquartile distance (distance between first and third quartiles) provides a measure of the dispersion of the distribution, while the distance from the median of the quartiles provides information about the shape of the distribution.

Figure 4. Box-plot (Italy, Portugal, Lithuania)



Source: World Bank

The distribution of values (Figure 4) is asymmetric for Italy because the distance of quartiles respect to the median is not equal. There are not present outliers, i.e. values that are extremely high or extremely low compared to the distribution.

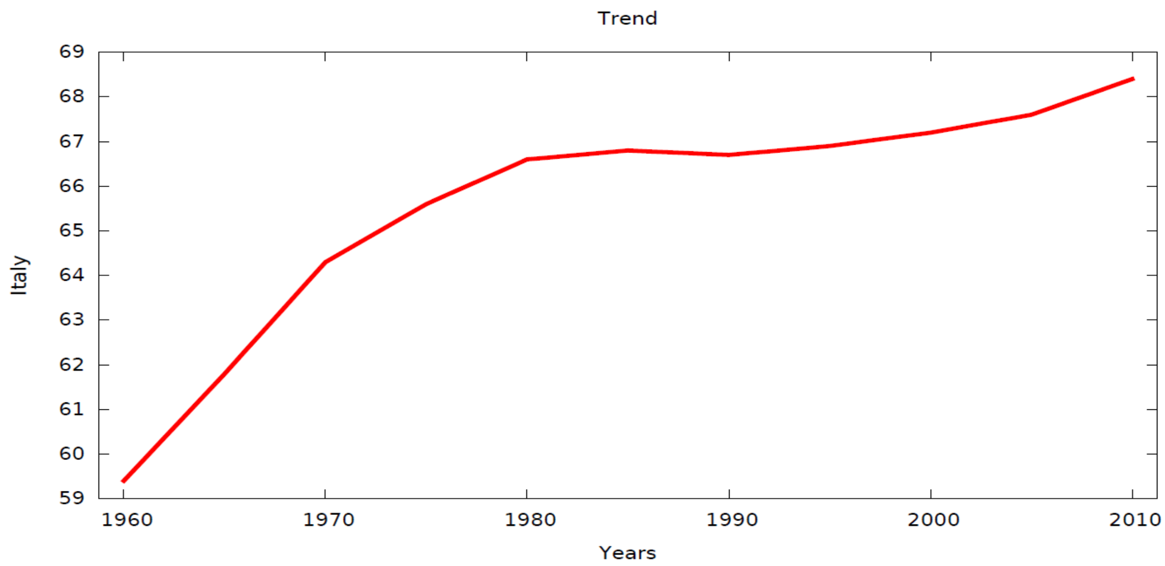
As for Italy, even in the case of the other two countries the distribution of values is asymmetric because the distance of quartiles respect to the median is not equal. In the case of Portugal, the interquartile interval is not very large, then half of the observations is highly concentrated around the median. Moreover, it's found also the presence of out of limit values (outliers). These values constitute a "fault" compared to the most of the observed values and therefore it's necessary to identify them to be able to analyse the characteristics and the possible causes which have determined them. We point out outliers for other European countries: Belgium, France, Greece, Hungary, Liechtenstein, Malta, Norway, Slovakia, Switzerland.

5.2 URBAN POPULATION

The urban population refers to people living in urban areas and in this analysis it's calculated as ratio of the total number of individuals living in urban areas, including metropolitan and suburban areas of a country, divided by the total population of that country. We can verify empirically the percentage of urban population of all European countries in the fifty years 1960-2010. The analysed data are extrapolated from the site of the World Bank yet and they are related to the urban population for the following countries: *i)* Austria; *ii)* Belgium; *iii)* Bulgaria; *iv)* Cyprus; *v)* Denmark; *vi)* Estonia; *vii)* Finland; *viii)* France; *ix)* Germany; *x)* Great Britain; *xi)* Greece; *xii)* Ireland; *xiii)* Iceland; *xiv)* Italy; *xv)* Latvia; *xvi)* Liechtenstein; *xvii)* Lithuania; *xviii)* Luxembourg; *xix)* Malta; *xx)* Norway; *xxi)* Netherlands; *xxii)* Poland; *xxiii)* Portugal; *xxiv)* Czech Republic; *xxv)* Romania; *xxvi)* Slovakia; *xxvii)* Slovenia; *xxviii)* Spain; *xxix)* Sweden; *xxx)* Switzerland; *xxxi)* Turkey; *xxxii)* Hungary. Once again the data have been modified in order to obtain a table containing only European states.

By way of an example, the reported analysis concerns only the percentage of urban population of Italy, Belgium and Liechtenstein population: the first for reasons of nationality of the author and curiosity of study, the second because it's the European country in the fifty years under review with the highest percentage of urban population, and finally the third because it's the European country in the fifty years under review with the lowest percentage of urban population. The time series is used to order the variables with respect to the time factor and it's possible to express its dynamics graphically. It's considered the urban Italian population as variable.

Figure 5. Time series Urban Population: Italy (1960-2010)

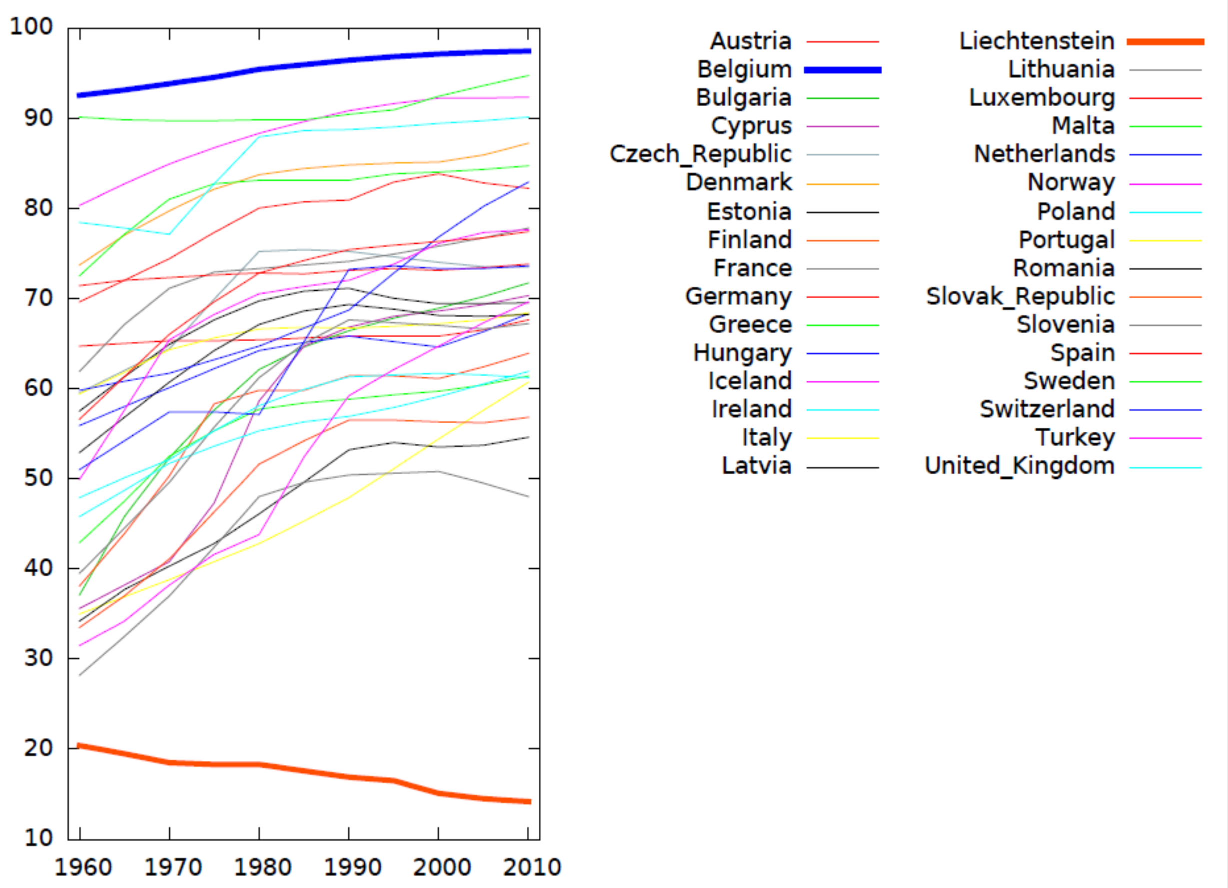


Source: World Bank

The data analysis covers the period from 1960 to 2010 and it has an annual frequency. The initial value is 59.4 percentage points, while the final value is 68.4 percentage points: the variation of considered time horizon is given, then, by subtraction between the initial and final value which corresponds, in the case of urban population is equal to - 9 percentage points. The percentage of urban population varies within a range of values starting from the minimum value of 59.4 percentage points in 1960, and then arrive at the maximum value of 68.4 percentage points in 2010. Therefore the width of the variation interval is of 9 percentage points. The dynamic is monotonically increasing.

As a demonstration, we propose a graph (Figure 6) that includes all European countries, highlighting through a thicker line those in which the percentage of urban population has been particularly high (Belgium) or particularly low (Liechtenstein), along the considered span of time, and then we analyse them jointly through a graphical representation (Figure 7).

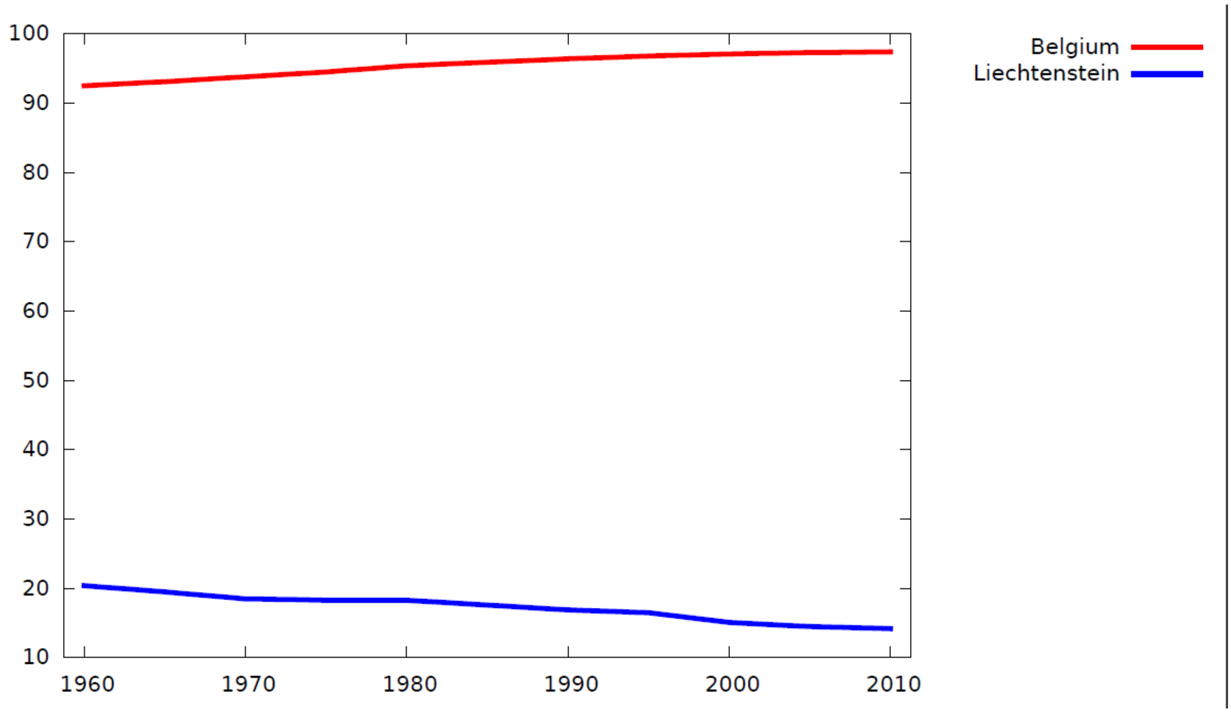
Figure 6. Percentage of Urban Population



Source: World Bank

The empirical analysis allows us to understand the percentage of urban population of Europe, which is an increasing trend in most cases.

Figure 7. Time series Urban Population: Belgium and Liechtenstein (1960-2010)



Source: World Bank

Figure 7 shows, through time series, the trend of urban population (%) simultaneously in Belgium and Liechtenstein: in both States, during the fifty years, the dynamic tends to be stationary.

The mean of all European States corresponds to a percentage of urban population of 65.11%, value very close to the median value (66.7%). The mean of the urban Italian population is 65.7%; the mean of the urban Belgian population is 95.51%; the mean of the Liechtensteiner population is 17.25%.

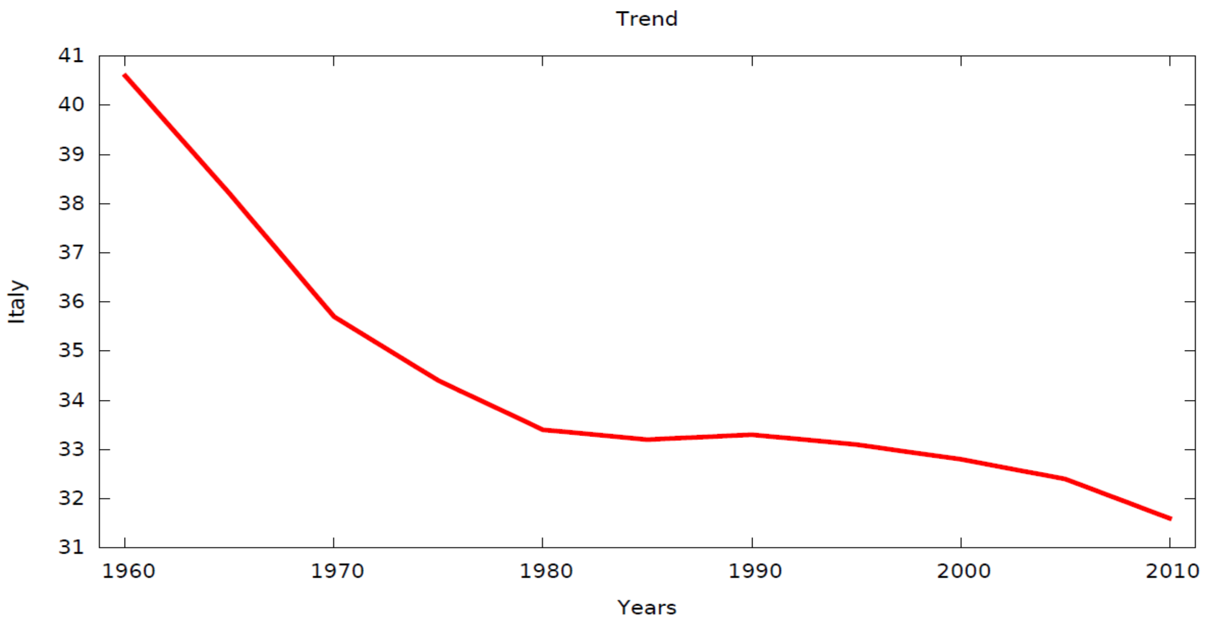
5.3 RURAL POPULATION

The rural population refers to people living in rural areas and in this analysis it's calculated as the difference between total population and urban population. The survey is conducted in a perfectly specular way on urban population. We can verify empirically the percentage of rural population of all European countries in the fifty years 1960-2010. The analysed data are extrapolated from the site of the World Bank yet and they are related to the rural population for the following countries: *i)* Austria; *ii)* Belgium; *iii)* Bulgaria; *iv)* Cyprus; *v)*

Denmark; *vi)* Estonia; *vii)* Finland; *viii)* France; *ix)* Germany; *x)* Great Britain; *xi)* Greece; *xii)* Ireland; *xiii)* Iceland; *xiv)* Italy; *xv)* Latvia; *xvi)* Liechtenstein; *xvii)* Lithuania; *xviii)* Luxembourg; *xix)* Malta; *xx)* Norway; *xxi)* Netherlands; *xxii)* Poland; *xxiii)* Portugal; *xxiv)* Czech Republic; *xxv)* Romania; *xxvi)* Slovakia; *xxvii)* Slovenia; *xxviii)* Spain; *xxix)* Sweden; *xxx)* Switzerland; *xxxi)* Turkey; *xxxii)* Hungary. Once again the data have been modified in order to obtain a table containing only European states.

By way of an example, the reported analysis concerns only the percentage of rural population of Italy, Liechtenstein and Belgium population: the first for reasons of nationality of the author and curiosity of study, the second because it's the European country in the fifty years under review with the highest percentage of rural population, and finally the third because it's the European country in the fifty years under review with the lowest percentage of rural population. The time series is used to order the variables with respect to the time factor and it's possible to express its dynamics graphically. It's considered the rural Italian population as variable.

Figure 8. Time series Rural Population: Italy (1960-2010)

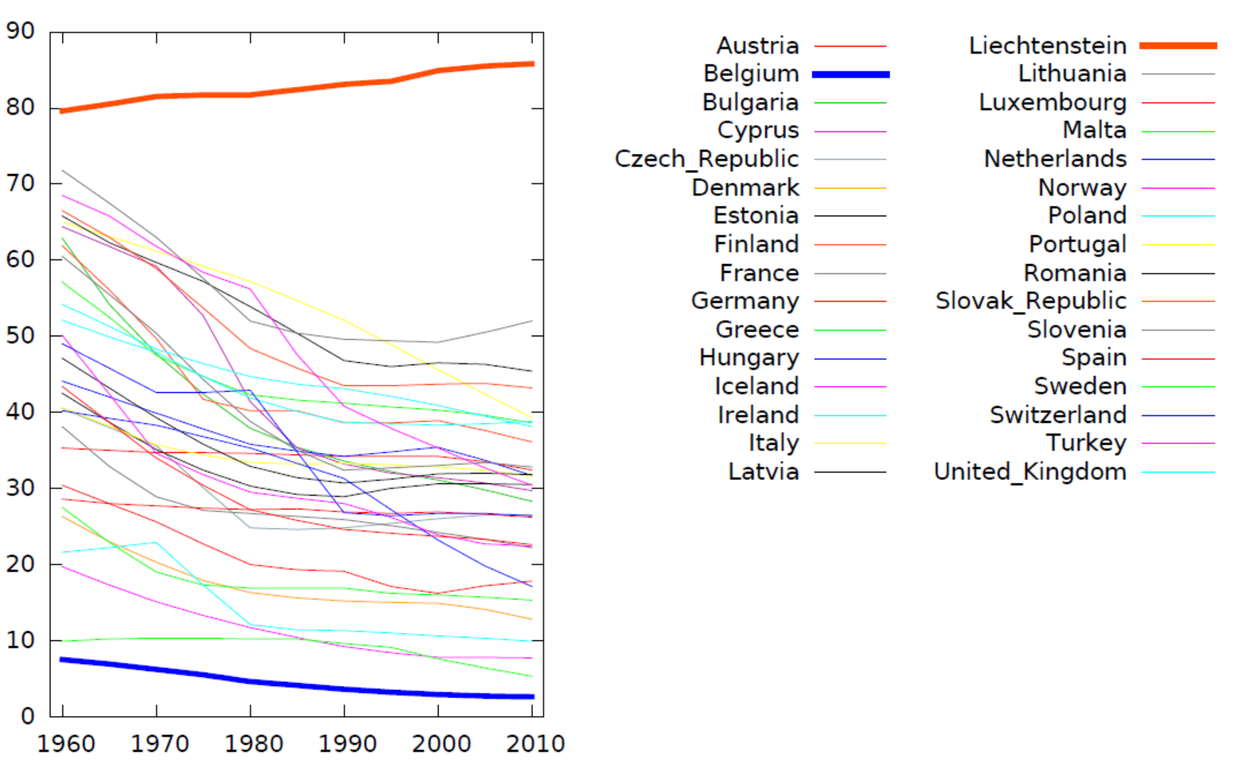


Source: World Bank

The data analysis covers the period from 1960 to 2010 and it has an annual frequency. The initial value is 40.6 percentage points, while the final value is 31.6 percentage points: the variation of considered time horizon is given, then, by subtraction between the initial and final value which corresponds, in the case of rural population is equal to 9 percentage points. The percentage of rural population varies within a range of values starting from the minimum value of 31.6 percentage points in 2010, and then arrive at the maximum value of 40.6 percentage points in 1960. Therefore the width of the variation interval is of 9 percentage points. The dynamic is monotonically decreasing.

As a demonstration, we propose a graph (Figure 9) that includes all European countries, highlighting through a thicker line those in which the percentage of rural population has been particularly high (Liechtenstein, this time in red) or particularly low (Belgium, this time in blue), along the considered span of time, and then we analyse them jointly through a graphical representation (Figure 10).

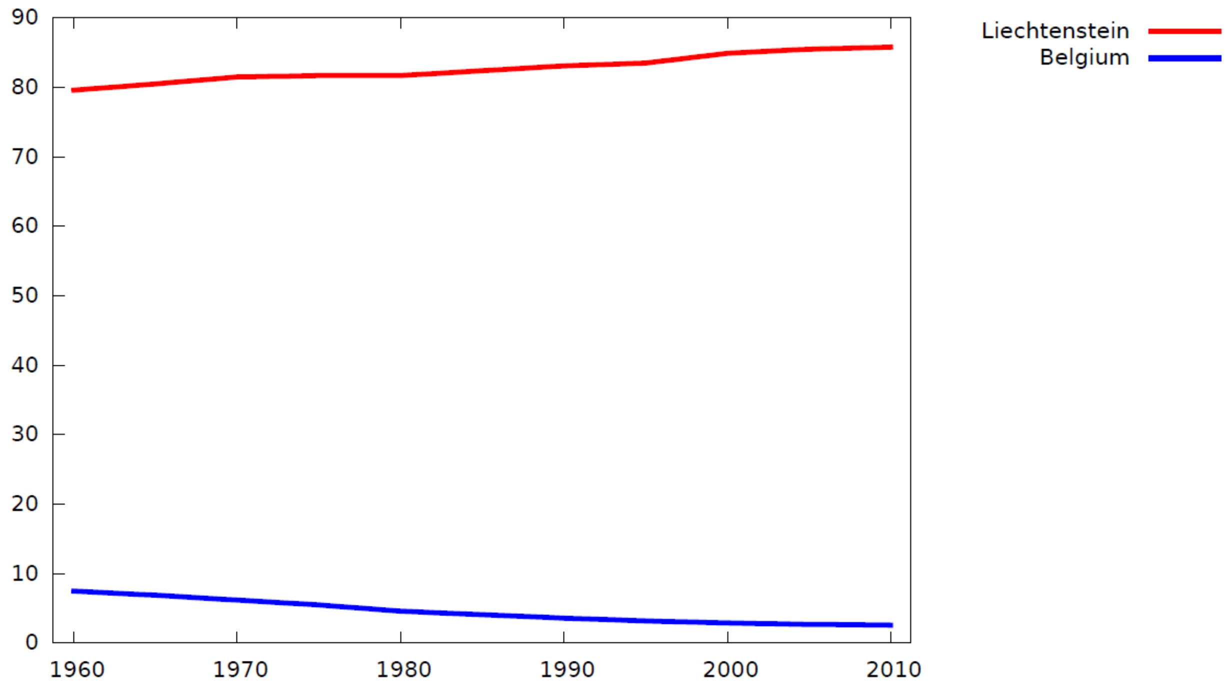
Figure 9. Percentage of Rural Population



Source: World Bank

The empirical analysis allows us to understand the percentage of rural population of Europe, which is a decreasing trend in most cases.

Figure 10. Time series Rural Population: Liechtenstein and Belgium (1960-2010)



Source: World Bank

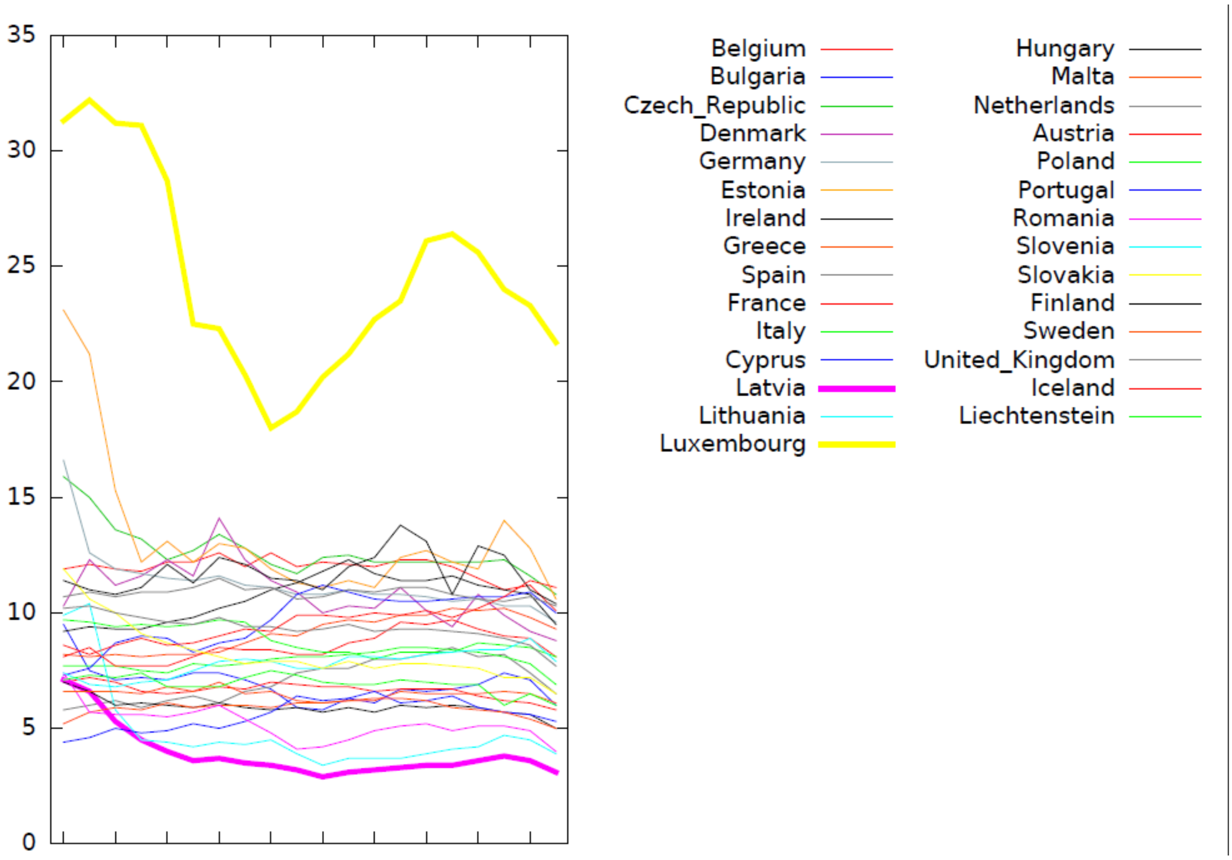
Figure 10 shows, through time series, the trend of rural population (%) simultaneously in Liechtenstein and Belgium: in both States, during the fifty years, the dynamic tends to be stationary.

The mean of all European States corresponds to a percentage of rural population of 34.89%, value very close to the median value (33.93%). The mean of the rural Italian population is 34.3%; the mean of the urban Belgian population is 4.49%; the mean of the Liechtensteiner population is 82.75%.

5.4 CO_2 EMISSIONS

The problems of urban development are closely connected to its impact on the environment. To get an idea of CO_2 emissions per inhabitant in the EU, we show a graph (Figure 11).

Figure 11. CO_2 Emissions per Inhabitant in the EU (1990-2009)



Source: European Environmental Agency (EEA)

The indicator compares the level of CO_2 emissions per inhabitant in the EU with levels in developing countries, in tonnes per inhabitant. We can see a CO_2 quantitative particularly high in Luxembourg.

$$g_t = \frac{\Delta x_t}{x_{t-1}} = \frac{x_t - x_{t-1}}{x_{t-1}} = \frac{x_t}{x_{t-1}} - 1$$

This ratio shows the growth rate of CO_2 emissions in the European Union and the analyses suggests the rate tends to negative (or slightly positive) in all countries under review.

The sectoral approach contains total CO_2 emissions (in million tonnes of CO_2) from fuel combustion and it includes emissions only when the fuel is actually combusted, and other considerable sectors.

Table 4. CO_2 Emissions from different sectors in the UE (2008)

Region/ Country/ Economy	Total CO_2 emissions from fuel combustion	Electricity and heat production	Other energy industries	Manufacturing industries and construction	Transport	of which: road	Other sectors	of which: residential
Austria	69,32	15,2	8,43	12,57	22,09	20,81	11,02	7,38
Belgium	110,96	22,97	5,26	27,44	27,09	26,56	28,2	18,6
Czech Republic	116,83	63,71	2,8	20,72	17,83	16,92	11,79	6,74
Denmark	48,41	21,77	2,47	4,83	13,7	12,76	5,63	2,92
Finland	56,58	24,32	2,7	12,16	12,7	11,52	4,72	1,89
France	368,23	50,79	18,86	70,53	124,7	118,67	103,35	58,54
Germany	**803,86**	337,27	26,01	118,14	148,36	139,86	174,08	121,43
Greece	93,39	46,38	3,49	9,19	22,06	18,96	12,28	8,33
Hungary	53,01	18,4	1,53	7,01	12,85	12,56	13,22	8,61
Iceland	**2,2**	0,02	0	0,69	0,91	0,83	0,59	0,01
Ireland	43,75	14,27	0,48	5,04	13,4	13,02	10,56	7,05
Italy	430,1	146,89	17,63	67,98	117,01	109,65	80,59	48,88
Luxemb.	10,4	1,06	0	1,48	6,44	6,4	1,42	1,34
Netherl.	177,86	57,15	10,85	37,78	34,96	33,84	37,12	16,82
Norway	37,61	0,76	11,8	8,01	14,04	10,43	3,01	0,5
Poland	298,69	158,41	8,38	37,73	44,16	42,67	50,01	31,29
Portugal	52,44	18,85	2,07	8,42	18,71	18,15	4,4	1,98
Slovak Republic	36,23	8,65	4,74	9,31	7,05	5,77	6,48	3,07
Spain	317,63	101,39	18,26	55,14	109,07	95,23	33,76	19,44
Sweden	45,87	7,96	2,52	9,64	23,26	22,02	2,49	0,42
Switzerl.	43,7	1,97	1,09	6,51	17,25	16,97	16,89	10,8
Turkey	263,53	104,12	8,42	38,51	45,1	39,52	67,37	39,61
United Kingdom	510,63	194,87	32,49	58,78	124,8	114,93	99,7	76,46

Source: International Energy Agency (IEA)

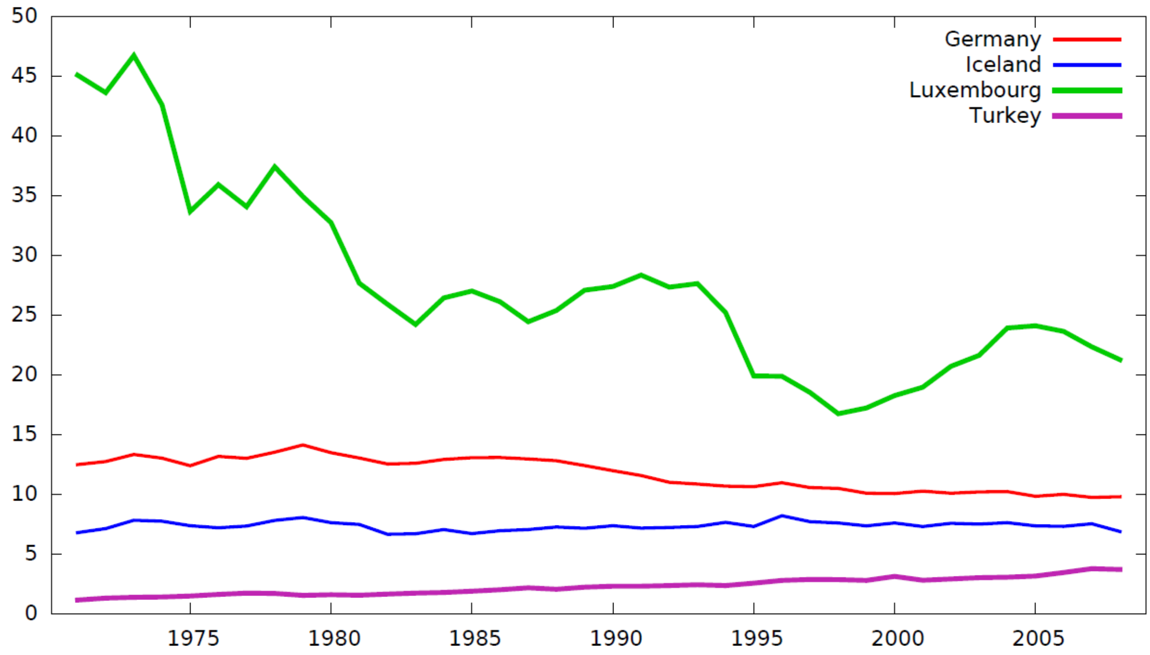
Table 4 shows a leading CO_2 emission from fuel combustion in each European country compared to other sectors in 2008. It's particularly high in Germany and the lowest CO_2 emission is in Iceland. In each European country, how does the situation change if we study the emission of carbon dioxide per capita? It's interesting to note that Germany is not the

European country with the highest CO_2 emissions per capita and Iceland is not the European country with the fewest CO_2 emissions per capita, but they are, respectively, Luxembourg and Turkey.

$$\frac{Carbon\ Dioxide}{Population}$$

This ratio is expressed in tonnes of CO_2 per capita and it's calculated from 1971 to 2008.

Figure 12. CO_2 per capita in Germany, Iceland, Luxembourg, Turkey (1971-2008)



Source: European Energy Agency (EEA)

Then, we can examine CO_2 emissions per capita through a sectoral approach.

Table 5. CO_2 Emissions per capita from different sectors in the UE (2008)

Region/ Country/ Economy	Total CO_2 emissions from fuel combustion	Electricity and heat production	Other energy industries	Manufacturing industries and construction	Transport	of which: road	Other sectors	of which: residential
Austria	8315	1823	1012	1508	2649	2496	1322	886
Belgium	10362	2146	491	2563	2530	2480	2634	1737
Czech Republic	11202	**6108**	268	1986	1709	1622	1130	646
Denmark	8815	3965	450	880	2494	2324	1026	532
Finland	10650	4577	507	2289	2390	2168	888	356
France	5743	792	294	1100	1945	1851	1612	913
Germany	9789	4107	317	1439	1807	1703	2120	1479
Greece	8311	4127	310	818	1963	1688	1093	741
Hungary	5281	1833	152	699	1280	1252	1317	858
Iceland	6888	**46**	-	2148	2844	2604	1850	**29**
Ireland	9847	3212	**108**	1134	3016	2931	2377	1587
Italy	7182	2453	294	1135	1954	1831	1346	816
Luxemb.	**21269**	2177	-	**3023**	**13166**	**13089**	**2903**	**2750**
Netherl.	10819	3476	660	2298	2126	2059	2258	1023
Norway	7888	160	**2476**	1677	2944	2187	630	105
Poland	7836	4156	220	990	1159	1119	1312	821
Portugal	4937	1775	194	792	1761	1709	415	187
Slovak Republic	6702	1599	876	1722	1305	1068	1199	567
Spain	6967	2224	401	1209	2392	2089	741	426
Sweden	4956	860	273	1042	2513	2379	**269**	45
Switzerl.	5668	256	141	844	2237	2201	2190	1401
Turkey	**3707**	1465	118	**542**	**634**	**556**	948	557
United Kingdom	8323	3176	530	958	2034	1873	1625	1246

Source: International Energy Agency (IEA)

Thanks to the investigation, we can see in Luxembourg the highest total CO_2 emissions from fuel combustion, from manufacturing industries and construction, from transport, from road and from residential; in Norway the highest CO_2 emissions from other energy industries; and in Czech Republic the highest CO_2 emissions from electricity and heat production (all coloured in red in Table 5). On the other hand, we can highlight the lowest total CO_2 emissions from fuel combustion, from manufacturing industries and construction, from transport and from road in Turkey; the lowest CO_2 emissions from electricity and heat production and from residential in Iceland; the lowest CO_2 emissions from other energy industries in Ireland; and the lowest CO_2 emissions from other sector in Sweden (all coloured in blue in Table 5).

Following the analysis of the growth rate of carbon dioxide emissions from 1971 to 2008 (International Energy Agency), it has emerged a significantly negative rate in 2008, in all European countries.

6 PRELIMINARY RESULTS

The current human consumption of agricultural products, wood fibre and fossil fuels causes a by nearly 30% excess of EF compared to the amount of ecologically productive land. Sustainability requires that human activities remain within the carrying capacity, but there are not concrete strategies for sustainability. The average global biocapacity is 1.78 global hectares per capita, but the data show that we are consuming resources faster than we could. Nowadays humanity uses the equivalent of about a planet and a half, that is, our planet needs a year and six months to regenerate what we use all in one year! Most human settlements are located in the most fertile areas in the world, therefore built-up land often lead to the irrevocable loss of those that were previously agricultural areas. For this reason, it's interesting to see how fast the population is growing and what percentage is spilled into the city rather than in the countryside. In all European countries, although not occur a high growth rate of population (positive, but slightly higher at 0.5%), the percentage of urban population is growing and this trend is affecting the environment and particularly the CO_2 emissions. Only in Belgium, France, Greece, Hungary, Liechtenstein, Malta, Norway, Portugal, Slovakia, Switzerland there is the outliers presence about the growth rate of European population in some years. In Italy, the dynamic is monotonically decreasing until 1999, then it's in a continuous and steady growth; on the other hand, in Portugal the trend presents some fluctuations along the time span considered. Belgium is the European country with the highest percentage of urban population, while Liechtenstein is the European country with the highest percentage of rural population. The highest CO_2 emissions from fuel combustion are in Germany; instead the lowest are in Iceland. There is a different situation if we study the CO_2 emissions per capita: this time, the highest are in Luxembourg, the lowest in Turkey. Nevertheless, the analysis carried out shows that CO_2 emissions per capita and CO_2 emissions for each sector are down in all European countries in a particular year: 2008.

The results are in the process of deepening and updating yet.

REFERENCES

Bruntland Commission (1987), *Our Common Future*. Report, Oxford.

Chambers, N., Simmons, C., and Wackernagel, M. (2000), *Sharing Nature's Interest: Ecological footprints as an indicator of sustainability.* Earthscan, London.

Cohen J.E. (1995), *How Many People Can the Earth Support?.* Norton.

Ewing B., Reed A., Galli A., Kitzes J., and Wackernagel M. (2010), *Calculation Methodology for the National Footprint Accounts.* Global Footprint Network, Oakland.

Wackernagel, M., and W. Rees (1996), *Our ecological Footprint: Reducing Human Impact on the Hearth*. New Society, Gabriola Island, BC Canada.

Wackernagel, M., and W. Rees (2000), *L'impronta ecologica. Come ridurre l'impatto dell'uomo sulla terra*. Edizioni Ambiente, Milano.

WWF (2004), *Living Planet Report*. World-Wide Fund for Nature, Gland, Switzerland.

SITOGRAPHY

www.ecologicalfootprint.com

www.eea.europa.eu

www.eurostat.eu

www.footprintnetwork.org

www.iea.org

www.istat.it

www.myfootprint.org

www.worldbank.org