SPATIAL SHIFTING OF PER-CAPITA GDP LEVELS IN THE EUROPEAN UNION

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Chapter 1: Background

The two most important politico-economic trends in the past few decades of Europe are: firstly, the difficult economic readjustment of the former Soviet bloc consequent to the collapse of the Soviet Union, and the integration of many ex-Soviet bloc countries into the European Union and globalized economy; and secondly, the strain on the Union, especially on its periphery, caused by the 2008 economic crisis. Both trends are prime examples of the interdependence between politics and economics. In the first case, politics — namely, the collapse of single-party Marxist-Leninist rule — transforms the affected states' economies, whereas in the latter, economic and financial stresses are affecting EU politics. This research will focus on the economic trends, using the new economic geography and secondarily the world-systems perspective as a geographically-based foundation upon which theory and explanation will be built, keeping in mind how politics interacts with economics in affecting these economic trends.

After the collapse of the Soviet Union in 1991, the former Eastern Bloc went through a dramatic period of economic pain as those countries were forced to completely overhaul and rebuild their formerly centralized economies. After a decade-long contraction, growth resumed for the region as a whole around 2000 until the more recent recession and crisis that began in 2007, with East Germany, helped by reunification with West Germany and extensive economic aid, being the first to have risen to levels similar to rural areas in France. But still, Eastern European countries tend to have very poor rural regions, with the major urban areas such as the capital city developing most quickly (Eurostat 2009). Along the way, the European Union, which had started out as a free-trade bloc, has evolved more recently into a currency union, with more and more countries joining the euro.

More recently, the Eurozone has experienced problems, with countries on the physical periphery — Greece, Ireland, Portugal, and Spain — exhibiting soaring bond yields and being forced to cover for exorbitant amounts of debt, which has forced their economies into protracted recessions with high unemployment (Lane 2012). Most of the EU is plagued by serious structural problems, including not only sluggish economic growth, but large amounts of government debt and aging populations which promise to strain, if not break, pension systems, brought on by a continually expanding modern welfare state. These high expenditures appear to be an investment by governments in "social imperialism", discussed by Flint & Taylor (1985, p. 86), wherein the elites in core states buy off the dominated middle and (especially) lower classes within the core via welfare policy. This is worsened by the constraint of a common currency which worsens matters for the periphery, with its high levels of deficit spending and lower productivity, combined with much more frugal consumer spending levels and consumption in Germany; convergence within the Eurozone is essential for the euro to "work", but appears unlikely (Feldstein 2012, Moravcsik 2012). A somewhat larger problem has also become clear: countries on the periphery, which include not only the aforementioned, but certain others such as the Baltic States, Romania, and Bulgaria, which are mostly still outside the Eurozone, are suffering high levels of unemployment and/or

emigration (as their unemployed, usually young citizens attempt to find jobs), plus low birth rates which literally threaten these countries' futures.

After World War II, the core of Europe, represented by France, West Germany, Italy, and Benelux, formed the European Economic Community, in an attempt to prevent another devastating war from ever happening again. At the time, the Iron Curtain prevented large-scale economic contact with the economies of Eastern Europe, and so growth was limited to the West. Labor shortages in the European core were satisfied by recruitment of immigrants from peripheries accessible to Western Europe — notably southern Italy, Portugal, Greece, Yugoslavia, Turkey, and the Maghreb, while the U.K. similarly relied on labor from Ireland, South Asia, and the British West Indies, and Sweden on Finnish labor; large-scale labor immigration — and birth rates — slowed down in the 1970s with the global oil shock and economic downturn (Zimmermann 1996). Later, in the 1980s, Spain, Portugal, and Greece were admitted to the EEC, which became the European Union in 1993 with the Maastricht Treaty.

Things changed with the establishment of the euro, also a feature of the Maastricht Treaty. Fixed exchange rates were established at the end of 1998, so that participating currencies could not fluctuate against each other, with the old currencies replaced with the euro at the start of 2002. However, Southern European countries such as Spain, Portugal, Italy, and Greece have had weak currencies, whereas those in core countries like West Germany, the Netherlands, and Britain were historically stronger. With the euro, most countries use the same currency, and the cost advantage that Southern European industry enjoys vis-à-vis the core is removed, leading to the industry shutting down; and with the loss of industry and the lack of robust commercial and financial sectors to pick up the slack, deindustrialization and impoverishment results.

Jeffrey Frankel (1997) has noted several effects of continental trading blocs when studying trade flows, which may be important in considering the European economy, especially considering the deeper integration spurred by the EU and the euro, and which should prove useful in choosing a theory on which to base this research. Firstly, it seems that the decrease of transportation costs over time does not have much of an effect in decreasing the effects of distance in constraining trade, when considering the same pair or set of countries over time; costs with distant trading partners may fall, but so do costs with nearby partners (Frankel 1997, pp. 73-74, 141-142). Secondly, he notes that trade between Australia and New Zealand is much higher than between Spain and Poland, despite their equal distances away from each other and rough equivalence in GDP, because of the existence of intervening opportunities, i.e., other countries in between the latter pair; the former pair trade more with themselves because they have no other alternatives (Frankel 1997, p. 143). Further, Fotheringham et al. (2001) find that a competing-destination model works better than a conventional one, although only with a hierarchical destination choice built into the model, and Hu & Pooler (2002) showed that a competing-destination model is superior to a production-constrained one. These findings suggest that transportation costs are not particularly relevant in who trades with whom; rather, it is the location of the nearest market. Therefore, in a free-trade zone with many closely-spaced countries, many of whom share a common currency — exchange rate variability (along with distance) has been demonstrated

by Engel & Rogers to keep prices from converging (Frankel 1998, pp. 180-181), and a common currency by definition eliminates this hurdle — to produce an identical product with identical input costs (in other words, barring the comparative advantage of a certain area due to cheaper factors of production), it should be more cost-effective to locate one's factory in the center of economic activity rather than on the edge. Another interesting effect that Frankel found is language links, which facilitate trade (Frankel 1998, pp. 74-75, 141-152): High competence in languages such as English and German, which would include most of the stronger economies of Northern Europe, may lower barriers to trade and innovation and thereby make a country's economy healthier. Other factors in the location choice of firms, according to Anderson (2012, p. 163-4), include the costs of transportation (of inputs to the facility, and the output to the market), taxes, land, utilities, labor (skilled and unskilled), as well as agglomeration with related or competing firms, undercutting the competition, and personal preferences and experience (which may include historical or governmental factors).

Combes, Mayer, & Thisse (2008) and Brakman, Garretsen, & van Marrewijk (2001) lay out some background of the core model of the new economic geography formulated by Dixit & Stiglitz in 1977 and later expanded by Krugman in 1979, 1980, and 1991 (the Dixit-Stiglitz-Krugman model, henceforth "DSK"). In this framework, two regions are considered, each of which contains an agricultural and a manufacturing sector. The agricultural sector is assumed to contain perfect competition and no labor mobility, and therefore homogeneous over both regions, whereas the manufacturing sector contains imperfect competition, an important concept called the "elasticity of substitution," which plays an important role in determining how strong the competition between firms is and consequently the prices of manufactured goods, and an explicit wage effect (agricultural wages are treated as a numeraire defined as 1 versus the manufacturing wages). Trading only takes place in the manufacturing sector (the inhabitants are assumed to always consume local agriculture), and goods sold in the other region incur an extra trading cost that they do not in the home region. Therefore, industries will tend to agglomerate in a central region, or "core", whereas outlying regions, or the "periphery", will tend to specialize in production of goods for which they have a comparative advantage such as lower raw-material or labor costs which outstrip the penalty incurred by a higher transportation cost.

There have been further elaborations of such models of the new economic geography since then, one important example being that of Fujita, Krugman, & Venables (1999, henceforth "FKV"). In Chapter 4 of their book, Brakman, Garretsen, & van Marrewijk outline the core DSK model, as well as additions by FKV.

Applications of the core model by other researchers are outlined in Chapter 5 of Brakman, Garretsen, & van Marrewijk, and this research hopes to contribute to this body of economic knowledge. Firstly, they discuss the research of Midelfart-Knarvik *et al.*, which applies the "Krugman specialization index" (defined as "the absolute value of a country's share in the production of an industry *k* minus the share of the other EU countries in the production of industry *k,* summed over all industries"), where a value of zero indicates no specialization, and a value of one that the country produces all output in industry *k* in the entire EU, and examines the agglomeration of manufacturing in the EU. It is immediately apparent that Krugman specialization is highest for peripheral countries, such as Ireland, Greece, and

Finland, whereas manufacturing agglomeration is highest in core countries, such as Germany, France, Italy, and Great Britain. This gives the core countries more maneuver, whereas the periphery has more limited bargaining power and a higher level of risk (as seen, for example, in government bond yields). Next, the research of Davis & Weinstein (1996 *et passim.*) looks at "idiosyncratic demand" and the home-market effect, Hanson (1997, 1998, 1999) examines wage levels in regions of Mexico after NAFTA, and Brakman, Garretsen, and Schramm (1993, 2000) examine the effect of the reunification of Germany on wage convergence, and in one model, attempt to use housing as a proxy for the immobile agricultural sector. All of this research appears to support the relevance of geographical effects and spatial differentiation on the economies studied at the intra-national level, and the methodology used for this research will be based on this New Economic Geography research.

The core model and its expansions will be further detailed in the "Theoretical Background" section below; they will provide the starting point for an analysis, and the methods by which these theories will be used are detailed in the "Analytical Methods" section. In addition, to discuss phenomena that may not be sufficiently explained by the core economic model, the world-systems perspective, which has gained traction in recent years for its strength in explaining certain political and financial phenomena, will be invoked. This perspective is both political and economic, as the worlds of politics and economics commonly overlap and affect each other via various interdependent processes.

First formulated by Immanuel Wallerstein and elaborated upon by many others, including Christopher Chase-Dunn (1998), the world-systems perspective is a neo-Marxist construct for explaining how countries tend to develop a hierarchy consisting of a well-off core, a poor periphery, and a semiperiphery in the middle, in both a geographic and a sociopolitical way. (Note that the world-systems perspective and the new economic geography both use the terms "core" and "periphery", albeit ostensibly independently.) This happens through core and peripheral *processes*, which push an area toward or away from core status respectively, and which may be considered under economic geography due to their relatively concrete nature — a core or peripheral "state" may be considered one wherein core or peripheral processes predominate respectively, and a semiperiphery where a mixture of the two do so, but due to this somewhat vague definition, it is more important to consider processes rather than states in this research. As Wallerstein (1989) describes, a "core" state or area is typified by a well-developed economy, high value-added industry or services, a well-developed role in trade and commerce, strong financial institutions, and effective government; whereas those in the "periphery" have a poorly-developed economy specializing in low-value-added goods (for example, a textile exporter such as Bangladesh) or mineral wealth (commonly petroleum) without any high-value-added processing, weak financial institutions, and ineffective government which often tends toward authoritarianism to stay in power. The "semiperiphery" is an intermediate ranking, and has its own unique traits, such as being notably more prone to socialist or communist revolutions than are either core or peripheral states. Core processes may include strong economic growth, employment increases leading to the formation of a robust middle class, economic diversification, and so forth, whereas the opposite processes — i.e., stagnant economic growth, increasing unemployment, a shrinking middle class, and economic specialization, especially in low-value-added industries or primary

resource extraction — are peripheralizing, leading to relative impoverishment. Because these processes may be captured in economic statistics (GDP growth rates, unemployment, and so forth), the corresponding statistics may be considered as trackers of core and peripheral status. Note that raw per-capita GDP level does not correlate with a region's placement in the world-system, for even apparently rich states that obtain their wealth from selling primary sector goods such as petroleum may be peripheral (for example, Equatorial Guinea, which has a very high per-capita GDP but ranks quite low in the UN's Human Development Index). More important is the placement of an economy on trade networks and commodity chains, and whether the economy produces materials of high value (production), has a robust trade infrastructure (commerce), and in particular, strong banking institutions (finance) which in turn help to increase the state's effectiveness, both at home and abroad. The concepts of core, semiperiphery, and periphery are affected by geography, with core processes more likely to be located in areas that are centrally located in the world economy, due to population density, history, and many other factors (Arrighi 2010, Braudel 1984).

This would also apply to present-day Europe. Areas may still be classified as core, semiperiphery, or periphery based on the characteristics that Wallerstein outlined, and moreover, it should be possible to analyze statistics over time to catch whether areas are improving or regressing. Evidence of improvement would include lowered unemployment rates, higher PCGDP, and a robust industrial sector where high-value-added goods are made. Regression may be indicated by specializing in agriculture or cheaper manufactured goods, high unemployment, and a PCGDP that is, even if stagnant, declining relative to the area. These metrics are available for most European countries in data provided by Eurostat, the statistics agency of the European Union, and have been for many years, and this study will therefore rely on Eurostat as the most complete and internally consistent source of data.

In this research, I will attempt to answer the following questions:

1) Is there empirical evidence of a distance effect? In other words, does the stronger industry and overall economic activity drift toward the economic center of the area, causing harm to the countries on the European periphery which adopt the euro, relative to when they had their free-floating currencies?
2) Does economic growth in the former communist countries of Central Europe, especially those which are spatially close to the Western European core, diffuse over time? If so, what diffusion processes cause it?
3) What is the configuration of this diffusion? Is it geographical, spreading from west to east, or more hierarchical, spreading down through cities and smaller towns, with rural areas being the last to see rising PCGDP? Is the Kuznets curve applicable here? How important are national boundaries? For example, has East Germany benefitted more than its former Warsaw Pact peers by being part of the (core) German state? How can the processes behind diffusion be translated from the core economic theory to a model?
4) If there is in fact a hierarchical aspect to this diffusion, how would a large financial sector, such as stocks, affect all this process? Is there an identifiable pattern in gross domestic fixed capital formation? What about government bonds and indebtedness, and risk perception?

To answer these questions, I will be measuring spatially relevant indicators of the prosperity of the European Union's NUTS2 regions, which are roughly population-equivalent statistical units that are meant to contain a couple million people each, reminiscent of U.S. congressional districts; for large countries like France or Italy, they are equivalent to their provinces, although small countries like Denmark or the Republic or Ireland may be their own "at-large" NUTS2 regions, and very populous subnational entities such as the U.K.'s England or Germany's North Rhine-Westphalia may be broken up into several NUTS2 regions of their own. Observing core and peripheral processes using these NUTS2 regions, such as increasing or decreasing employment, GDP, and so forth, will provide some idea of how these roughly population-equivalent regions are faring in the European world-economy. These will eventually include those of various Eastern European countries. A preliminary study is first done by taking a Moran's I measurement of the per-capita GDPs (PCGDPs) of all countries over time. Then, the Eurostat NUTS2 data from 1996 is used to ascertain indicators that correlate with PCGDP to a greater or lesser degree, in hopes of determining which will be relevant for further examination of PCGDP equalization (or lack thereof), both within Eastern European countries, and between them and their Western European counterparts. Not only PCGDP, but population density, employment (agricultural, industrial, and services), and unemployment (among males and females) will be considered as well. After that, the two methods will be combined, namely, by examining such Eurostat indicators as in the 1996 set over time, adding further indicators to flesh out the model.

The use of NUTS2 data in a contiguity setup such as this as opposed to a connectivity setup may seem at first to be difficult to justify given links across countries via rail and air, as well as communications. However, "spatial contagion" effects have been noticed by researchers such as Thisse (Combes, Mayer, & Thisse 2008, p. 17), who includes a NUTS2 map of EU PCGDP for 2004. It is the purpose of this research to track these "spatial contagion" effects over time.

This research operates on assumptions based on the world-systems perspective discussed above. In core regions of Europe, employment will be based less on agriculture (as a proxy for the production of primary sector goods) and more on industry and services. PCGDP should be higher in the core, and unemployment lower. Other demographic information such as birth and death rates would be useful; although typically one assumes that birth rates in the core will be lower than in the periphery (viz., Europe versus Africa), in some local cases this is not true —— poor parts of Eastern Europe often have lower birth rates than core states like Britain or France, which would suggest that, at least within Europe, other factors influence the birth rate. Nevertheless, studying the birth rate and migration rates may provide further interesting information about shifts in the core, as former peripheries may capture core status over time due to sheer weight of numbers, with the most obvious example being the United States, but also local intra-European cases such as the rise of Germany versus France in the 19th century. Another interesting factor relevant to position in the world-systems hierarchy would be increased or decreased perception of risk (Dezzani & Johansen 2011), which may provide further backing for the analysis. Thus, this research may be considered a study in the impacts of spatial structure on economic phenomena.

The justification for this research lies in its contributions to explanations of how economies evolve spatially, which would have implications for investment and development in other places throughout the world. However, while this evolution would necessarily mean that some areas would improve relative to others, this is not to say that the economy of a given region is a zero-sum game, but that insofar as the entire region develops or improves, there will be a rich core and laggards in the periphery. Targeted investment and development may pay off more if the spatial situation of the targeted area is more favorable for international trade relative to core areas, such as a specialization in higher-value-added goods that uses factors in which the targeted area has an advantage. In addition, the scourge of high levels of unemployment, which is associated with peripheralization, is perhaps the most serious concern among young people in Europe and elsewhere today, and their lack of opportunities and a consequent inability to live independently, let alone start families, would be a severe demographic hindrance for these countries, and in the case of many countries in Southern and Eastern Europe, could literally threaten these countries' long-term viability.

In addition, if this research succeeds in demonstrating a distance and/or proximity effect, it should provide an empirical boost to the new economic geography, which, while it does include the concept of transport costs, does not as of yet explicitly include spatial or temporal functions. It should also help support the world-systems perspective by showing how inequality, and a "natural" core and periphery", can be sustained over time, and in a way that reflects system development.

Chapter 2: Literature Review

An earlier study by Cappelen et al. (2003) have found that convergence between countries within the EU is significant, but not within countries, and credits regional support with lifting the PCGDPs of peripheral EU states. But this study only considered data before former Communist countries joined the EU starting in 2004, and does not model the effects of that on EU convergence, or if they are comparable to the stresses on the German economy upon the integration of East Germany. As part of this thesis, a study will therefore be conducted on German *Länder* alone, or more correctly, the Eurostat NUTS2 regions of Germany, comparing GDP equalization (or lack thereof) within Germany upon reunification, in line with that in the entire EU upon the admission of former Soviet Bloc countries.

Other research, such as the finding of an improbably long time until convergence even with a Markov model, supports a world-systems-like layout of the European economy (Fingleton 1999). And if this is so even *without* the former Warsaw Pact, the situation should be much more striking and obvious *with* the former Warsaw Pact — or even within Germany. The admission of former Communist countries gave first Germany, then the EU, a new periphery that it did not have before, and modeling convergence should be much more interesting given these conditions.

Meanwhile, the lack of convergence *within* EU states is consistent with the expectation of this research that the relative distribution of income within countries, i.e. inequality, will remain. The capital city of a typical Eastern European country will always be wealthier than the smaller cities, which will remain wealthier than rural areas. The question here is: will the smaller cities and rural areas rise out of abject poverty in those former Communist countries close to the European core? Chase-Dunn describes semiperipheral states as having a mixture of core and peripheral characteristics, and core-like capital cities versus impoverished rural areas would certainly fall within this expectation.

Kopstein & Reilly (2000) report that "some countries have it easier than others": Eastern European states closer to the core are in fact doing better. They also explicitly study "distance from the west" in their model (defined as Berlin and Vienna), to European and former Soviet countries, and find it on the cusp of being convincing ($z = -1.933$, $P = 0.05$) in the case of political freedom, and extremely convincing ($z = 2.616$, $P = 0.009$) for economic freedom. Other variables studied, such as the efficiency of bureaucracy and corruption, did not appear to be significant at a 5% level. Moran's I tests for spatial autocorrelation, which examines spatial units rather than cities, came to a similar conclusion, finding significant clustering on political and economic levels, bureaucratic rectitude, and openness. These conclusions fit well into a world-systems perspective, in regards to the spatial effects of being near the core, with stronger state institutions, and provide crucial preliminary support for this research. Other research has corroborated the findings of a spatial effect within the pre-1990 European Union (Ertur, De Gallo, & Baumont 2006).

Hammond & Thompson (2006) report that in the United States, there was a tendency toward convergence between 1969 and 1999, but with urban areas exhibiting more downward mobility and weaker convergence. This is the opposite of what has happened in

Eastern Europe, where urban areas, especially country capitals and primate cities, have shown most economic growth from the post-Soviet economic expansion. The differences between the U.S. and Eastern Europe may be due to other factors, such as the Rust Belt hollowing-out of the economies of many cities in the Northeast and Midwest United States, and the research does suggest that rural areas should experience converge in Eastern Europe eventually. Ezcurra & Rapun (2006) find that regional inequality within countries does rise with increasing per capita GDP to a point, beyond which the inequality starts to fall again as the country becomes wealthy enough. This would suggest rural areas in the more prosperous Eastern European countries will eventually become better off.

Erik Reinert (2008), has provided important hints as to how peripheralization on the one hand, and movement toward the core on the other, may happen. Sustained targeted protectionism by a country of its industries to produce high value-added goods to sell to the rest of the world (and they must be high value-added, or at least heading toward that over time à la Akamatsu's famous "flying geese" paradigm; a textile exporter like Honduras or Bangladesh will hardly improve its status on textile exports alone [Arrighi, Silver, & Brewer 2003]) has been a tried-and-true method of lifting a semiperipheral country into core status, having been pursued by England and the United States historically, and the East Asian Tigers more recently. Currently, however, neoliberalism and the idea of comparative advantage and free trade has a stranglehold on the public consensus, but the facts that Reinert lays out suggest that areas with high-value-added industry should be more likely to rise, and on the other hand also may be more resilient to economic downturns than those which rely on services, such as (most cynically) the manipulation of financial products. During the current EU economic troubles, the country weathering the crisis best, Germany, is also the most prolific exporter; of the debt-ridden PIGS, the one in least worst shape fiscally, Ireland, is also the only one with a large trade surplus.

Meanwhile, Neil Smith (2008) draws on Marxist ideas of the production of space through both capital and state institutions. Even as the Internet and faster transportation render the barriers of space to communication and the movements of goods irrelevant, space itself becomes a commodity to capital, like labor and resources, and is therefore used in such a way as to produce the highest profit. As countries and subsets of countries are partitioned into parcels by geography, the different regions of the globe thus will tend to settle into the niche that capitalism assigns to them, whether a poor raw material producer, an industrial center, or for services. One interesting corollary of Smith's is his "seesaw theory of capital", where capital seeks out the cheapest possible area to place industry, and when the area it invests in becomes higher-income, it will abandon it and search out a new area that is cheaper, and perhaps invest in the first area again when it has turned into a Rust Belt and is profitable again.

Chase-Dunn (pp. 199-294) provides specific world-systems support for this thesis, namely the core/periphery hierarchy in the European subregion of the world-system. The concept of "nested hierarchies" is explained (pp. 209-210) wherein each region, as well as the world city system as previously mentioned by Taylor, exhibit their own hierarchies. This is important when considering Europe as its own system with core and periphery. He considers what defines a core area, and settles on those areas that produce capital-intensive products,

whether via agriculture, industry, or services; while older literature tended to emphasize industry as opposed to agriculture, Chase-Dunn brings up the counterargument that agriculture in core states has the same advantages over that in the periphery as core industry and services do, namely by being capital-intensive and more advanced.

He does reject the idea of using PCGDP alone, bringing up states like oil-rich Libya that obtain their wealth in the primary sector and exporting to the core, but otherwise lack core institutions or an economic structure that would survive a theoretical removal of their primary-sector source of wealth. Perhaps a better measure would be PCMGDP — "per-capita *man-made* GDP" — which would thereby exclude resources, as from mining and extraction, that may be very valuable but do not involve the input of any human skill to procure. This problem should not be highly relevant for this study, as Europe does not possess any such resource-exporting countries; the only major oil exporter — or primary resource exporter of any kind — in Europe is Norway, and it is otherwise arguably a core state, so PCGDP should provide a reasonable approximation for "coreness" within Europe. It would complicate this research were it to be extended to Russia, which *is* dependent upon primary resource extraction and export, and other measures of "coreness" other than PCGDP would have to be considered in that case. But considering PCGDP within Europe should not seem to pose problems, especially when one considers this in conjunction with Taylor's classification of world cities, with the four Alpha world cities of London, Paris, Frankfurt, and Milan embedded within a high-PCGDP zone helping to define Europe's core.

The "new economic geography" as explicated by Krugman (1991) and Fujita, Krugman, & Venables (1999) and further detailed by Combes, Mayer, & Thisse (2008) and Brakman, Garretsen, & van Marrewijk (2001) will provide the theoretical bedrock upon which this research will be built. Krugman's work has been perhaps the most influential in helping to bring economic geography into the forefront of economics research, and the two outlines of Comes, Mayer, & Thisse, and Brakman, Garretsen, & van Marrewijk, provide overviews of the various frameworks and models, with the former at a more comprehensive but more abstruse level, and the latter at a more basic but more detailed and explicated level. In addition, Brakman et al. give examples of research done in the "new economic geography". One of these is a study of the Mexican production post-NAFTA (Hanson 1997, 1998, 1999), detailing how Mexican industrial production shifted toward the *maquiladora* complexes in the northern part of the country to service the United States, leading to a somewhat higher PCGDP relative to the southern parts of Mexico, even doing well compared to the Mexican core around Mexico City.

Also, a study on the structure of the German economy post-reunification (Brakman & Garretsen 1993, Brakman, Garretsen, & Schramm 2000) showed that whereas the former East Germany at first headed toward convergence with the West in economic growth, by 1997 the East's economic growth slowed down to parity with the West and remained about the same for the rest of the decade (2000 being the latest year), suggesting that the East was settling down into a stable peripheral status vis-à-vis the West. Another particularly interesting bit of research was a study of specialization within the European Union (Midelfart-Knarvik et al. 2000), which used the "Krugman specialization index" for three different periods in the 1970s, 1980s, and 1990s, and manufacturing agglomeration in the 1970s and

1990s, which showed clearly that manufacturing overall agglomerates in the core (Germany, France, Italy, and the U.K.) whereas specialization is highest in the periphery (Ireland, Greece, Finland, Denmark, and Portugal).

Also mentioned by Brakman et al. (2001), Davis & Weinstein (1999) examine the effects of economic geography on regions within Japan, and conclude that economic geography, while seemingly less important in explaining the *international* structure of production, seems to be very important for regional production structures *within* states. This is in line with Chapter 3 of Krugman 1991 (pp. 69-100), wherein Krugman finds much stronger economic differentiation and specialization within large regions of the United States than among the main Western European economies, and suggests that international barriers are significant factors in squelching the effects of economic geography. This research, as mentioned above, will attempt to determine whether or not these international barriers have weakened within the European Union due to the introduction of the euro, free labor mobility, and lack of tariffs, and by how much, and whether the recent troubles in the European periphery may be explained by this weakening of international barriers.

Finally, it would be remiss not to mention my own inspiration for this research as being provided by the work of the likes of Arrighi & Drengel (1986), Babones, and in particular Dezzani (2001, 2002), which sparked many questions in my mind about the ability of Eastern European and other semi-developed countries to “catch up” to the west.

In the following section, the economic theory underpinning this analysis will be described in further detail.

Chapter 3: Theoretical Background

The theoretical support for this work will be based on the "new economic geography" as promoted most famously by Paul Krugman, but with auxiliary support using the world-systems perspective. One particularly important work for these purposes is Christopher Chase-Dunn's book *Global Formation: Structures of the World-Economy,* which attempts to lay out a theoretical framework using world-systems as a basis. Jeffrey Frankel's works on regionalization (1997, 1998) are also useful in helping to apply Chase-Dunn's theory, which uses the world-systems perspective, to a regional bloc like the European Union, due to its examination of the structure of trading networks.

The DSK (Dixit-Stiglitz-Krugman) model, supplemented by the later FKV (Fujita-Krugman-Venables) model, underpin the new economic geography, and integrate space (and hence geography) into economics. This is detailed by Brakman, Garretsen, & van Marrewijk ("BGvM", 2001) as well as Combs, Mayer, & Thisse ("CMT", 2008), and their works will be consulted here as a reference in this theoretical outline.

The first spatial economic model cited by CMT is the Arrow-Debreu model, dating from 1954, in which a firm's profit in a location *i* is determined by the equation $\Pi_i = p_i y – w_i – R_i$, with the y being the quantity of sold goods, p the price, w the wage paid to the firm's workers, and R the land rent. Moving a good from one region to another to sell, however, introduces an "iceberg cost", by which a fraction of the good is lost in transit. This is elaborated by DSK into a "transport cost", which includes the total cost of transporting the good from one region to another: iceberg cost, fuel cost of shipment, and paying the transport service.

BGvM details the effects of transport costs and a firm's potential customers affect the decision of a firm to locate. If a firm sells products in two regions, North and South, and the North has 4 "farmers" (immobile workers not in the industry) and the South only has 2, it is more profitable to locate in the North. However, if there are enough other firms located in the South, it would be more profitable to locate there rather than in the North. The intermediate case here would be if 3 firms are in the South and 1 in the North, in which case the firm will be indifferent between the two regions because transport costs from selling to firms *and* farmers in the other region, here assumed to be 1 per firm or farmer, will be 5 in either case. But unlike in the case where all firms are either in the North or South, this is an unstable equilibrium; a single firm relocating would make one region or the other more profitable. The DSK model operates fundamentally in this way, although there are some embellishments, such as that manufacturing firms and their workers are mobile across regions and farmers are not, that the food that farmers sell is a *homogeneous good*, that is, identical across regions, that manufactures are heterogeneous but may be substituted for if they become too expensive, measured using an "elasticity of substitution" index ε (called σ by CMT; the higher above 1 the index ε is, the closer to homogeneous and substitutable the goods are, like food). But these are details to the basic picture, which remains the same; given the mobility of the manufacturing firms and their workers, hereby arises the phenomenon of *agglomeration,* by which firms will tend to concentrate in one area over others in a country — or a group of countries that have integrated their economies to some level, as with the

EU. The *home-market effect* introduces a bias toward populous regions, ensuring that a high population density will attract firms; the "ideal" situation here would appear to be a dense population near the center of the market area.

Therefore, the DSK theory suggests that all else being equal, profitability is higher when transport costs are lower; that barring incentives such as lower input or labor costs, firms will prefer to locate in such centrally-located areas; and therefore these areas with lower transport costs — the core — will benefit and the periphery will suffer. This phenomenon of transport costs and agglomeration would also affect the EU, and the Eurozone in particular. A list of Cif/fob ratios between 1965 and 1990 detailed in BGvM (2001, p. 82), which approximate the transport or iceberg costs, is given for various countries, courtesy of Radelet & Sachs 1998; among those in Europe, Switzerland has a ratio of 1.8%, West Germany 3.0%, France 4.2%, Britain 6.0%, Spain 6.4%, Italy 7.1%, Portugal 10.3%, and Greece 13.0%, largely conforming to expectations that countries on the European periphery would have higher transport costs and therefore that agglomeration would be expected to appear in the EU, especially given the relative lack of formal trade barriers and free labor mobility.

The Fujita-Krugman-Venables (FKV) model builds on the DSK model, but introduces more variables. One important criterion is an assumption that $\rho > \delta$, known as the "no-black-hole" condition, where ρ is a quasi-reciprocal of the elasticity function equal to $1 - 1/\varepsilon$ (in other words, a "rigidity of substitution" index that may vary between 0 for most elastic to 1 for most rigid), and δ is the share of the consumers' income spent on manufactures as opposed to food (agriculture). While agricultural products are assumed to be basically homogeneous, industrial products are more specialized, and spending more money on them will automatically increase "rigidity". Having $\rho > \delta$, combined with sufficiently large transportation costs, introduces a "spreading" factor in conflict with the more obvious agglomeration phenomenon from the more basic DSK theory, meaning that the economy cannot, like a black hole, agglomerate into a single point. However, if transportation costs are low, this effect vanishes and agglomeration resumes. But it does suggest that the home-market effect also helps preserve substantial industries in populous peripheral regions, provided that transport and shipping costs are high, which would reduce the incentive of the industry to locate in the region's core, and instead force the industry to remain at the local level to minimize these transport costs (Brakman, Garretsen & van Marrewijk pp. 111-115). FKV also includes speculations on a "racetrack economy", where the number of production centers on a circle depend upon transport costs and the elasticity of substitution; low transport costs again decrease the number of production centers, while a higher elasticity of production does the opposite, meaning that common goods and services will spread to many locations, whereas highly specialized goods and services (with a low elasticity of substitution) will tend to concentrate in one location (Brakman, Garretsen & van Marrewijk pp. 120-123).

According to the DSK and FKV models, industry is assumed to be mobile, and agriculture to be immobile. In other words, agriculture will remain in the same areas tied to the land, but industry (both capital and labor, or industrial workers) may become established wherever costs are lowest and profitability the highest. Because of industrial mobility, therefore, industry will choose some areas, but avoid or abandon others. This causes areal differentiation of different regions into a "core" and "periphery"; these terms are used both

by Krugman in an economic sense, as well as in the world-systems perspective in a more political sense. Per Krugman, a "core" is where industry concentrates, whereas the "periphery" is where there is little to no industry (or, at most, cheap, labor-intensive, low-technology, low-cost industry, such as Bangladesh's garment industry and Haiti's production of baseballs). Agriculture, being tied to the land so to speak, is found in both areas, but the periphery is more reliant on income from agriculture due to the fact that it lacks industry.

The core or peripheral status of an area is dependent upon processes involving capital and labor. Capital considerations include the fixed costs of establishing a production center in an area and other administrative costs, plus transports costs, whereas labor costs depends upon the availability of workers and the wages they demand. In the absence of any other considerations (such as patriotism or noblesse oblige), firms will establish wherever their profits are highest. All these considerations taken together results in equilibria which may be stable at one point in time, but may become unstable later and cause a new shift. For example, if industry finds it more profitable to relocate from the United States to China due to lower raw material, fixed, and labor costs, even if transportation costs are incurred, the industry will do so. A cascading effect occurs as other industries follow this first industry in order to remain competitive, with the result that all the industry will relocate to China, resulting in a stable equilibrium. But eventually, the equilibrium may become unstable as transportation or labor costs from producing in China increase to the point where producing somewhere else (or even relocating back to the United States) becomes more profitable.

While the models of the new economic geography do explain how a given situation may be a stable or unstable equilibrium, they do not provide any clues as to how quickly, or how far, a shift out of an unstable equilibrium will occur. Dimensions of space and time are not explicitly included, unless one considers transport costs and country-level dichotomies as rudimentary ways of considering space. Temporal aspect is completely ignored; although the state equations do suggest potential directions in which an economic shift may go (as, for example, toward agglomeration or dispersion), it does not attempt to explain how quickly the shift will take place. Thus, while DSK and FKV do include several important functions for explaining economic phenomena, space and time are not among them. In addition, a narrative notion of the history of the region should be kept in mind, and economic models, including DSK and FKV, do not account for these unique factors either.

The world-systems perspective, although it is never referenced by Krugman, extends these economic phenomena to the realm of history and politics. Governments will do whatever they can to improve their relative influence and position, or maneuver, in the world, even if some of these decisions may appear on the surface to be economically disadvantageous if the political advantage proves to outweigh the relative economic disadvantage. The differing laws and political motivations of states act to result in regions being affected by whichever state has sovereignty over them, which extends to, for example, economic development and location of industry. In other words, states are artificial "containers" of regions. One example below is the map on the right of Figure 6a, where the location of industry shows strong state effects in France, Italy, Spain, and Portugal, which would possibly not exist if each region was its own state: industry "piles up" in the northernmost or northeasternmost sections of the state closest to the European core, and is

relatively scarce in the southernmost or southwesternmost regions of the same state, leading to the effect of northeastern Spain and northern Italy being much more industrialized than southwestern France, even though the latter is arguably closer to the European core.

Being based on the new economic geography, this analysis will be fundamentally a nomothetic analysis. While individuals have free will, their decisions in aggregate may still be subject to a probabilistic (rather than deterministic) model that may be based on prior behavior and an understanding of human nature. As Chase-Dunn writes (Chase-Dunn, p. 307), "Models in social science are most usually probabilistic rather than deterministic, thus to allow for the complexity and indeterminacy of human behavior." This research uses a fundamentally structural approach, relying on empirical observation, such as the Eurostat data used here. At the same time, to avoid the Althusserian trap of excessive structuration (p. 301), it offers speculations to explain divergences from the model, with the world-systems perspective proving particularly useful here. Giddens (1984) discusses aspects of structure in Chapters 3 and 4 of his work *The Constitution of Society,* which informs the attitude toward structuration in this research, seeking to balance structure with the decisions of the actors in this scheme. For example, states, which are among the most important actors involved here, influence the economic layout of Europe in important ways, such as tax laws, investments, and other incentives, as well as by the simple fact that their citizens will communicate more with each other than with foreigners. But their influence and control is limited by cross-border communication and trade, as well as by superstate structures, especially the EU, and intrastate entities, such as transnational corporations.

Of the three increasingly complex model types specified by Chase-Dunn, it will be the first of these, a descriptive model, which "specifies the relationships in time between the several cycles and trends which are features of the world-system that vary over time" (p. 303), which will include a discussion of causal relations that may later be covered by the next level, a causal relations model, or even the highest level, a deep structure model.

Also, world-system analysis most often concerns the global world system, but this study will focus on Europe and the European Union. Therefore, to avoid the ecological fallacy, where "an association between two variables at the level of a set of larger units of analysis (e.g. census tracts [or the world]) is used as evidence in support of an assertion about an analogous relationship at a smaller unit of analysis (e.g. households, individuals [or Europe])" (p. 313), an understanding of the differences between the Europe-wide and the global scales is essential. But even so, because the world-systems perspective allows for cores and peripheries at different scales, many of the concepts that apply to the world core and periphery may also apply, at a smaller scale, to the European core and periphery. The challenge, of course, is determining which ones, or even to decide if a given phenomenon in the European periphery is rather more comparable to the world semiperiphery rather than the world periphery. After all, Europe itself is a core region, and even the poorest parts of Europe, such as Moldova or Kosovo, may be semiperipheral by world standards. One problem with attempting to consult world-systems theory for this research is that the timescale, a mere ten years, is not really long enough to capture a good understanding of historical and classical world-systems processes. However, it may be long enough to, in certain instances, capture whether or not a given area is rising or in decline, as by, for example, enjoying an

expansion (or suffering a contraction) in its manufacturing, commercial, and financial sectors (Dezzani 2001, Dezzani 2002).

When defining what exactly is the "core" of Europe, finding which areas within Europe have the most important financial and economic influence is useful. Taylor, Walker, and Beaverstock (2002) define "world cities" by a ranking that involves binning into "alpha", "beta", and "gamma" ranks based on "world-cityness" index, defined as how many of twelve world-city criteria they possess. There are only 10 Alpha world cities, of which the U.S. possesses three (New York, Los Angeles, and Chicago), and the other seven being London, Paris, Tokyo, Frankfurt, Hong Kong, Milan, and Singapore. The European core thus should contain the four Alpha cities within Europe: London, Paris, Frankfurt, and Milan. Countries that lack such alpha world cities but still have a high per-capita GDP, especially those with few natural resources but that specialize in the creation of high-value-added goods, such as Sweden, Switzerland, and Belgium, or even in spite of having natural resources, like Norway, also qualify.

The temporal aspect is important as well. Chase-Dunn discusses studies of K-wave and systemic cycles, including of hegemony, war, and so forth (p. 50-51), and this research will operate on the assumption that K-waves do exist, and that the global economy continues to be in a down-cycle since a peak in IT in 1990s, that is now manifesting in soaring unemployment and monetary deflation typified by desperate pumping measures by central banks (which encourages unproductive financial speculation by those with first access to these funds) with low or even zero interest rates for core economies. What effects would this have on core-periphery differentiation within a free-trade bloc such as the European Union?

Frankel's book *Regional Trading Blocs* attempts to define what a "natural" trading bloc is, and how it affects the relations between countries. It should also provide support for considering the European Union as a region, as in this study. The EU has been supported by its members and the U.S. as a way of preventing wars, and it may have been this rationale, spurred by the Yugoslav wars, that impelled it to expand to Eastern Europe. The question as to whether including the former Warsaw Pact created a "natural" trading union, rather than adding a sharply-defined periphery to the EU, is quite a different question. Will convergence happen? Or instead, will the periphery specialize at being poor? Or, is it possible that pockets of the former Soviet bloc will rise, but at the expense of former beneficiaries in Western Europe?

Because much of the Eurostat data is based on NUTS regions, it will suffer from some inaccuracies as long as other things are not taken into consideration. Fernand Braudel has made it clear in his historical thick description of trade networks that the economy does not work on areal units like the NUTS used in the Eurostat data, but rather more like the nervous (or circulatory) system of the human body, with the hegemonic center (whether Amsterdam in the 17th century, or London in the 19th) operating somewhat like the brain (or heart). Unfortunately, data by areal units is more accessible and easier to use than along networks, and the latter will have to be kept in mind. One way is to use a distance method such as k-nearest neighbors (KNN) rather than adjacency criteria, which would have the added benefit of including islands such as Britain or Sicily in a way that adjacency cannot.

But on the other hand, areal units are useful in regards to taking into account the effects of being in one state over another, as the laws, currencies, and so forth would tend to give all the regions in a state certain properties in common — processes of territorialization — that they would not share with neighboring regions of other states. To give one example of the tug-of-war between trade networks and areal units, note that Slovakia has joined the euro but the Czech Republic has not. While this would appear at first to not make much sense, as the Czech Republic is arguably more developed than Slovakia, it does once one considers that the center of the Slovak economy is its capital, Bratislava, located a short distance down the Danube from euro-using Vienna — an example of a trade network effect that would not be obvious by considering areal units alone. The Czechs, by contrast, are surrounded by mountains on all sides, with no such close connections to their neighbors. Therefore, eastern Slovakia, because it is under the sovereignty of Bratislava, is also in the Eurozone, unlike anywhere in the Czech Republic. Therefore, as a suggestion, both trade networks and areal units should be considered, but that while areal units are easier to intrinsically consider due to the NUTS data being in that form, trade network effects will have to be kept in consideration. As with Frankel's research that showed how trade between Australia and New Zealand was much more extensive than between Spain and Poland, despite their being similar distances from each other, there will be an assumption of trade preferences being ordinal rather than strictly based on distance, so that the nearest market is most preferred — a justification for using the nearest-neighbors method.

Given the considerations posed by Reinert, in combination with the observations here in the literature that core-periphery relations are stable, even with economic cycles, next is to consult Krugman's models of how per-capita GDP may reorganize itself within the EU. It is based on the fact that if the cost of production of an identical good, c, also includes transport costs t if produced in a foreign country, which does not include just fuel, but residual tariffs, language barriers, and so forth, as per Frankel's research. Producing an identical good domestically (c_d) always makes more sense than producing it abroad (c_f), because, simply, $c_d = c_f < c_f + t$. However, if producing in the foreign country is cheaper than domestically, factories will relocate to the foreign country not only if $c_f < c_d$, but if $c_f + t < c_d$. With independent currencies, more peripheral countries will have weaker currencies to cut production costs so that $c_f + t < c_d$. But, in the case of the Eurozone common currency area, the euro will have a flattening effect on costs, making it more advantageous to produce in those parts of the bloc where t is minimized; namely, toward the center.

One other facet of this theory, per Reinert, is this: A robust, high-value-added industrial sector should play a crucial role in the improvement of semiperipheral EU countries to core status, and the maintenance of core states of their status. The competitiveness of the industry may also be monitored: Part of the NUTS data includes the percentage of employment within industry, and looking over time, increasing or slowly declining values would suggest robust industry, as opposed to rapidly collapsing numbers suggesting outdated industry that is in the process of being mothballed.

One important justification of this research is that it attempts to address and balance the limitations of both the new economic geography and world-systems in hopes of more accurately explaining economic phenomena. Specifically, in the case of the new economic

geography, space and time are not explicitly included, and its theory operates under nomothetic assumptions that ignore a narrative view of history. For example, the new economic geography cannot explain why former hegemons such as Britain and the Netherlands have great financial and commercial heft despite their relatively small industrial sectors. Nevertheless, because the new economic geography does not explicitly include space or time, and research done on this basis relies on nonspatial OLS models (for example, Button & Pentecost 1995, Davis & Weinstein 1999 *et. passim.*), supplementing these models with spatially and temporally explicit ones should be done. World-systems does include consideration of a narrative view of history, but the limitations of explaining phenomena over the course of a single decade via world-systems is also apparent. Nevertheless, ten years may be enough to capture certain temporal aspects, such as waves and cycles, or a continuing decline from a previous position of power. In other words, the new economic geography appears to be a great way of modelling the *present*, whereas world-systems and a narrative view of history help to explain the *past*.

This research will not include SAR models, but the rationale and methodology of such supplementation will be discussed as a basis for future research. In addition, while the OLS models do not include a spatial component, they will include a temporal component by considering change over the course of a year. For example, the dependent variable of choice will be ΔGDP rather than simple GDP. Therefore, it is hoped that future SAR models that model change may be able to explain both space and time in how economic variables influence, and are influenced by, each other.

Chapter 4: Data

Eurostat provides data for those European countries who have become members of the EU. Nationwide data are available for all EU countries (plus a few non-EU countries, including Norway, Switzerland, and Turkey) for years from 2000 to 2011. This is satisfactory for the purposes of this survey, as the year 2000 is approximately when the post-Soviet collapse of Eastern European economies ran its course and their sizes reached their minimum; this is true most importantly for the Russian Federation, which is the largest in the region. Thus, by beginning the survey at 2000, the trends since then may be attributed to the size of the region's free-market economies growing faster than the post-Communist state sectors were contracting.

Within countries, larger amounts of data are required. Ideally, it would be per capita income figures for different cities in Europe, or at least their metropolitan areas, as city boundaries often do not include the entire relevant metropolitan area around the city. Less satisfactory but undoubtedly easier to procure are PCGDP figures by administrate regions of each country. Many Eastern European countries define their capital cities' metropolitan areas as their own province-level jurisdictional units, but a few (Poland and Bulgaria, for example) do not. Nevertheless, the data should be useful in capturing how well the regions with capitals do relative to those without, and each region may be classified into categories by population or population density. For within-country comparisons, the source will be *Regions: Statistical Yearbook 1999* from Eurostat (2000), with shapefiles provided by Eurostat for creating maps from NUTS2 2010 administrative statistical units. While only a single year of data is available, it should be sufficient to do a purely *spatial* analysis of European regions, as opposed to a *spatiotemporal* analysis with the full-country data since 2000.

Eurostat data sets based on NUTS2 regions are collected, which includes the following data: education levels, employment by sector, fertility (birth rate), fixed capital formation, total GDP growth, per capita GDP, total GDP, transportation infrastructure, unemployment rates, and current accounts for exports and imports.

For a few tables, such as those involving different sectors of the economy (for example, fixed capital formation or employment), there are NACE classifications used by Eurostat. In addition, there was a revision in the NACE classifications in the past decade, with the second revision being somewhat more detailed than the first in the services sector. The classifications are detailed below:

Table 1: NACE activities, Revisions 1 and 2

NACE Revision 1:
A_B: Agriculture; fishing
C-F: Industry
C-E: Industry (except construction)
F: Construction
G-Q: Services
G-I: Wholesale and retail trade; hotels and restaurants; transport

J_K: Financial intermediation; real estate
L-Q: Public administration and community services; activities of households; extra-territorial organizations
NRP: No response

NACE Revision 2:
A: Agriculture, forestry, and fishing
B-E: Industry (except construction)
F: Construction
G-I: Wholesale and retail trade, transport, accommodation and food service activities
J: Information and communication
K: Financial and insurance activities
L: Real estate activities
M_N: Professional, scientific, and technical activities; administrative and support service activities
O-Q: Public administration, defense, education, human health, and social work activities
R-U: Arts, entertainment, and recreation; other service activities; activities of household and extra-territorial organizations and bodies
NRP: No response
TOTAL: All NACE activities

Comparing NACE Revision 1 with Revision 2 may be done by consulting the Eurostat documentation on the matter (Eurostat 2008, p. 49). Therefore, when combining the two NACE schemes for those datasets which use them, the following combined classification system is used in this research:

A: Agriculture (A_B in Revision 1; A in Revision 2)
Ba: Industry excluding construction (C-E in Revision 1; B-E in Revision 2)
Bb: Construction (F in both revisions)
Ca: Commerce (G-I in Revision 1, G-I and J in Revision 2)
Cb: Finance (J_K in Revision 1; K, L, and M_N in Revision 2)
Cc: All other services (L-Q in Revision 1; O-Q, and R-U in Revision 2)

Unfortunately, there are some wrinkles. For example, mining and quarrying is included in sector Ba rather than A, despite it being a primary sector good that any underdeveloped country may produce in large quantities, and not strictly speaking an industry.

Variables

The variables in the Eurostat data will be considered for the timeframe from 2000 to 2010 if possible, which is when GDP data is available for most European countries and NUTS2 regions. The first and most important variable examined here is GDP, both for 2000 and 2010, as it will be the dependent variable used for bivariate analyses.

GDP: There are two ways to examine GDP which will be considered: NPCGDP, or normalized per-capita GDP, by which the per-capita GDP is normalized to the EU average, which is set at 100; and total GDP, which simply takes the GDP figure for the country or area in millions of euros. Furthermore, total GDP will be examined mainly by examining its change over a time period, usually a year, in other words, ΔGDP.

Employed labor force (ELF) by sector: The 2010 labor force is examined, as the change in the size of the ELF is not considered to be significant; rather, in these models, the effects of

differing sizes of the ELF across sectors and NUTS2 regions is considered. Because NUTS2 regions are not actually population equivalent, the maps in these results will instead depict the percentages of the ELF in each of the economic sectors described above, based on the combined NACE classifications described above (namely A, Ba, Bb, Ca, Cb, and Cc).

Fixed capital investment (FCI): The FCI data suffers from a restricted time frame, namely, 2002 to 2006, as Eurostat lacks data for France during 2007 and later, and for many German regions before 2002. The year 2010 data, in fact, contains all European countries except Belgium, France, Germany, and Spain —– four of the most important. FCI data is available for different sectors of the various economies. As with GDP, analyses on ΔFCI is performed.

Unemployed Labor Force (ULF): As with ELF, the unemployed labor force will be considered as a percentage of the size of the employed labor force, for 2010 and for men and women. This definition means that hypothetically the unemployment rate as defined here could exceed 100%, but its purpose is to give an overall view as to the "excess" labor force existing in each area, and thereby the possible sources (and, perhaps, destinations) of jobless migrants in the EU.

Trade Current Account (CA): This figure was used rather than pure trade figures, because Eurostat only provides the latter for trade outside of the EU. As with FCI, whole-country data is considered.

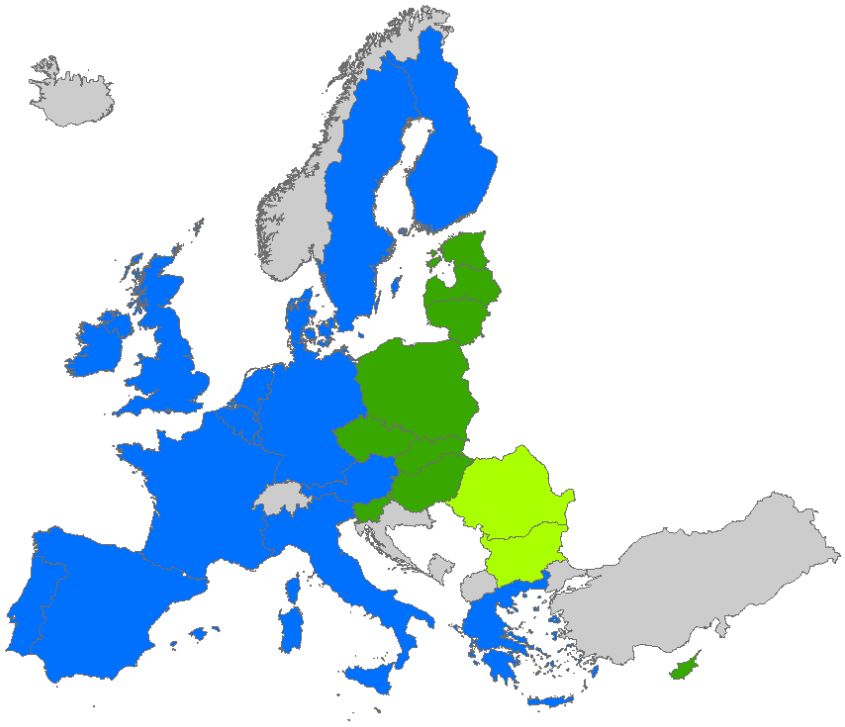


Figure 1: EU Membership expansion between 2000 and 2010. Blue indicates EU members in 2000, dark green indicates countries that joined the EU in 2004, lime indicates those that joined in 2007, and gray indicates countries that were not EU members in 2010, but are included in the Eurostat shapefile and in at least some Eurostat datasets.

Chapter 5: Analytical Methods

A Markov random field would be the ideal option for examining this data, and a SAR or CAR model provides a reasonable estimator, but other spatial statistical methods may be utilized to approximate the effect desired. Three methods will be used: Moran's I, LISA, and non-spatial OLS, although this last will include spatial Moran's I measurements.

Moran's I and LISA

Moran's I is an indicator of spatial autocorrelation which describes how a variable changes across a given space. A global Moran's I statistic considers the entire area, while LISA (local indicators of spatial association) is geared more toward examining specific clusters in the region. The countries, and especially the NUTS2 regions, are ideal for performing Moran's I operations

The equation for a univariate global Moran's I is as follows:

$$I = \frac{N}{\sum_i \sum_j W_{ij}} \frac{\sum_i \sum_j W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - x)^2}$$

Here, N is the number of regions being considered and W_{ij} the weighting matrix, *i* the region being considered (with all regions being summed and counting toward the final value of Moran's I), and *j* a region other than *i*. The weighting matrix is crucial here, for it determines how relevant the values of the other regions are in the measurement. For example, a simple weighting matrix may define w_{ij} as "1" if regions *i* and *j* border each other, or "0" if they do not (with Wij being the matrix of all w_{ij}s in the measurement). Moran's I may vary from –1 to +1, with +1 indicating that like clusters with like, or the values in each region are segregated with each other; –1 indicating that like is maximally clustered with *unlike,* as with the colors in a checkerboard; and 0 indicating that like values are randomly clustered with like and unlike values around the board.

For a bivariate global Moran's I, the equation is as follows:

$$I = \frac{N}{\sum_i \sum_j W_{ij}} \frac{\sum_i \sum_j W_{ij}(x_i - \bar{x})(y_j - \bar{y})}{\sqrt{\sum_i (x_i - x)^2} \sqrt{\sum_i (y_i - y)^2}}$$

Weighting matrices may follow a number of schemes. Firstly, a "rook connectivity" weighting matrix considers a region's neighbors that share borders with the region, while "queen connectivity" extends those to neighbors that share corners, named for the possible moves of a rook or queen in chess. So for example, in the case of the Four Corners states in the southwestern United States, Arizona shares a rook connectivity with Utah and New Mexico, but a queen connectivity with Colorado. In addition, "order" considers how many rook or queen moves it would take to get to the regions in the matrix; a "first order" only considers immediate neighbors, whereas a "second order" considers not only immediate neighbors, but the neighbors' immediate neighbors (the second order) as well.

Secondly, a "k nearest neighbors" (KNN or NNK) matrix considers the "nearest" k neighbors of the region under consideration (in this case, "nearest" is defined by the centroids of the regions), and has an advantage of being able to include island regions that do not have direct borders with the bulk of the study area. Thus, for example, Sicily, having no land borders, would be isolated in a rook or queen connectivity scheme, but it still could participate in a KNN scheme because its nearest neighbors would include the areas such as Calabria and Malta which are "nearest" to Sicily.

Lastly, a "distance weighting" matrix considers the neighboring regions within a given distance, such as 500 km. Varying the distance cutoff in a distance weighting matrix has an effect similar to varying k in a KNN scheme, or order in a connectivity scheme.

In all cases, if the weighting matrix becomes very large (large k for KNN, large order for connectivity, or long cutoff distance for distance weighting), the Moran's I of the variable will tend toward zero. But, if it is very short, the Moran's I may show a spurious positive that rapidly drops off to zero if the variable is not actually spatially autocorrelated. A plot of Moran's I versus varying order is known as a "correlogram", and it is useful in helping to choose an appropriate weighting matrix. Results here are shown in Table 2 and Figure 3.

LISA (local indicators of spatial association) is an elaboration on Moran's I which provides more detail at the local level, as opposed to providing a single global value. A full description of LISA is provided by Anselin (1995). It differs from a global Moran's I statistic by considering local clustering. The equation for univariate LISA is as follows:

$$I_i = \frac{N(x_i - \bar{x})}{\sum_i (x_i - x)^2} \sum_j W_{ij} (x_j - \bar{x})$$

If a variable deviates significantly from its neighbors as defined in the weighting matrix, that region will be indicated on a LISA map, of which there are several in this thesis. LISA maps here are created in GeoDa, and follow its scheme. For example, if a region is significantly higher than average, but its neighbors are lower than average ("high-low"), the region will be colored pink; if it is "high-high", it will be red; if "low-high", light blue; and if "low-low", dark blue.

Nonspatial OLS (Ordinary Least-Squares)

This is the simplest analysis, as it does not require a weighting matrix at all. Here, a dependent variable (usually GDP or its derivatives, such as ΔGDP or NPCGDP) is compared to one or more independent variables. If comparing ΔGDP with employment in sector Ba, for example, the OLS will look like this:

$$\Delta GDP = \beta_0 + \beta_1(ELF_{Ba}) + \varepsilon_0$$

A t value of significance provided, which will give an indication whether the variable (or the intercept β_0) is significant or not. Nonspatial OLS, like Moran's I and LISA, will be performed with GeoDa, which unfortunately does not give the option to exclude β_0 from an

OLS equation, even though in some cases it may be warranted; if the t-test for β_0 is insignificant, it may be treated as 0 under the null hypothesis.

This OLS model for examining GDP convergence within the European Union is not unlike that of Button & Pentecost (1995), which likewise used the basic form

$$\Delta GDP = \beta_0 + \beta_1(Var_1) + \beta_2(Var_2) + \ldots + \varepsilon_0$$

except that ΔGDP was expressed in terms of percentage change of NPCGDP ("average per annum growth rate in GDP per capita") rather than absolute change as used in this research. OLS models such as Button & Pentecost (1995) and Davis & Weinstein (1999) are appropriate for analyzing and explaining nonspatial correlation between economic factors, and in fact, such analysis must be done before including explicitly spatial factors.

In future, the OLS model used here ($\Delta GDP = \mathbf{X\beta}$) will be elaborated upon by using a SAR model, where a spatial weighting matrix of lagged GDP is added to the model

$$\Delta GDP = \Delta GDP\mathbf{W}\rho + \mathbf{X\beta}$$

and in the case of testing for regionalization within Europe, GWR will be considered as well. Choosing a weighting matrix for these analyses will be discussed below. By comparing OLS models generated in this work with future SAR models, if in fact spatial effects are important, adding the spatial factor to the models will improve them significantly. On the other hand, if the null hypothesis that spatial effects are unimportant is true, supplementing an OLS model with a corresponding SAR will not significantly improve the fit. As to which SAR model is best (spatial lag, spatial error, or geographically weighted regression), this may be done by testing which of the three most effectively accounts for spatial effects in the errors, leaving the error term with a Moran's I closest to zero.

Before the main analysis on the 2000-2010 Eurostat data at the NUTS2 level, two preliminary analyses will be performed. The first is a simpler Moran's I analysis of the normalized per-capita GDP (NPCGDP) of all countries for which data is included in Eurostat for the years 2000-2010, and the second will be an analysis of older 1996 Eurostat data which does not include the newer EU members in the former Warsaw Pact to determine the best weighting matrix to use for the data at the NUTS2 level.

Full-country Moran's I Analysis, 2000-2010

The first full-country (NUTS0) Moran's I analysis of NPCGDP for the 2000-2010 period is shown below in Figure 2.

For a preliminary study of NPCGDP using whole-country data between 2000 and 2011, the simplest analytical method would be to make a binary connectivity matrix (Haining 2004), with each EU state occupying one row and column of the matrix, and those with either readily-crossable land borders or close sea connections (cf. Britain and France, Denmark and Sweden, Finland and Estonia) given a value of 1 in the spatial weighting matrix and 0 otherwise. Moran's I would be expected to decrease toward 0 between 2000 and 2011, as Eastern European countries closer to the European core increase to match it, while countries further removed from the core slide down or at least rise more slowly. Financial crises, such

as that which happened in 2008, are expected to hit the European periphery harder, because the core has more industrial capability and therefore moneymaking capacity. Therefore, while the European Union pays lip service toward getting the Moran's I down to 0 (absolute equality), in practicality, this attempt is expected to break down as peripheral countries like Portugal and Greece fail to compete in a tariff-less system with core countries like Germany, and therefore Moran's I will show the inclination to rise once again.

1996 Eurostat Data

Analysis of the 1996 Eurostat data will include the following:

1) Univariate Moran's I of the variables available in the 1996 Eurostat data, to determine the optimal type of weighting matrix (Table 1);
2) A correlogram of the optimal type to determine the optimal order (Figure 3);
3) Univariate LISA for the variables (Figure 4a through 3f); and
4) Bivariate Moran's I of the variables, to obtain an idea of broad correspondences among them (Table 3).

The variables in the 1996 Eurostat data are more restricted than those for the full 2000-2010 Eurostat data described previously in the "Data" section. For the 1996 Eurostat data, the available variables considered include NPCGDP; population density; agricultural, industrial, and services employment; and male and female unemployment.

Descriptive Analysis

A simple descriptive analysis of each of the variables described above in the "Data" section will be performed first. Maps will be provided for the descriptive analysis, and they will follow this scheme:

1) NPCGDP for 2000 and 2010 as percentage of EU average (Figure 5a);
2) Change in percentage GDP growth from 2005 to 2010, compared to 2000 to 2005, based on 2000 GDP (Figure 5b);
3) Percentage employment in 2010 by broad NACE economic sector (Figures 5a, 5b, and 5c);
4) Change in fixed capital formation between 2005 and 2006 by economic sector, expressed as a percentage of 2005 GDP, by broad NACE economic sector (Figure 7);
5) 2010 unemployment rate measured as a percentage of the total *employed* labor force; for men and for women (Figure 8a);
6) Difference between 2010 unemployment rate of men and women (Figure 8b); and
7) Current account balance expressed as a percentage of GDP, for 2001, 2005, and 2010 (Figure 9).

Univariate Analysis: 2000-2010 Data

Univariate analysis will involve examination of NPCGDP over the NUTS2 regions in Europe. Two different methods will be used; namely, Moran's I and LISA. Moran's I analysis will be

done on the NUTS2 regions of Europe, comparing them with the whole-country data performed earlier (Figure 20), as well as for the largest European countries individually with the most NUTS2 regions (Figure 21). Univariate LISA on NPCGDP will be done, also for NUTS2 regions, for 2000 (Figure 22a) and 2010 (Figures 11b and 11c), and finally for the change in NPCGDP (ΔNPCGDP) between 2000 and 2010 (Figure 22d), to provide an overview of the structure of the economy via NPCGDP, and how the economy has been changing between 2000 and 2010.

The LISA maps provided in this thesis are read thusly: the variable under consideration is compared in a given region to either the same variable (univariate LISA) or a second variable (bivariate LISA) in the surrounding regions, according to the desired weighting scheme. If the variable in the region under consideration is significantly higher than average, the region is colored red; dark red and labeled "high-high" in the legend if the variable in the surrounding regions is significantly higher than average, but pink and "high-low" if the variable in the surrounding regions is significantly lower than average. For example, in Figure 22c below, a univariate LISA is done with NPCGDP. In Poland, Masovian Voivodeship (where Warsaw is located) is significantly higher than the EU average, but is surrounded by regions that are lower, hence it is "high-low" and colored pink. In a univariate analysis of NPCGDP, "high-high" and "low-low" are the most common, as wealthy regions tend to border other wealthy regions, and poor ones other poor ones. In a bivariate LISA, by contrast, "high-low" and "low-high" regions may be the most common if the two variables are inversely correlated (such as, one might expect, NPCGDP and unemployment).

Bivariate Analysis: 2000-2010 Data

Bivariate LISA will not be performed at this point, although it is a possibility in future research. In the meantime, for bivariate analysis, this research will concentrate on the simpler OLS regression, which will provide a good overview of the processes involved.

When comparing ΔGDP at the substate level with independent variables, NUTS2 divisions available in the Eurostat data will be used whenever possible; otherwise, NUTS0 (full-country) data will be used. The differences between Europe-wide data (defined as all available countries) and Eurozone-only data are examined, as the results are expected to be somewhat different in many cases due to currency fluctuations. Ideally, all data from 2000 to 2010 would be used, which is the year range for which Eurostat total GDP data is available, comparing it to whichever years the relevant variable is available, matching it to ΔGDP. For many variables, the whole year range may be missing (for example, NUTS2 fixed capital investment data is only available EU-wide between 2002 and 2006) or NUTS2 data may be lacking (for example, current account data only contains whole-country data), and in such cases these variables are compared only against the corresponding stripped-down ΔGDP dataset.

Upon determination of an independent variable or variables to consider, an OLS regression will be performed with ΔGDP as the dependent variable, at whichever precision (NUTS2 or NUTS0) or time period is available, solving for the following equation:

$$\Delta GDP_i = \beta_0 + \beta_1(var_{1,i}) + \ldots + \beta_n(var_{n,i}) + \varepsilon_i$$

GeoDa is used to perform this task, with a KNN weighting matrix to check the Moran's I to see if it is significantly divergent from zero. The aim is to find OLS regressions that come closest to explaining ΔGDP — in other words, to obtain an R^2 as high as possible. It is hoped that by these methods, the factors and processes that help to increase GDP over time, or conversely, to hinder it, may be determined; and via LISA, the effects of geography examined and confirmed. In later research, SAR and GWR will be used as well to elaborate upon the OLS models constructed here.

The following bivariate OLS regressions, with ΔGDP (change of GDP between the current year and the previous year, in millions of euros) as the dependent variable, will be performed:

1) ΔGDP versus the employed labor force ("ELF", in thousands of persons) for start year by NACE economic sector from 2000-2001 to 2009-2010 (Table 4);
2) ΔGDP versus the change in fixed capital investment (ΔFCI) in millions of euros *and* ELF for start year from 2002-2003 to 2005-2006 (Table 5);
3) ΔGDP versus the change in current account payments (ΔCA) for exports and imports in billions of euros from 2003-2004 to 2009-2010 (Table 6); and
4) ΔGDP versus the change in the unemployed labor force (ΔULF) for males and females in thousands of persons from 2000-2001 to 2009-2010 (Table 7).

The selection of these models is based upon Krugmanian economics, which bases economic output on capital and labor. Here, FCI is the variable of choice to represent capital investment, while ELF represents the labor force. CA and ULF are considered to enumerate the effects of the various regions' economic performance on the labor force and the trade deficit.

Chapter 6: Results

Preliminary Moran's I Analysis

For a preliminary study, the Moran's I of the per capita GDPs of all the countries in the current European Union, normalized to the EU average (at 100), will be done, and how it changes over time, modeled after a method used by Dezzani (2006) to examine convergence of PCGDP in Europe. Per capita GDP data is available from Eurostat, and the Internet has data back to 2000, albeit with a break in the time series at 2005 in the original data (table used is "GDP per capita in PPS"). The resulting data is shown below in Figure 2.

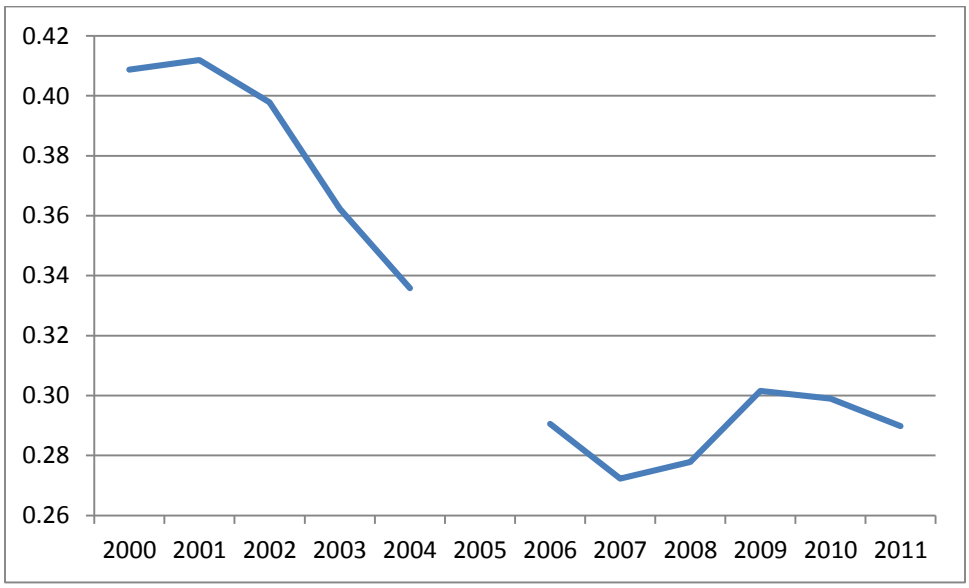


Figure 2. Moran's I for the normalized per-capita GDP of the 2007 European Union members. The year 2005 had extrapolated data and so is not shown.

The presumed goal of the EU is for the Moran's I of the countries' PCGDPs to head toward zero, that is, that the regional disparity in European PCGDP will disappear. These measures of Moran's I do include those Eastern European countries that joined the EU in 2004 and (in Romania's and Bulgaria's case) 2007, which shows that convergence was happening even before they joined, suggesting that it was not contingent on Eastern European countries being EU members, or, as some cynics may suggest, was happening *because* they weren't. The peak of the financial crisis struck in 2008 and 2009, which caused a jump in Moran's I; since then, it has started to fall again, as the EU has managed to delay the threatened collapse for perhaps a few years, bringing down government bond yields in threatened countries.

Regional Data

Regional data is available from Eurostat, in more detailed datasets. Regional NUTS2 data is available for 1996 only, but that is sufficient for getting a spatial, rather than spatiotemporal, picture of the European economy. These regional data cover select regions of each EU country, as well as the entire country in the case of some smaller countries. While

total population is not available by country, it may be substituted with the region's population density, which is included in the Eurostat regional data. This has the added benefit of accounting for capital cities which are not their own jurisdiction, as in Poland and Bulgaria, since more populous cities may be expected to increase their local jurisdiction's population density more if the region only covers the immediate metropolitan area as opposed to a large portion of the surrounding countryside. Other possible metrics to observe are the employment rate, which is also subdivided into agriculture, industry, and services; and the unemployment rate, which is also subdivided into figures for men and women.

The shapefile used was obtained from Eurostat, and was NUTS_RG_03M_2010.shp. It contained four levels of administrative units, from countries on down. A table was obtained with the region names, which were joined to the shapefile. Then, the table containing the Eurostat 1996 data was joined to the shapefile; nearly all the regions were transferred over. The only exceptions were region UKD5 (Liverpool-Merseyside), which has since been split into UKD6 and UKD7; and Trentino-Alto Adige province in Italy, which has been split into the Autonomous Province of Bolzano and Trento regions (ITH1 and ITH2); a similar wholesale reclassification in Finland forced the use of full-country data for that nation, although it should not be too much of a problem since it has only about five million people, similar to Denmark and Ireland, for which there already are single features. Columns containing country identification were added so as to possibly enable weighting based on whether two regions are within the same country or not; this was done by adding a new field and giving a numeric ID number unique to a given country to each group of regions within that country.

Next, since the polygons in the shapefile contained multiple administrative levels, meaning that there was redundant data, the data was winnowed out until the lowest level of 1996 Eurostat data was joined to the appropriate polygons, with every area being represented by a polygon of the appropriate level. To fix the Merseyside and the Trentino problems, UKD6 and UKD7 were merged in the shapefile to a single feature as existed in 1996, as were ITH1 and ITH2. A European Lambert Conformal Conic projection was applied to the shapefile, enabling it to be analyzed in OpenGeoDa, which provides the statistical tools needed for this analysis.

In the case of the PCGDP data between 2000 and 2010, it was similarly attached to a shapefile, which included Eastern European members of the EU. There were additions to the PCGDP data in 2008, when countries such as Norway were added, and in 2010, when a tweak in the Italian regions of Emilia-Romagna and Marche was made, and so therefore three separate shapefiles were made: one for those NUTS2 regions that were in the full 2000-2010 set, those which were only in the 2008-2010 years, and the one for 2010 with the Italian change.

Regional Results: 1996 Eurostat Data

The first task was to determine the best weighting matrix for this study. In GeoDa, a series of weights files were created; first, 10 separate .gal weights files from 1st to 10th order contiguity one based on rook contiguity order; second, two .gwt distance weights, using the minimum and maximum threshold distances (of 1,183 and 5,354 km respectively); and third, 10 more separate .gwt weights files from 1 to 10 nearest neighbors based on k-nearest

neighbors (KNN). The rook contiguity and k-nearest neighbors weights files enable the creation of correlograms, while the .gwt distance weights, which used centroids rather than polygons, enabled incorporation of island regions and groups of island regions (such as the United Kingdom, but also Sweden and Finland, which aren't connected by land to the rest of the 1996 EU) into the dataset as a whole.

Table 2: Univariate Moran's I results, 1996 data

	Rook Connectivity		Distance Weight		Nearest Neighbor	
Variable	1st order	5th order	Short cutoff	Long cutoff	k = 1	k = 5
Female Unemployment	0.7135	0.1176	0.1719	–0.0056	0.6780	0.6406
Agricultural Employment %	0.6386	0.0764	0.2709	–0.0056	0.5669	0.5911
Total Unemployment	0.6065	–0.0049	0.0985	–0.0056	0.5833	0.5436
Male Unemployment	0.5037	–0.1235	0.0402	–0.0056	0.5026	0.4504
Relative GDP	0.4783	0.1695	0.1922	–0.0056	0.4900	0.5188
Log Population Density	0.4678	0.0800	0.0756	–0.0056	0.4633	0.3524
Industrial Employment %	0.4315	0.0046	–0.0054	–0.0056	0.4839	0.3798
Population Density	0.2217	–0.0150	–0.0050	–0.0056	0.3071	0.0768
Services Employment %	0.0035	–0.0085	–0.0088	–0.0056	0.0413	–0.0047

These results show that of the three types of weighting model, distance weighting appears to be the weakest using Moran's I values, even with the shortest possible cutoff value. First-order connectivity is better, but again, it has the disadvantage of not being able to include islands separated from the European core, and while a couple of variables show better results with that than for nearest neighbor (log population density, agricultural employment, and unemployment), the improvement is very slight over the k = 1 nearest neighbor weighting matrix. K-nearest neighbor, meanwhile, enables the use of both correlograms and island data, and is about as effective as first order rook connectivity; furthermore, KNN should show a more interesting correlogram than rook connectivity, in that it better distinguishes variables that are significantly clustered from those which are not; rook connectivity shows a uniform drop-off toward zero (or below) with increasing order for all variables. Therefore, it would appear that KNN is the best method for the data. Of the variables, all show significantly clustered Moran's I values, with the exception of employment in services, and using log population density rather than raw population density improves the Moran's I of that metric. The clustering of agriculture, randomness of services, and intermediate status of industry was also particularly interesting.

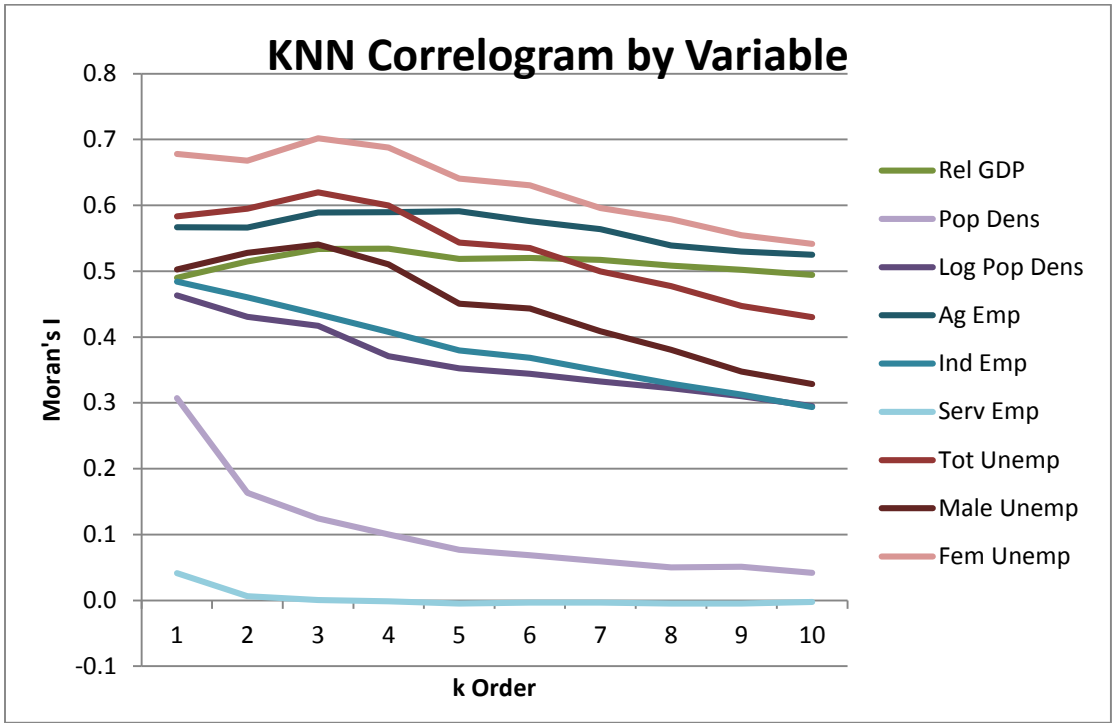


Figure 3: KNN Correlogram by Variable.

The cluster maps produced by KNN were also more useful due to the ability to incorporate island data, and unlike connectivity, and preliminary test runs indicated that the higher-order KNN maps, such as with k = 5, were in fact more useful than those for k = 1. The KNN correlograms for each of the variables were then calculated.

As seen in Figure 3, the values for all variables dropped off with increasing order of k above k = 5, but while a few, including the weakest variables, had their highest Moran's I value with order k = 1 (namely, raw and log population density, and industrial and services employment), others hit their peak at higher orders. The unemployment variables had highest Moran's I at k = 3, normalized relative GDP at k = 4, and agricultural employment at k = 5 (slightly ahead of k = 4). Despite this, when univariate LISA cluster maps and significance maps were created, k = 10 showed the largest number of EU administrative areas with significant data. This, however, may be due to national-level effects influencing the data, so the most significant order, k = 4, will be used for each variable to capture the strong local effects observed. This order, k = 4, appears to most robustly separate variables which appear randomly distributed from those that are significantly clustered, which in Figure 3, would mean services employment and population density from everything else.

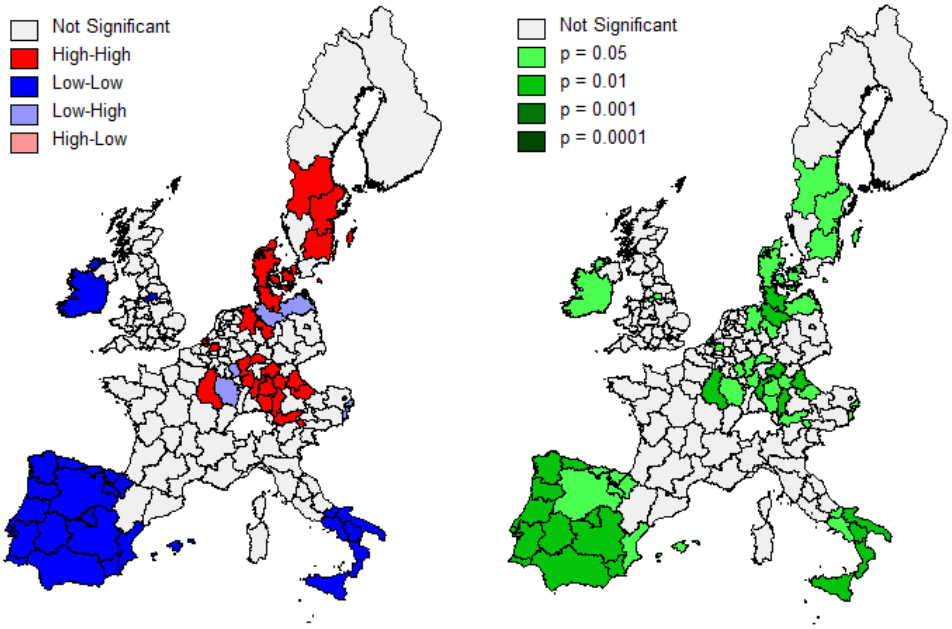


Figure 4a: Univariate LISA Cluster map (left) and significance map (right) for relative GDP, with k = 4 nearest neighbors, p = 0.05. Red is high GDP, blue is low GDP, while pale red and pale blue are those which are next to a region of opposite polarity.

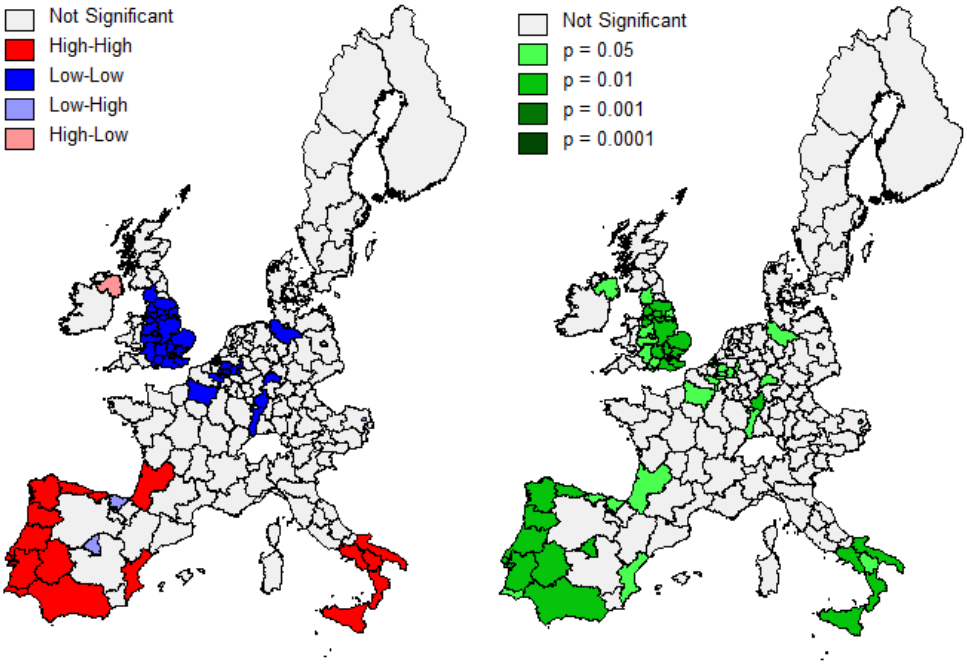


Figure 4b: Univariate LISA Cluster map (left) and significance map (right) for agricultural employment, with same conditions as in Figure 4a.

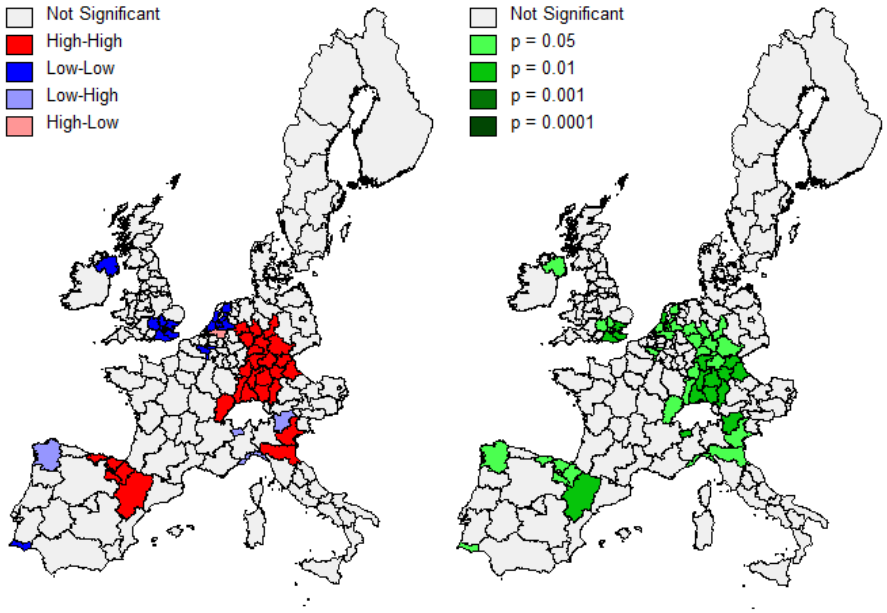


Figure 4c: Univariate LISA Cluster map (left) and significance map (right) for industrial employment, with same conditions as in Figure 4a.

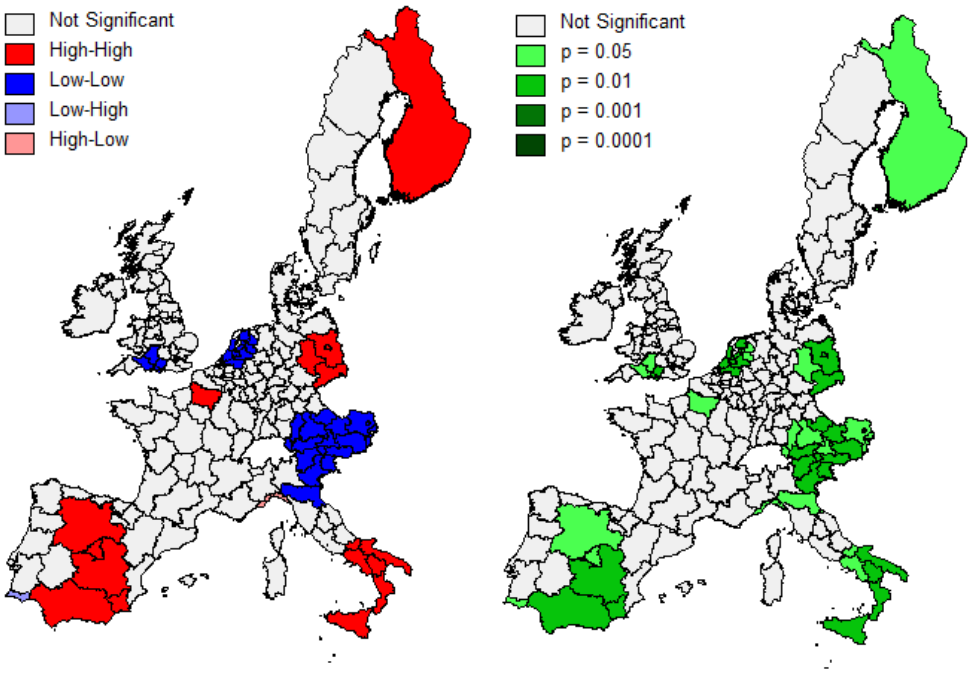


Figure 4d: Univariate LISA Cluster map (left) and significance map (right) for male unemployment, with same conditions as in Figure 4a.

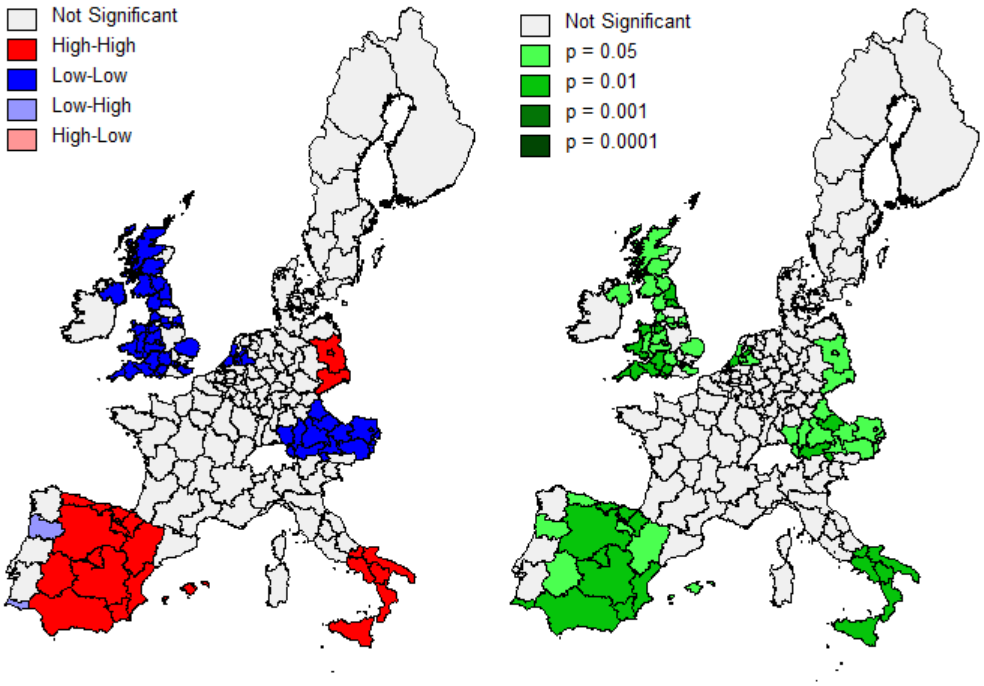


Figure 4e: Univariate LISA Cluster map (left) and significance map (right) for female unemployment, with same conditions as in Figure 4a.

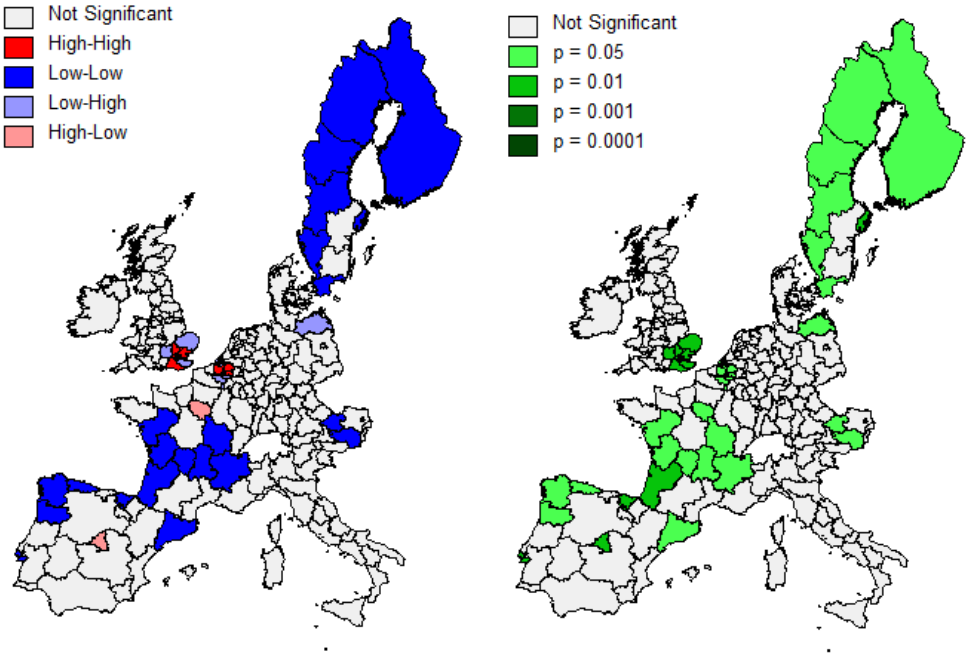


Figure 4f: Univariate LISA Cluster map (left) and significance map (right) for population density, with same conditions as in Figure 4a.

From Figures 3a through 3e, the core-periphery setup of the 1996 European Union is apparent, with the wealthier regions in a belt from the United Kingdom to Austria contrasting with poorer areas in Spain and southern Italy. (Here, “core” and “periphery” are defined according to a Krugman economic model more than to the world-systems perspective, as the

former is easier to quantify with economic variables.) As is immediately apparent, the core has higher per capita GDP, lower unemployment, higher industrial employment, and lower agricultural employment with the periphery showing the opposite. While there is some slight variation in the LISA cluster maps between the metrics, with industry being most divergent – – unsurprising since it appears to be shifting from the core to the semiperiphery worldwide, most notably to China — the overall trend holds, with the European core being "best" off and most of Spain and southern Italy "worst" off. Population density, meanwhile, appears to show no correlation with these metrics. Female unemployment could prove useful in later studies when comparing with the birth rate, although the 1996 Eurostat NUTS2 dataset used here has poor-quality birth rate data and is therefore not used here.

The next step is to consider multivariate Moran's I results, by considering the six variables of: Normalized per-capita GDP, agricultural and industrial employment, male and female unemployment, and population density, although this last variable is predicted to show little correlation in Moran's I with the other five. The results are shown below in Table 3.

Table 3: Bivariate Moran's I results (Weighting matrix: KNN with k = 4).

	Y Variable					
X Variable	PC GDP	Ag Emp	Ind Emp	M Unemp	F Unemp	Log PDens
Relative Per Capita GDP	**0.5341**	–0.3517	0.1555	–0.2534	–0.3573	0.0353
Agricultural Employment	–0.3639	**0.5896**	0.0103	0.2074	0.4231	–0.2889
Industrial Employment	0.1856	–0.0150	**0.4079**	–0.0422	–0.0142	–0.0244
Male Unemployment	–0.2420	0.2224	–0.0225	**0.5104**	0.4921	–0.1633
Female Unemployment	–0.3615	0.4582	0.0025	0.4894	**0.6880**	–0.2196
Log Population Density	0.0004	–0.2069	–0.0221	–0.1473	–0.1606	**0.3711**

The results of multivariate Moran's I show that along the diagonal, population density is least likely to be correlated with itself, which somewhat makes sense considering the example of cities such as Berlin or Paris, which are quite dense but surrounded by fairly sparsely populated regions. In addition, population density appears to show no correlation with per capita GDP at all. This may not turn out to be as true for Eastern Europe, where typically the capital cities benefit, but the question there will be: if population density is correlated with relative GDP there *now,* will it be in the future, or will it converge as it has in the rest of the EU? Results so far, as seen on Figures 11b and 11c below, suggest that convergence has not happened yet, and indeed, divergence has sharpened.

The other indicators are consistent with expectations. Underdeveloped areas tend to have the most people employed in agriculture, with industry developing with the economy, while the randomness of services employment may be credited to its wide range of meaning. Agriculture thus has a strong inverse relationship to PCGDP. The weaker link of industry to PCGDP may be noted in the low LISA values in the Netherlands and England, compared to high values in western Germany, northern Spain, and northern Italy. Also, female unemployment seems to be a stronger indicator of underdevelopment than that of males, with women seemingly entering the labor force after men as a country develops. Differences in female and male unemployment may be analyzed in future work. One noticeable discrepancy is between the unemployment rates in Portugal versus Spain; is this a real effect,

or does Portugal use an "actively seeking employment" metric like the "official" U.S. employment rate, versus Spain reporting something more like the U.S. "U-6" rate to Eurostat, which is roughly twice as high as the "official" rate?

Descriptive Analysis of Variables Used in 2000-2010 Eurostat Data

GDP: In Figure 5a below, there are two maps of NPCGDP, one for 2000, and one for 2010.

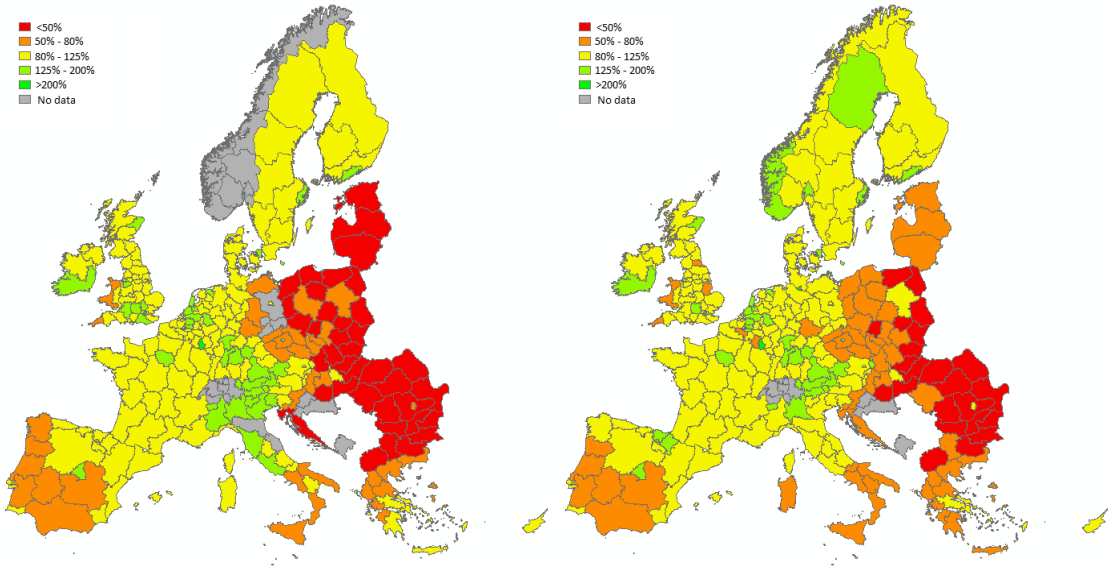


Figure 5a: Normalized per-capita GDP (NPCGDP) for 2000 (left) and 2010 (right), as percentage of EU average.

According to Figure 5a, there do indeed appear to be signs of a geographical contagion effect over time in evidence in Northern Europe in particular, although as this contagion or diffusion is a second order effect in space and time, future work involving a SAR model will be required to show this robustly. While a few areas, such as the Czech Republic and Hungary, showed little change, the Baltic states, the former East Germany, Poland, and Slovakia all showed improvement, with Poland in particular appearing to show such improvement in a geographical, and not just hierarchical expansion. In other words, whereas the capital regions such as Masovian Voivodeship in Poland showed the largest increases, there also appears to have been a sharper rise in western Poland and the former East Germany than in eastern Poland. A smaller, primarily hierarchical effect is seen in Slovakia, Romania, and Bulgaria, with their capital regions either reaching the EU average (represented in yellow) or just below (orange), but the most westerly-located non-capital NUTS2 regions of Slovakia, Romania, and Croatia also showed a relative rise. Meanwhile, certain areas of Western Europe have shown relative decline, such as Italy, England, Wallonia in Belgium, and Greece.

ΔGDP is quite variable over the decade; the Great Recession caused a sharp decline in many areas. By considering the difference between growth during the first five years and that for the last five years, how ΔGDP changed over the decade may be more easily seen.

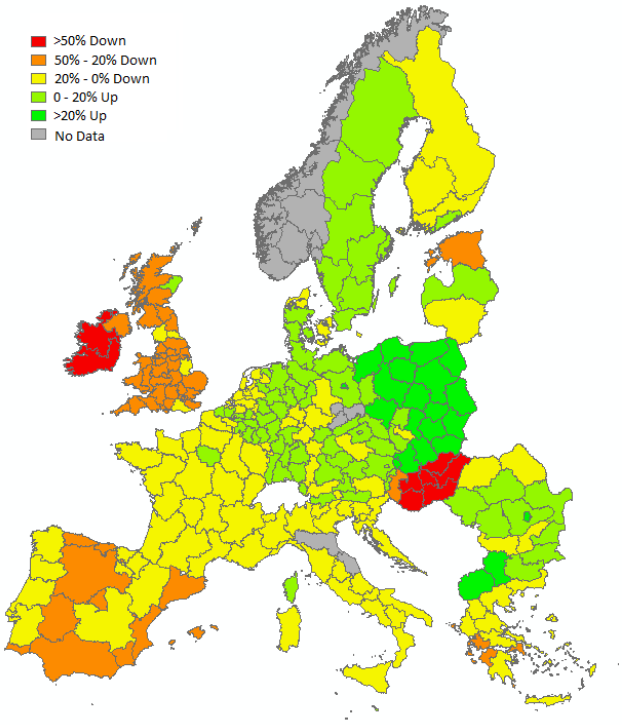


Figure 5b: Change in percentage GDP growth from 2005 to 2010, compared to 2000 to 2005, based on 2000 GDP. For example, ">50% Down" indicates areas where ΔGDP from 2005 to 2010 was more than 50% of the 2000 GDP *less* than the ΔGDP from 2000 to 2005, and indicates those areas hardest hit by the financial and real estate bubble and subsequent collapse.

Ireland and Hungary, but also the UK and Spain, have experienced the most stagnation in their GDP in the latter half of the decade. Some of the GDP differences may be explained by currency fluctuations, as in the cases of the UK and Hungary, whose currencies suffered large crashes against the euro of 30-40% around 2008 (for a source, historical online currency exchange data was consulted); however, the currencies of other EU countries underwent similar crashes during that time, but unlike the UK and Hungary, the countries exhibited enough economic growth and their currencies recovered, at least enough to mask the decline. Meanwhile, Ireland, Greece, and Spain, all of which are euro users, were instead forced to undergo harsh austerity measures and accept bailouts from the EU. Either way, the growth those areas had in the first half of the decade was lost to a greater or lesser extent during the second half, whereas other countries, such as Poland, managed to exhibit sustainable growth over the decade. Hungary's poor performance during the second half of the decade may be due to factors peculiar to itself, and its location would appear not to be one of them.

Employed labor force (ELF) by sector: Below, in Figures 5a, 5b, and 5c, are a series of maps depicting the employed labor force by economic sector.

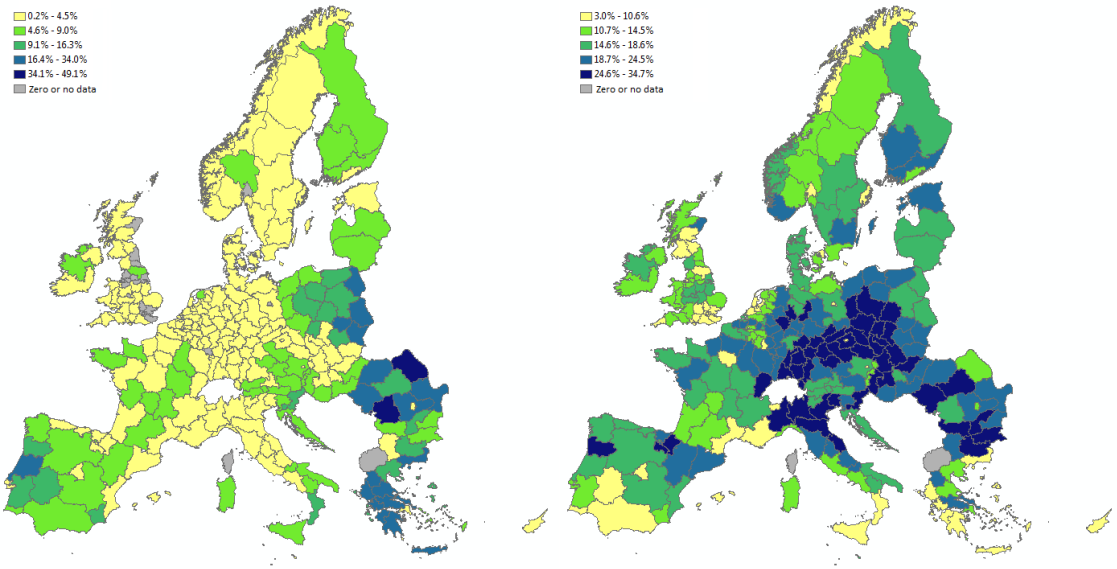


Figure 6a: Percentage employment in 2010 by economic sector: A (agricultural) and Ba (manufacturing and resource extraction).

As shown in Figure 6a, agricultural employment is uniformly low across most of the continent, generally less than 9%. However, pockets remain in Portugal, Poland, Romania, and Greece. It is also the most variable, with percentages ranging from near zero to near 50%. Manufacturing, on the other hand, appears to occupy large swaths of the middle of the continent, with major concentrations extending through southern Germany into central Poland, as well as northern Italy, with pockets of northern Spain, northern Portugal, Romania, and Bulgaria. Particularly notable is how in many countries, such as France, Spain, Italy, and Portugal, manufacturing employment is highest in the provinces closest to the European core, and quite low in the furthest provinces, leading to abrupt discontinuities at national boundaries (e.g. southern France versus northeast Spain and north Italy). This layout appears to be predicted by the von Thünen model, by which land use corresponds to that which most profitably produces a given product (in this case, manufactures), as well as by agglomeration effects predicted by Krugman's new economic models.

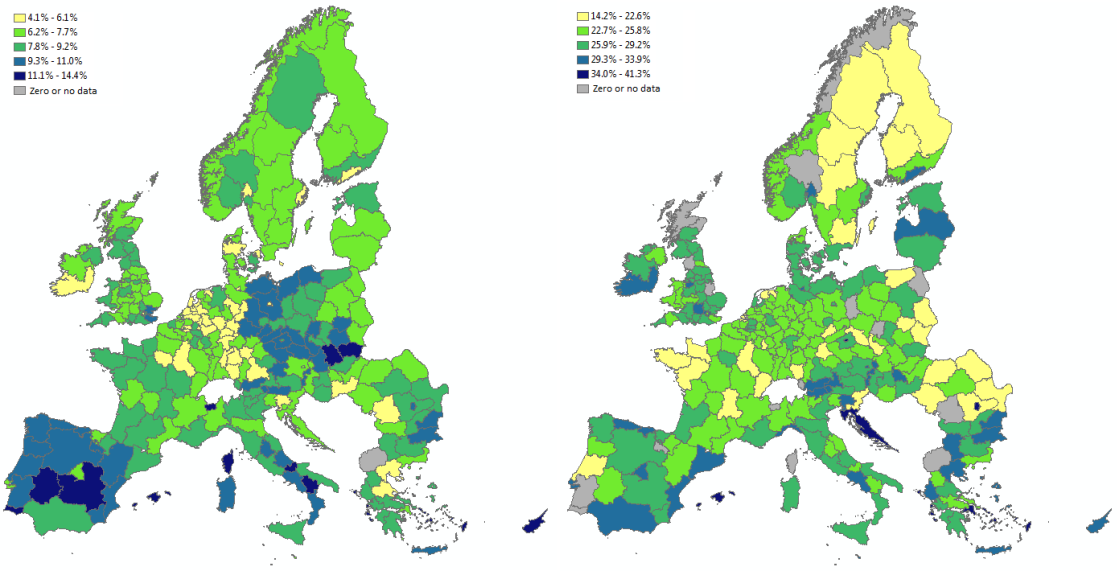


Figure 6b: Percentage employment in 2010 by economic sector: Bb (construction) and Ca (commerce).

The construction sector is separated from the rest of the manufacturing sector in the NACE classification. It is by far the smallest of the sectors considered here, not exceeding 14.4% of the workforce in any region. Notable pockets include Spain and Portugal, southern Italy, and a swath of Central Europe including the former East Germany, the Czech Republic, and Slovakia, in particular the portions of Central Europe closest to the former location of the Iron Curtain. As described below, the construction sector appears to be tied closely to the financial sector in exhibiting a boom-bust cycle over the decade; this is to be expected given the influence of finance on real estate, which accounts for much of the construction sector. Meanwhile, the commercial sector (defined in NACE Revision 2 as wholesale and retail trade, transport, accommodation and food service, and information and communication) is fairly evenly spread throughout the continent, although some tourist destinations such as coastal Spain, the Greek islands, and Dalmatia rank higher.

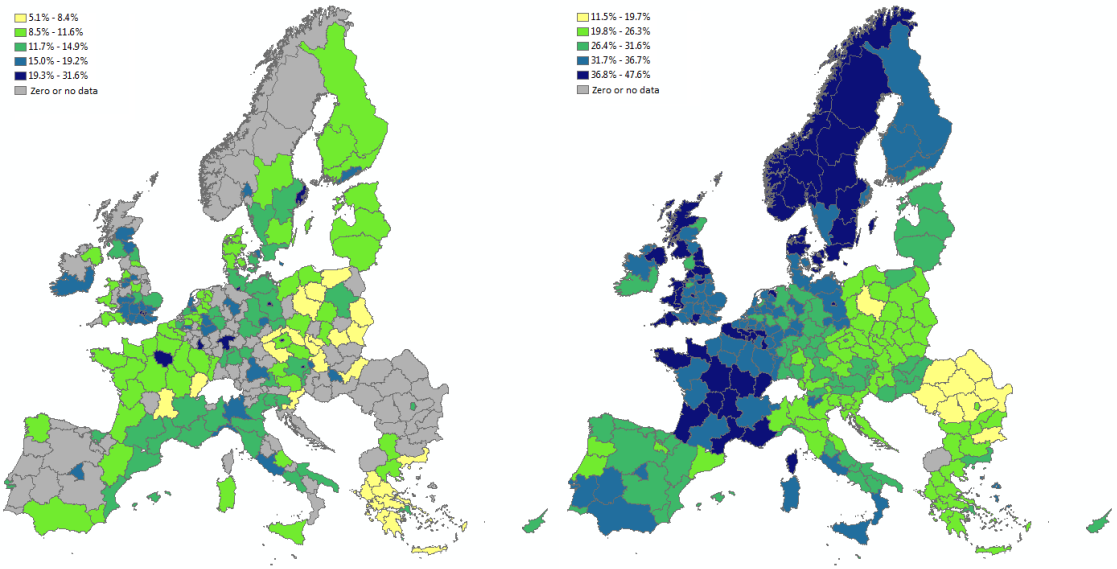


Figure 6c: Percentage employment in 2010 by economic sector: Cb (finance) and Cc (all other services).

The "financial" sector (defined in NACE Revision 2 as financial, insurance, real estate, professional, scientific, technical, administrative, and support service activities) is definitely more concentrated in moderate to large urban centers; many more rural NUTS2 regions have employment defined as not significantly different from zero (the gray areas on the map). This sector of the economy may expect to also involve much of the employment of transnational corporations, who will tend to conglomerate in "home base" areas with ready access to finance, law, and other businesses important for TNCs to operate across different states (Dicken 1998, pp. 193-199, 208-214). Lastly, the "other services" sector (defined as public administration and defense, education, health and human services, arts, entertainment, and recreation, and activities of households and extraterritorial organizations and bodies) is concentrated in certain Western European countries, including France, the UK, and Scandinavia, and reaches its lowest levels in the former Eastern Europe, especially Romania. As with the contagion effects above, a SAR model will be useful in capturing the spatial interdependence between sectors, although this would be bivariate or multivariate, rather than univariate as for measuring GDP contagion effects.

Fixed capital investment (FCI): The following maps in Figure 7 will depict ΔFCI for 2006-2005, the latest available timeframe, normalized to the percentage of the 2005 GDP, for each of the six sectors as for ELF, and using whole-country data.

The ΔFCI figures do appear to help provide an explanation as to the poor performance of Hungary's economy during the crisis; the manufacturing sector (Ba) in Hungary was not attracting as much investment as its neighbors, especially compared to the Ca (commerce) sector. The situation was very similar in the UK. To test this speculation robustly, a model comparing the growth of exports over the decade to FCI in manufacturing and/or Ba labor force over NUTS0 regions could prove useful.

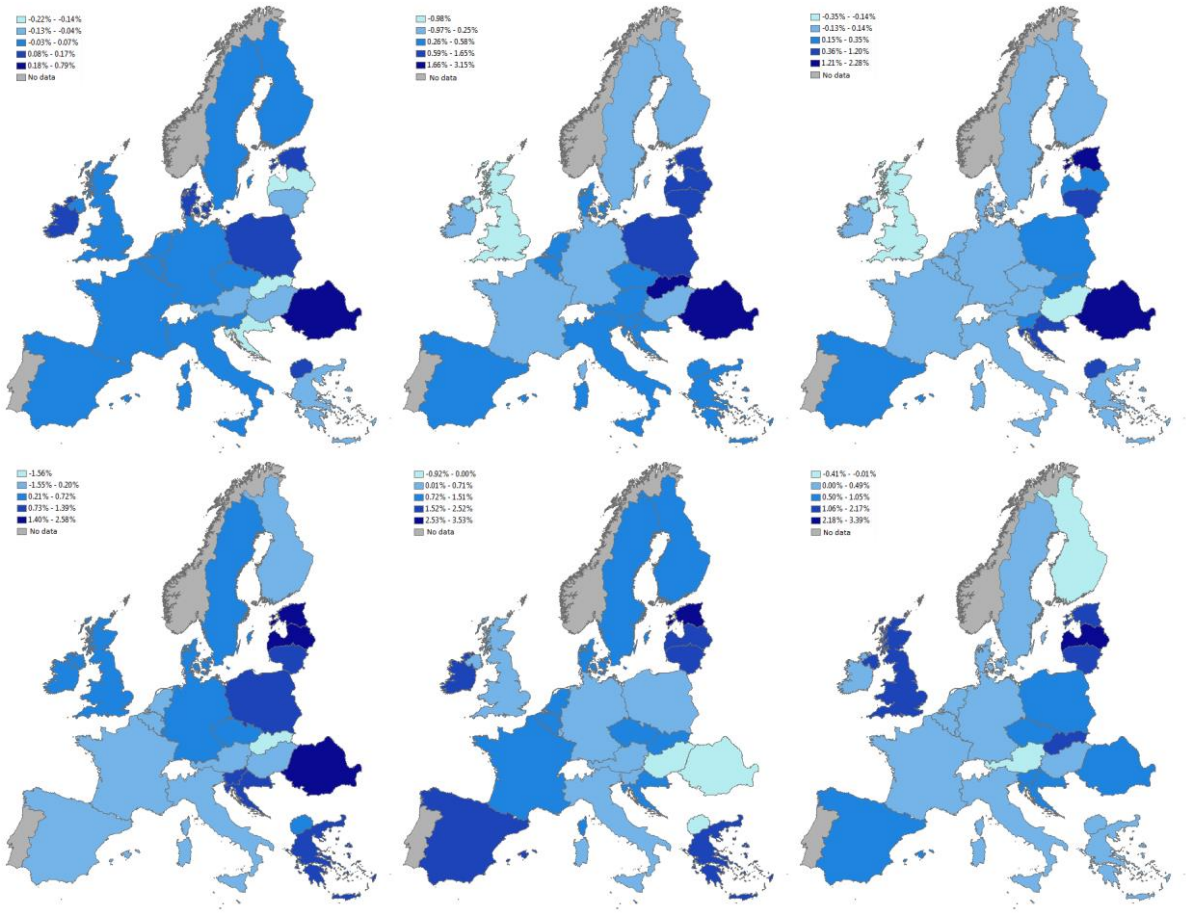


Figure 7: Change in fixed capital formation between 2005 and 2006 by economic sector, expressed as a percentage of 2005 GDP. Shown are A (top left), Ba (top center), Bb (top right), Ca (bottom left), Cb (bottom center), and Cc (bottom right).

Unemployed Labor Force (ULF): Figure 8a below shows the 2010 employment rate as a percentage of the employed labor force, for men and women, with Figure 8b showing the difference between male and female unemployment.

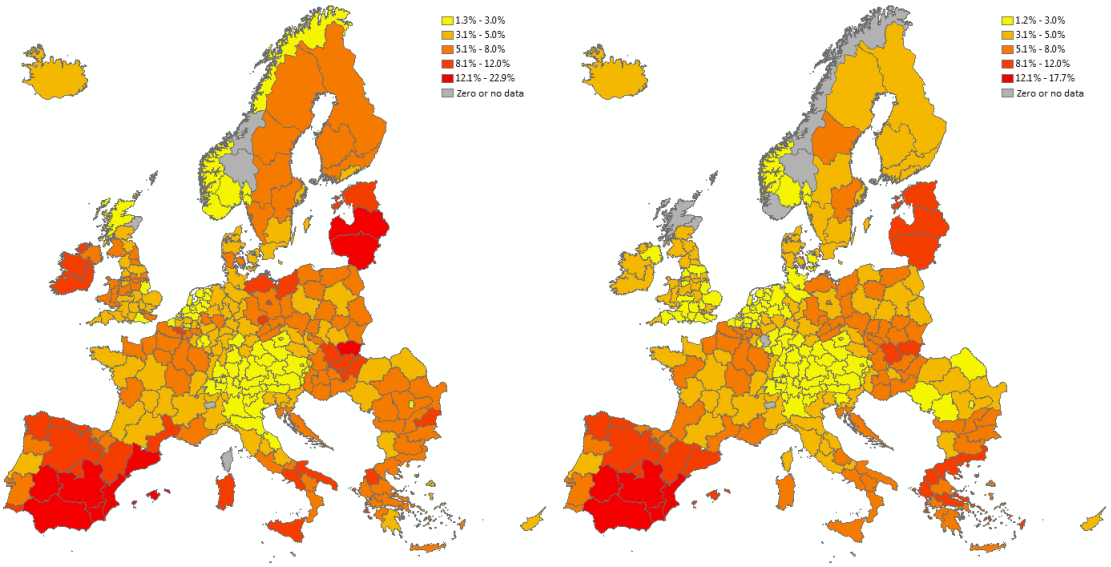


Figure 8a: 2010 unemployment rate measured as a percentage of the total *employed* labor force; for men (left) and for women (right).

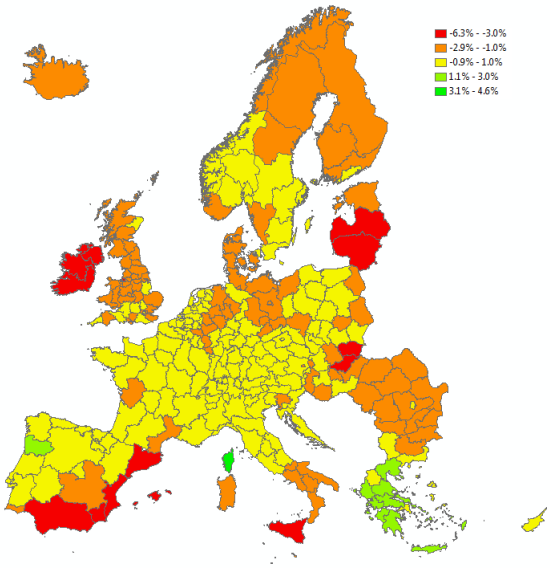


Figure 8b: Difference between 2010 unemployment rate of men and women. Yellow indicates approximate parity; red a higher male unemployment, and green higher female.

It is apparent that overall, the scourge of unemployment has affected more or less the same areas. Hotspots of unemployment include Spain, southern Italy, the Baltics, and parts of Slovakia and Hungary. In addition, unemployment is particularly bad for men in Ireland, the Baltics, and the Spanish coast, and for women in Greece. Generally, unemployment rates are higher for men than for women.

Trade Current Account (CA): Figure 9 shows the current account balance by country for 2001, 2005, and 2010:

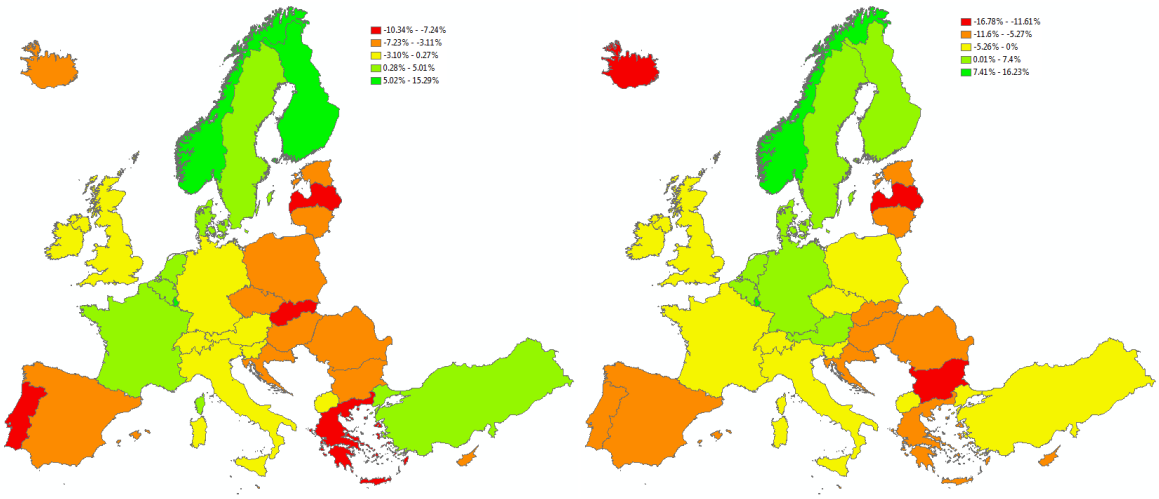
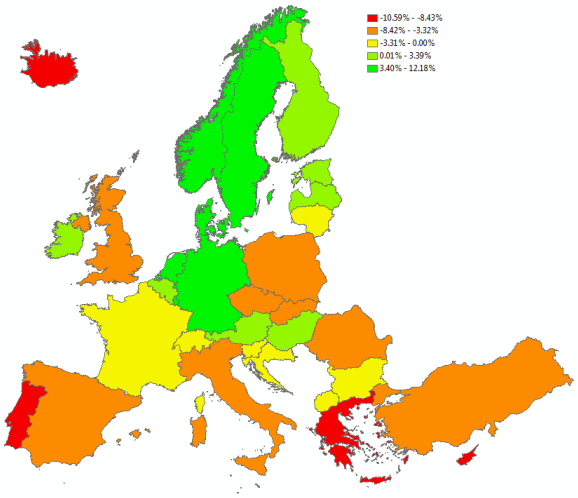


Figure 9: Current account balance expressed as a percentage of GDP, for 2001 (top left), 2005 (top right), and 2010 (bottom left).



Some countries with large trade deficits have them due to apparent economic strength, such as Poland and Turkey. With recessions, contradictory things happen. Sometimes, they decrease or vanish, as with Ireland and Hungary, but sometimes they worsen, as with Greece and Portugal. Germanic Europe (excluding the UK) exhibits trade surpluses more or less over the entire decade, and at the end of the period, it was economically the healthiest. A robust statistical link to this effect has not been proven in this research, but SAR models and observation of the effects of the increase in exports as discussed above may provide some clues.

Also, the effect of FCI investment in manufacturing appears to be exhibited in current-account export figures: exports from Hungary did double between 2001 and 2012 (from €44.9 bln to €99.6 bln), but they tripled from Poland (€64.0 bln to €191.6 bln) and Romania (€17.1 bln to €59.7 bln), and quadrupled from Slovakia (€17.8 bln to €72.1 bln). At the other extreme, exports from the UK increased less than 20% (from €685.9 bln to €814.3 bln) — the smallest increase in all of the countries in this dataset (which included, in addition, the USA and Japan).

Univariate Analysis: 2000-2010 Eurostat Normalized Per-Capita GDP data

Applying univariate Moran's I measurements to the regional normalized PCGDP data for the NUTS2 regions, using KNN4 weighting, that were consistent over the entire 2000 to 2010 time series, the following results are obtained, shown below in Figure 20.

When NUTS2 regions are considered rather than whole countries, the Moran's I is considerably higher in 2000, but also shows a slightly sharper drop between 2000 and 2009, a possible scale effect due to less smoothing of the data as with the whole-country data.

Between 2000 and 2010, Moran's I fell by 0.110 for countries, but by 0.164 for NUTS2 regions. The percentage drop, however, was closer — 26.8% for countries and 29.8% for regions. If a shapefile containing points representing NUTS2 region centroids instead of regions is used, the trend remains the same, with the only difference being that Moran's I is about 0.01 lower for each of the years; the percentage drop is slightly larger with points (30.5%) than with polygons (29.8%). If the 2008-2010 regions are added (for polygon data), Moran's I increases slightly by about 0.003 in each year; adding the two missing Italian regions to the 2010 data increases the 2010 Moran's I figure by an additional 0.0003.

One of the most interesting results from the NUTS2 regional data is that whereas the decrease in Moran's I for countries stopped in 2008 and backtracked in 2009, only starting to resume a decline in 2011, the regional data continued to show a robust decrease until 2009, with a slight backtrack in 2010 (NUTS2 2011 data is not yet available). What this entails exactly is unclear, but one possibility is that whereas the 2008 crisis affected specific countries more — such as Greece, Ireland, or Portugal — the 2010 increase in regional inequality was due more to lingering EU-wide economic malaise that was less specific to any given country.

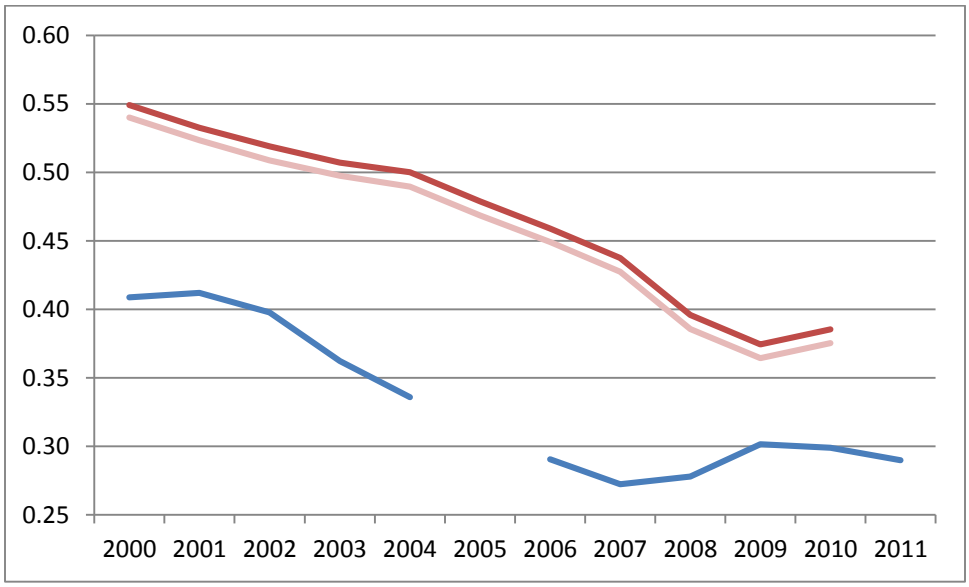


Figure 20: Comparison of Moran's I of normalized PCGDP for countries from Figure 2, shown in blue, with the same data for NUTS2 regions, shown in red. Pale red represents the same data as the solid red, except that a NUTS2 centroid point file is used instead of a polygon file as for the other two trends.

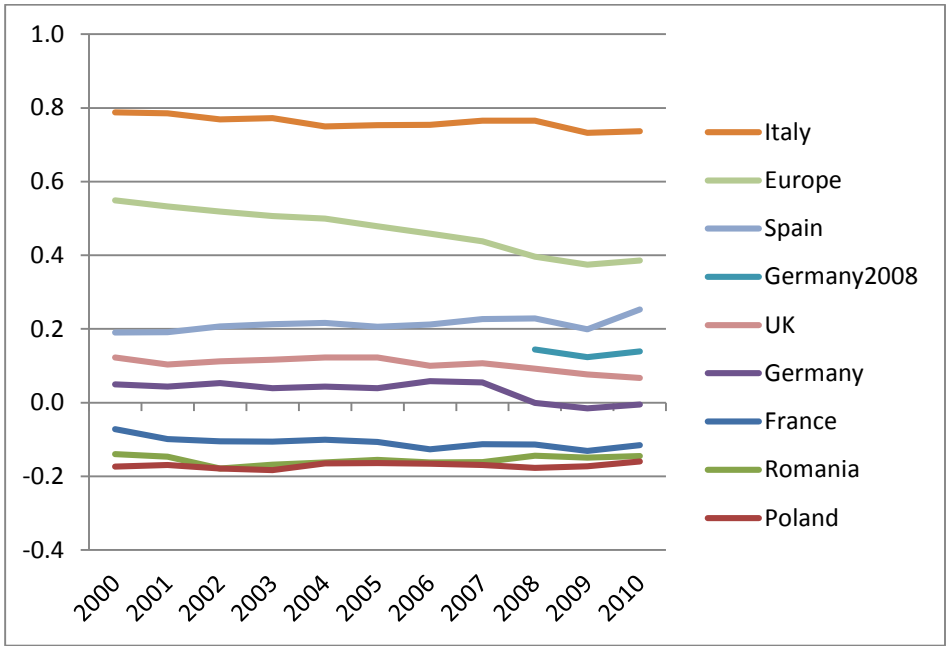


Figure 21: Comparison of Moran's I of normalized per-capita GDP for the NUTS2 regions of the largest European countries. "Germany" excludes Brandenburg and Saxony, for which data was unavailable until 2008; "Germany2008" includes the two missing former GDR states. "Italy" excludes Emilia-Romagna and Marche, for which data did not exist until 2010; the 2010 figure including the two missing states is 0.73.

In Figure 21, the Moran's I figures *within* selected countries are examined. Whereas the EU-wide Moran's I is positive and falling, the figure within countries is usually fairly close to zero and steady. In addition, the within-country data supports the 2010 rise in EU-wide Moran's I in Figure 20, as the Moran's I increased within all four countries. In fact, regional disparities in PCGDP are most severe not in Germany (its 2010 Moran's I is only 0.14, actually lower than Spain's) but in Italy, which has only declined about 10% from 0.79 to 0.74 since 2000, compared to a 30% drop from 0.55 to 0.39 for the whole EU. (Does Berlin suppress Germany's Moran's I? Not really; if Berlin is excluded, the 2010 figure increases only slightly, to 0.17.) The Moran's I figures in Spain and the U.K. are actually comparable to Germany's, with Spain's figure showing a rise over the course of the decade and the U.K.'s a drop. France, Poland, and Romania are notable for their negative Moran's I figure, suggesting that a richer than average region in those countries is actually more likely to border a poorer than average region than another richer one, and vice versa. The lack of a regional disparity in Poland and Romania seems to answer one of the research questions — whether increased PCGDP spreads spatially *within* each of the former Soviet Bloc countries — in the negative.

Univariate LISA was performed on the model of normalized PCGDP, again with KNN4 weighting, with the results shown below as cluster maps in Figures 11a through 11c. Data for the Canaries, Azores, and Madeiras are included but not shown on the maps (in all cases, their data are not significant outliers). So as to make a direct comparison between 2000 and 2010, Figures 11a and 11b include data for only those NUTS2 regions for which NPCGDP data was available in 2000 (excluding the states in Italy and former East Germany, as well as Norway), whereas Figure 22c displays 2010 data for all NUTS2 regions available in 2010.

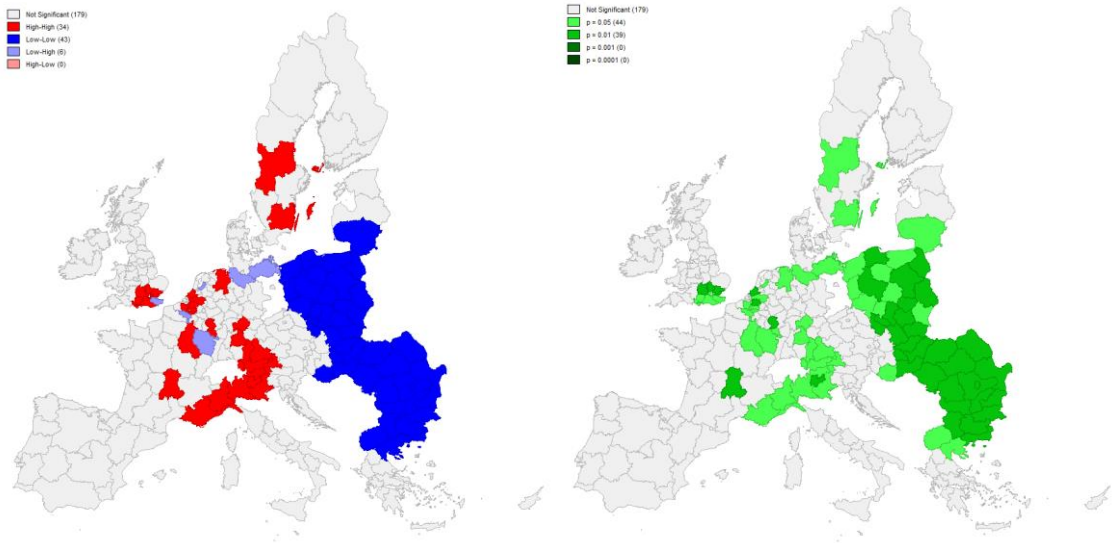


Figure 22a: Univariate LISA (using KNN4 weighting) of normalized per-capita GDP for all available NUTS2 regions in 2000.

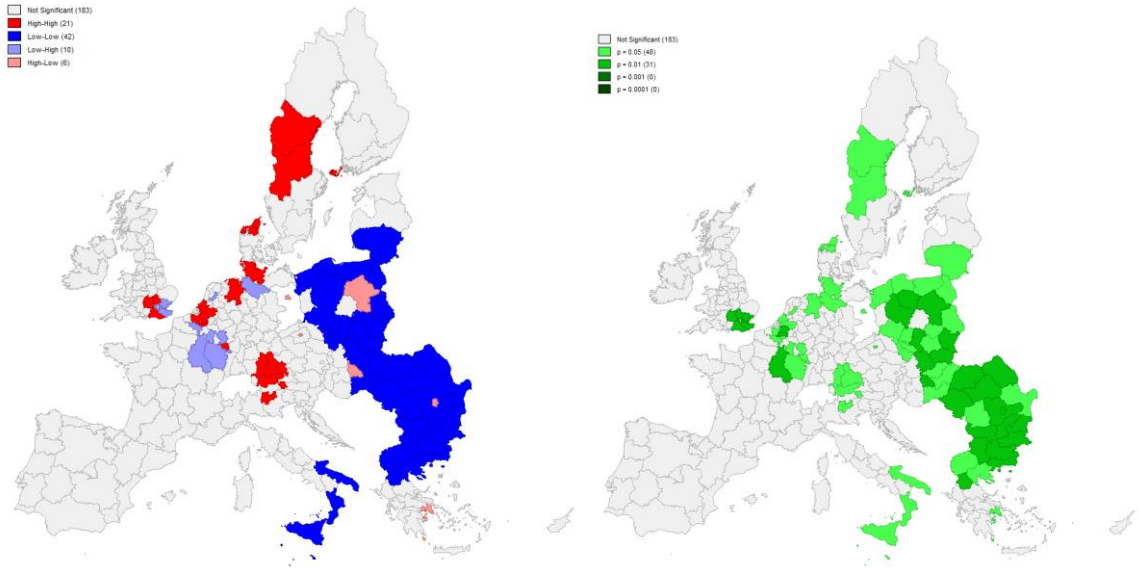


Figure 22b: Univariate LISA of normalized per-capita GDP for all NUTS2 regions for which 2000 data is available (as in Figure 22a) in 2010.

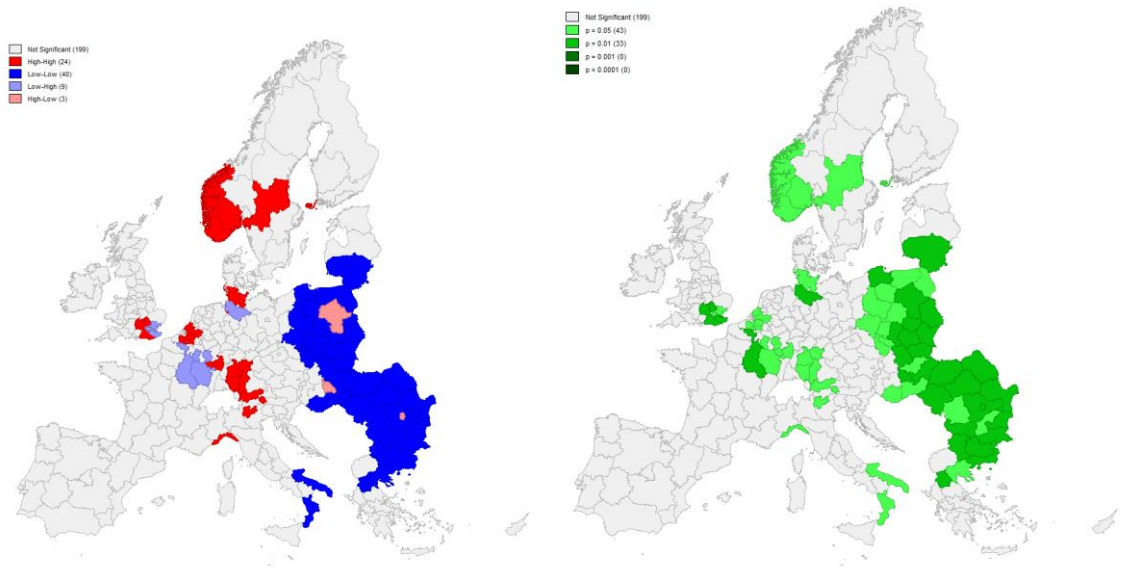


Figure 22c: Univariate LISA of normalized per-capita GDP for all available NUTS2 regions in 2010.

The results alter the point about Poland and Romania found earlier. While the maps do appear to weakly show that rising PCGDP spreads from west to east, the more important effect on PCGDP is in the capital regions, which benefit the most. Whereas in 2000, most of Eastern Europe was solid blue "low-low," with the exception of Estonia, Latvia, most of the Czech Republic, and parts of western Slovakia and Hungary, by 2010, the NUTS2 regions containing several *capital cities* in Central Europe, including Warsaw/Masovian Voivodeship, Budapest, and Bucharest, were "high-low," i.e., unusually high PCGDP surrounded by poorer regions. (Berlin, Prague, and Athens/Attica were also "high-low" in the restricted data excluding regions that lacked 2000 data, but not the full data.) Also, whereas the "low-low" area did not shrink all that much between 2000 and 2010, with the exception mostly of those NUTS2 regions containing the abovementioned capitals, the significance worsened above $p = 0.01$ in many of the "low-low" regions. For example, Romania and Bulgaria were entirely "low-low" *and* $p < 0.01$ in 2000, but not by 2010. This result suggests that rather than a west-east spread of higher PCGDP, there exists a hierarchical bleeding-down of higher PCGDP starting in the capital cities and spreading to the smaller cities and towns, with the countryside improving last. Again, this will be more fully explored with a SAR model.

On the other hand, PCGDP declined in many areas in Western Europe. As the former Soviet bloc countries' areas of extreme poverty eroded, parts of the southern Italian *Mezzogiorno* started to appear as "low-low" on the 2010 maps. "High-high" areas in southern France, southern England, and northern Italy mostly vanished between 2000 and 2010, and "low-high" areas spread in northeastern France and Wallonia, and southeastern England. Thus, despite the economic crisis in Greece, Ireland, Portugal, and Spain, the slow-motion evolution over the entire past decade appears to actually have been harder on France, Italy, and the UK.

To confirm this, one final LISA was performed, on the difference between the 2010 and 2000 values of normalized PCGDP (again, excluding the regions for which 2000 data is unavailable). Note that the colors are reversed for the most part, as the lowest PCGDP regions

have tended to show the greatest rise over the ten years. The erosion of the PCGDP standing of France, Italy, and the UK are confirmed, and indeed, appear more obvious, especially in the UK, although London, Paris, and (to an extent) Brussels are "high-low" areas that have actually improved their standing relative to the surrounding areas. The rise of Eastern European PCGDP is also confirmed. Meanwhile, Lower Austria and Vienna, and Greek Macedonia, are "low-high" areas next to former Communist areas to which that they no longer appear as relatively wealthy.

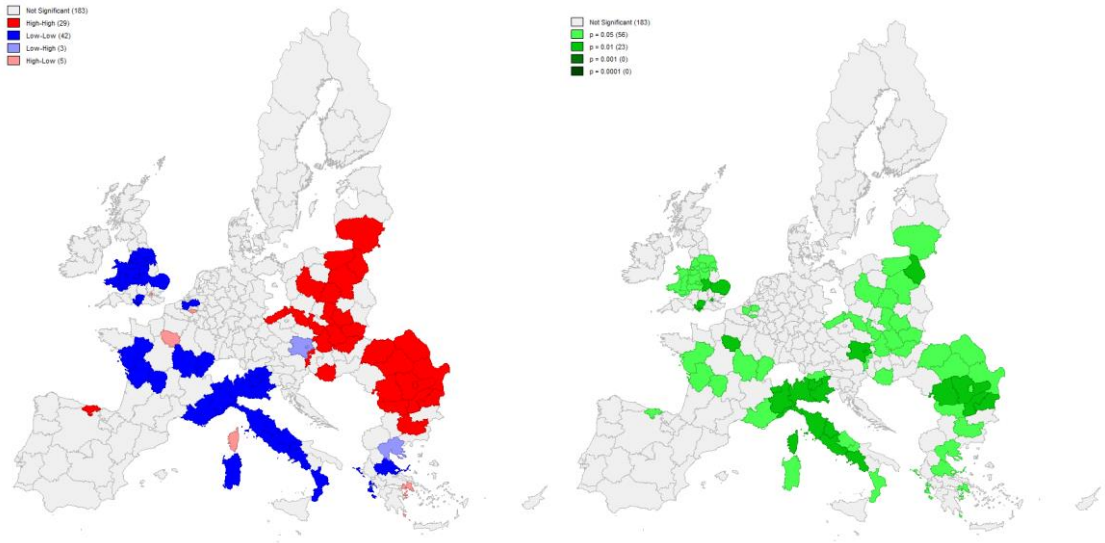


Figure 22d: Univariate LISA of the difference in 2010 and 2000 normalized per-capita GDP for all NUTS2 regions for which 2000 data is available. Blue indicates a significant drop in PCGDP relative to the EU average over the decade, red indicates a rise.

1) There does indeed appear to be a distance effect, as shown above in Figure 22d. However, the details were unexpected; rather than being centered in the countries on the periphery that have been famously suffering from sovereign debt troubles, the relative decline appears to instead be centered in areas that used to be closer to the EU core and are now closer to the periphery — namely, France, Italy, and the UK. The new part of the EU, meanwhile, has benefitted. Countries in the periphery both then and now, such as Iberia, and in the physical core both then and now, such as western Germany (or arguably both, such as Scandinavia), have not changed all that much.
2) There is confirmation of the diffusion of economic growth in the new Eastern countries over time. The configuration, however, appears to be much more hierarchical than from west to east, with Eastern capital cities increasing their standing the most. From an examination of Figures 11c and 11d, though, a small west to east effect may still exist in that southeastern Poland and northeastern Romania, which are the most remote both from western Europe and their own capital cities, have increased less than the rest of the region. (As for the former East Germany, there is a lack of data for Brandenburg and Saxony. While Figure 21 suggests that it has already received its benefit from joining with West Germany before 2000, and has

shown no significant relative improvement over the past decade, Figure 5a suggests continued improvement.)

The next question is: why? What exactly is happening? In other words, what are the *processes* producing these effects? To answer this, other factors beyond only normalized PCGDP will be considered, expanding upon what was touched on earlier with the 1996 Eurostat data above, and thereby attempt to identify the processes by which PCGDP rises or falls over time. Bivariate Moran's I and LISA measurements and non-spatial regression models will be the method of choice in this quest.

Bivariate and Multivariate Analysis: Nonspatial Regression

1996 Eurostat data: This more restricted dataset suggests a preliminary non-spatial regression model of per capita GDP:

$$NPCGDP_i = \beta_0 - \beta_1 AgEmp_i + \beta_2 IndEmp_i - \beta_3 MUnemp_i - \beta_4 FUnemp_i + \varepsilon_i$$

where the signs simply indicate direct or inverse correlation between NPCGDP and the variable specified. Once a linear regression is performed (perhaps using SAS), a spatial component may be added to create a MRSA model, and the betas tweaked further. In a case where nonstationarity in the data is significant, GWR may be applied to further refine the model.

The 1996 data shows that the strongest indicators of successful development, and hence a rising per capita GDP, appear to be a falling female unemployment and falling employment in agriculture. Rising industrial employment and falling male unemployment are also indicative, but it would seem at a considerably weaker level. In addition, there could be other societal problems in a hypothetical situation where the male unemployment is higher than female (cf. the terms "man-cession" and "he-cession" applied to the Great Recession in the United States), so that metric should be monitored as well. Correlation does not necessarily mean causation, and in fact, Erik Reinert makes a convincing case for industrial employment causing high GDP, yet its correlation is weak here. Nevertheless, the correlations do seem to uncover interesting trends as far as the prosperity of different regions goes.

2000-2010 Eurostat data: The 1996 dataset, however, suffers in that, while it does show two strong *negative* correlations between PCGDP on the one hand and female unemployment and agricultural employment on the other, it does not seem to show any strong *positive* correlations. The 2000-2010 Eurostat dataset, in contrast, affords the opportunity to find such strong positive correlations. To help answer the research questions more fully, variables that would show this must be considered. For the dependent variable, ΔGDP, or the change in total GDP over a time period (usually one year), is considered, as opposed to consideration of NPCGDP in the univariate analysis and in the restricted 1996 Eurostat dataset. Meanwhile, ΔGDP was selected over ΔNPCGDP because the NPCGDP data is only expressed as whole numbers, making any ΔNPCGDP data too coarse.

OLS regressions on ΔGDP were performed using several different variables. The first independent variable was the employed labor force, henceforth "ELF" (as well as ΔELF); the

second was the change in fixed capital investment, or "ΔFCI"; the third was the change in current accounts, or "ΔCA"; and the fourth was unemployed labor force, or "ULF". Two different OLS regressions were performed with each variable setup, one with all-Europe data including Eastern European countries, and the other restricted to the Eurozone.

Employed Labor Force: ELF was the most complete, with data covering the entire decade from 2000 to 2010, and including NACE subsets as described above in the Data section. Comparing ΔGDP with ELF was done in the hopes of identifying sectors of the economy that are more dynamic or more stagnant. Whereas the 1996 Eurostat data only included agriculture, industry, and services as a whole, the NACE subsets are more comprehensive, and should provide answers as to, for example, which kinds of services are more important in a dynamic developed economy versus those that exist in any economy of whatever level of development.

Table 4: OLS regression of ΔGDP (millions of euros) versus ELF (thousands of persons) for start year by NACE economic sector

Formula: $\Delta GDP(t-1,t) = \beta_0 + \beta_A ELF_A + \beta_{Ba} ELF_{Ba} + \beta_{Bb} ELF_{Bb} + \beta_{Ca} ELF_{Ca} + \beta_{Cb} ELF_{Cb} + \beta_{Cc} ELF_{Cc} + \varepsilon$, where ELF(t–1)

All Europe:

Year	β_0 (t value)	β_A (t)	β_{Ba} (t)	β_{Bb} (t)	β_{Ca} (t)	β_{Cb} (t)
	β_{Cc} (t)	Adj. R^2	MCN	Moran's I		
2000-01	89 (0.61)	–0.31 (–0.39)	0.67 (0.59)	9.78 (1.84)	**6.32 (2.14)**	**9.64 (3.61)**
	–5.31 (–2.94)	0.519	19.92	0.182		
2001-02	**313 (2.55)**	–0.90 (–1.35)	**–2.35 (–2.57)**	**11.04 (2.41)**	**5.80 (2.09)**	**13.28 (6.10)**
	–6.07 (–4.19)	0.602	22.78	0.169		
2002-03	–262 (–1.50)	–0.68 (–0.59)	–0.50 (–0.41)	**23.04 (3.68)**	–0.71 (–0.19)	**6.43 (2.13)**
	–3.04 (–1.52)	0.282	23.47	0.536		
2003-04	**663 (4.42)**	–0.72 (–0.72)	**–3.37 (–3.11)**	**13.70 (2.70)**	4.98 (1.53)	**13.46 (5.46)**
	–4.71 (–2.90)	0.575	22.93	0.193		
2004-05	312 (1.90)	**4.52 (3.69)**	**–6.66 (–5.65)**	5.42 (0.97)	**9.57 (2.49)**	**17.68 (6.82)**
	–6.13 (–3.33)	0.622	25.37	0.019		
2005-06	**614 (4.38)**	0.45 (0.41)	–1.34 (–1.25)	**24.10 (5.15)**	**–6.77 (–2.06)**	**16.81 (7.46)**
	1.08 (0.68)	0.709	25.77	0.062		
2006-07	**550 (2.58)**	**6.37 (3.72)**	–2.26 (–1.43)	–3.63 (–0.57)	–2.58 (–0.58)	**43.79 (13.21)**
	–5.32 (–2.20)	0.762	23.94	0.038		
2007-08	**–1486 (–3.84)**	1.61 (0.52)	**5.75 (2.02)**	**–60.65 (–5.35)**	**47.53 (5.78)**	**–23.26 (–4.02)**
	–9.72 (–2.40)	0.227	25.43	0.623		
2008-09	**–1649 (–7.42)**	0.85 (0.37)	–0.43 (–0.23)	**–23.60 (–2.35)**	**12.94 (2.31)**	**–30.25 (–7.83)**
NACE R1	4.60 (1.81)	0.415	25.52	0.452		
2008-09	**–1104 (–4.28)**	0.69 (0.33)	–1.74 (–0.96)	1.39 (0.19)	–1.36 (–0.33)	**–15.25 (–4.48)**
NACE R2	0.39 (0.17)	0.427	21.37	0.565		
2009-10	**908 (3.78)**	2.74 (1.48)	**9.12 (5.62)**	**–46.32 (–5.83)**	–6.11 (–1.85)	**22.42 (7.35)**
	8.57 (3.87)	0.577	20.18	0.303		

Eurozone Only:

Year	β_0 (t value)	β_A (t)	β_{Ba} (t)	β_{Bb} (t)	β_{Ca} (t)	β_{Cb} (t)
	β_{Cc} (t)	Adj. R^2	MCN	Moran's I		
2000-01	**375 (2.50)**	–0.32 (–0.10)	–0.37 (–0.33)	3.88 (0.71)	**9.72 (3.30)**	**11.10 (3.70)**
	–6.31 (–3.66)	0.687	20.22	0.280		
2001-02	**314 (2.01)**	–0.63 (–0.20)	**–3.17 (–2.93)**	**13.05 (2.11)**	**7.99 (2.23)**	**14.87 (4.69)**
	–8.30 (–4.87)	0.655	24.57	0.171		

2002-03	132 (0.93)	0.65 (0.21)	**–4.19 (–4.42)**	9.09 (1.63)	**12.28 (3.64)**	**10.20 (3.74)**
	–8.57 (–5.63)	0.676	26.01	0.331		
2003-04	**488 (2.89)**	–5.22 (–1.53)	–2.01 (–1.73)	**12.92 (2.17)**	**7.98 (2.15)**	4.89 (1.66)
	–3.54 (–2.05)	0.610	24.58	0.259		
2004-05	**389 (2.29)**	–7.04 (–1.93)	**–8.79 (–7.53)**	**20.50 (3.26)**	6.93 (1.67)	**15.43 (5.28)**
	–4.50 (–2.53)	0.743	28.15	0.200		
2005-06	**737 (4.56)**	**–13.99 (–3.78)**	–2.03 (–1.72)	**31.61 (5.52)**	–4.27 (–1.09)	**11.35 (4.01)**
	1.41 (0.83)	0.776	28.13	0.126		
2006-07	**680 (2.47)**	5.14 (0.82)	**–6.34 (–3.20)**	6.41 (0.75)	–9.24 (–1.57)	**50.86 (11.14)**
	–3.42 (–1.14)	0.793	25.44	0.030		
2007-08	44 (0.19)	–1.18 (–0.22)	–2.33 (–1.45)	**–23.65 (–3.24)**	**16.70 (3.16)**	7.44 (1.91)
	–3.97 (–1.70)	0.483	29.11	0.153		
2008-09	–311 (–1.62)	4.14 (0.83)	**–7.32 (–5.11)**	–6.86 (–0.85)	4.13 (0.92)	**–12.43 (–3.61)**
NACE R1	1.39 (0.72)	0.606	28.03	0.147		
2008-09	–308 (–1.47)	4.63 (0.97)	**–8.10 (–5.56)**	4.63 (0.71)	–0.82 (–0.23)	**–9.38 (–3.02)**
NACE R2	0.81 (0.44)	0.591	23.69	0.162		
2009-10	20 (0.09)	1.78 (0.37)	**13.53 (8.73)**	**–59.34 (–7.20)**	0.05 (0.01)	**12.70 (3.84)**
	8.48 (4.16)	0.706	23.96	0.012		

A t value higher than 1.97 is significant at the 5% level for a two-tailed test with 256 (Europe-wide) or 159 (Eurozone only) degrees of freedom. Significant positive are in **bold black**, significant negative in **bold red**. For 2008-09, NACE R1 and R2 refer to the two different NACE revisions, with the newer one coming online in 2008; 2008 includes both revisions, those up to 2007 use Revision 1, and those from 2009 on use Revision 2. "MCN" is the multicollinearity condition number.

The results from Table 4 capture the effects of the sizes of the labor force in each sector of the economy on economic growth, and how they fared before and during the Great Recession. The intercept β_0 should theoretically be frozen at zero, as having no labor force at all means no economy (or economic growth), but GeoDa does not allow this. Sector A (agriculture) is usually insignificant for both Europe as a whole and the Eurozone, as is to be expected. Sectors Bb (construction) and Cb (finance) showed the greatest signs of being in a bubble, as they are correlated most strongly with sharp growth during the early 2000s boom, but they crashed hard during the Recession, and Bb in particular is still contracting. Ba (manufacturing) and Cc (health, education, and recreation) have been the most negative *relative* performers, especially within the Eurozone where they may have been hurt by the strong euro, but both seem to have suffered less during the Recession and even to be showing robustness for the most recent period (2009-10). Lastly, Ca (commerce) has on the whole shown a correlation with healthy yet moderate growth throughout the period.

Thus, when considering robust development, sectors which provide good growth prospects and are relatively unsusceptible to bubbles — which, according to this test, are Ba, Ca, and perhaps Cc — appear to be the way to go. It would collaborate the classical models of development, where a country builds a manufacturing base, followed by a commercial sector, before finally moving into finance. Unfortunately, the financial sector, while providing the power of money, also has a major downside in being vulnerable to bubbles and crashes, and governments then feel obliged to rescue it with horrendously expensive bailouts.

Multicollinearity is very high, due apparently to overlap between the various sectors. Also, the R^2 of the equation is roughly negatively correlated with the Moran's I of a KNN4 weighting

matrix of the data; R^2 rises as high as nearly 0.8 in Eurozone-only 2006-07 data when the Moran's I falls close to zero. R^2 is generally lower for the Europe-wide data, in particular for 2002-03 and 2007-08, and in both cases, Moran's I exceeded 0.5.

Fixed Capital Investment: FCI also includes NACE subsets, but is more restricted in scope, as France has failed to report any data (whether whole-country or NUTS2) after 2006, and Germany was missing NUTS2 data for some of its eastern states until 2002, leaving a fairly restricted four-year range from 2002 to 2006, which unfortunately will miss the effects of the Great Recession at a Europe-wide NUTS2 level. The correlation between ΔFCI and ΔGDP should be more airtight, as if an economy is growing, investment in new businesses and equipment for them should also increase. As with the employed labor force data, examining different NACE economic classifications should prove useful as to discovering which economic sectors are attracting more investment and helping to boost the economy.

Table 5: OLS regression of ΔGDP versus ΔFCI (millions of euros) and ELF for start year

All Europe:

Year	β_0 (t value)	$\beta_{\Delta FCI}$ (t)	β_{ELF} (t)	Adj. R^2	MCN	Moran's I
2002-03	–498 (–3.18)	0.63 (5.84)	1.53 (9.39)	0.312	2.65	0.439
2003-04	240 (1.61)	0.48 (5.12)	1.98 (12.16)	0.471	2.91	0.305
2004-05	–227 (–1.32)	0.28 (2.71)	2.53 (13.47)	0.478	2.93	0.077
2005-06	342 (2.52)	0.43 (7.14)	2.21 (13.06)	0.669	3.51	0.083

Eurozone only:

Year	β_0 (t value)	$\beta_{\Delta FCI}$ (t)	β_{ELF} (t)	Adj. R^2	MCN	Moran's I
2002-03	–249 (–1.67)	0.50 (4.81)	2.00 (13.87)	0.563	2.43	0.258
2003-04	281 (1.86)	0.38 (4.44)	1.94 (12.63)	0.593	2.62	0.162
2004-05	–219 (–1.16)	0.40 (3.83)	2.34 (11.94)	0.579	2.69	0.130
2005-06	393 (2.57)	0.36 (5.71)	2.34 (13.07)	0.743	3.22	0.100

A t value higher than 1.97 is significant at the 5% level for a two-tailed test with 256 (Europe-wide) or 160 (Eurozone only) degrees of freedom.

This model does not consider different economic sectors of the ELF as done before in Table 4. Again, the intercept β_0 appears to be irrelevant, with t values usually insignificant at the 5% level, and in this case, less significant than in Table 4, where it does seem to vary with economic growth — which means the ELF-only model is insufficient. This model indeed shows that ΔFCI and ELF are both correlated with economic growth. In addition, R^2 and Moran's I exhibit their inverse relationship again, with the former rising over the period and the latter sinking. As before, R^2 was higher for the Eurozone-only data. Multicollinearity was low, but rose over the time period along with R^2. A Moran's I significantly different from zero meanwhile suggests spatial effects that warrant usage of a SAR or GWR model.

Current Accounts: CA, the current account data, was used as a proxy for trade, as it includes data on exports and imports; Eurostat did include statistics on exports and imports, but only for trade outside of the Eurozone. CA was more restricted in that only full-country data was available, but on the other hand, the timescale included was wider than for FCI, extending from 2003 to 2010. The correlation between ΔGDP and ΔCA should be quite obvious in the case of imports — a wealthy, growing economy would be expected to increase

consumption of imports — but for exports, it should be more complex. Because exports involve selling products to other countries and repatriating profits, a country that has a strong export base should be able to maintain economic growth better than one which posts chronic trade deficits, and weather economic difficulty better. Thus, while normally imports would correlate more closely with ΔGDP, when economic difficulties appear (as in the latter part of the 2000s decade), exports should show a better correlation than otherwise.

Table 6: OLS regression of ΔGDP versus ΔCA for exports and imports (billions of euros)

Year	β_0 (t value)	$\beta_{\Delta CA(exp)}$ (t)	$\beta_{\Delta CA(imp)}$ (t)	Adj. R^2	MCN	Moran's I
2003-04	–4090 (–1.83)	**–514 (–3.45)**	**2222 (10.59)**	0.876	5.06	0.110
2004-05	6058 (1.83)	**–1094 (–2.53)**	**1608 (3.91)**	0.571	11.37	–0.032
2005-06	1997 (0.94)	**–508 (–2.55)**	**1215 (5.89)**	0.894	12.13	–0.006
2006-07	976 (0.23)	396 (1.08)	760 (1.72)	0.719	9.56	–0.052
2007-08	–892 (–0.41)	264 (0.85)	**1559 (6.24)**	0.941	6.20 (extreme)	–0.174
2008-09	4652 (0.88)	244 (0.69)	506 (1.43)	0.742	12.62	0.205
2009-10	1523 (0.40)	**–1403 (–4.39)**	**2167 (6.76)**	0.770	9.60	0.048

A t value higher than 2.04 is significant at the 5% level for a two-tailed test with 29 degrees of freedom. Significant positive values are in **bold black**, significant negative in **bold red**.

According to the current-accounts test, usually, increasing imports are positively correlated with economic growth, and increasing exports, ironically enough, negatively correlated. (Would this perhaps be because exports reflect a lack of demand at home?) During the Great Recession between 2006 and 2009, however, increases in trade were insignificant.

Unemployed Labor Force: The dataset for the unemployed population included subsets for certain age groups and the two sexes. Here, total data was used, along with data by sex as with the preliminary 1996 study. As for the ELF dataset, data was available in most cases for all of the years needed (2000 to 2010) as well as at the NUTS2 level. Unemployment is negatively correlated with economic health, confirmed in the 1996 dataset, and thereby provides another clue as to the structure of the European economy.

Table 7: OLS regression of ΔGDP versus ΔULF for males and females (thousands of persons)

Year	β_0 (t value)	$\beta_{\Delta ULF(M)}$ (t)	$\beta_{\Delta ULF(F)}$ (t)	Adj. R^2	MCN	Moran's I
2000-01	**1192 (9.87)**	8.90 (0.56)	**–68.92 (–4.21)**	0.114	2.99	0.090
2001-02	**1160 (9.77)**	27.05 (1.79)	30.07 (1.54)	0.022	1.56	0.073
2002-03	**552 (4.83)**	**81.16 (4.25)**	–32.74 (–1.57)	0.069	2.13	0.314
2003-04	**1786 (13.66)**	**–43.24 (–2.13)**	**46.12 (2.39)**	0.016	1.99	0.207
2004-05	**1529 (10.46)**	**–120.45 (–4.83)**	18.09 (0.86)	0.091	2.00	0.082
2005-06	**2132 (13.64)**	**–95.20 (–3.25)**	**95.42 (3.02)**	0.032	3.15 (extreme)	0.097
2006-07	**2127 (7.80)**	85.41 (1.75)	**–204.43 (–4.02)**	0.065	3.54	0.034
2007-08	54 (0.22)	**66.39 (1.98)**	**–165.20 (–3.22)**	0.036	3.42	0.670
2008-09	**–2059 (–9.90)**	–38.14 (–1.34)	–14.44 (–0.31)	0.095	7.86	0.477
2009-10	**2096 (10.48)**	**–146.47 (–4.27)**	**123.68 (3.29)**	0.056	3.08	0.215

A t value higher than 1.97 is significant at the 5% level for a two-tailed test with 272 degrees of freedom. Significant positive values are in **bold black**, significant negative in **bold red**.

Unemployment change, ΔULF, should be negatively correlated with ΔGDP; if ΔGDP is positive, one would hope that ΔULF is negative, and if an economy is in a recession and ΔGDP is negative, ΔULF would be expected to be positive. The reality is more complex —— the R^2 is very low —— and seems to differ between the sexes. For men, the expected result occurs in the middle of the decade and for 2009-10, when economic growth is fairly robust, whereas for women, it is the exact opposite. Perhaps women have cultural expectations for being homemakers in many European countries, and tend to work more during hard times when their husband is out of a job, and then less again when economic growth resumes, although this is pure speculation at this point.

Chapter 7: Discussion

The first measurement, the Moran's I of the NPCGDP of the 2004 European Union members, showed a sustained drop between 2001 and 2007 from 0.41 to 0.27, with the Great Recession that slammed many European currencies in 2008 forcing it back up to 0.30 in 2009, but since then, it has resumed a decline, albeit more slowly than earlier in the decade. This result is consistent with expectations that during "normal" times, the economic union will trend toward uniformity, i.e., a Moran's I of zero, whereas during economic crises, the countries with the weakest financial and commercial sectors will suffer relatively more, causing inequality and therefore Moran's I to increase. But overall, at the national level, convergence is occurring within the European Union, so long as major economic crises such as the sovereign-debt crisis in Greece and Portugal and the banking crisis in Ireland can be successfully contained.

For the weighting matrices at the NUTS2 level, KNN4 showed the most robust results, as shown in Figure 3, in preference to a connectivity matrix, such as queen or rook connectivity, which would exclude island areas from consideration vis-à-vis the main European landmass, even if orders higher than first are considered. The distance weighting scheme showed by far the weakest results, much worse than either the connectivity or nearest-neighbor matrices. Therefore, for the rest of this analysis, a fourth-order KNN connectivity matrix was used for those models in which a weighting matrix is used.

The 1996 Eurostat data was examined both by LISA, as well as via bivariate Moran's I, for the available variables: NPCGDP, agricultural, industrial, and services employment, male and female unemployment, and population density. LISA indicated that NPCGDP was highest in the core and unemployment lowest, with the opposite in the periphery as expected, but that industrial employment and population density showed weak correlation with core status. The bivariate Moran's I results likewise indicated that NPCGDP had no correlation at all with services employment or population density, a weak positive correlation with industry, and a strong negative with agriculture and unemployment, with female unemployment being somewhat stronger negative than male. Unfortunately, none of these covariances with NPCGDP were strongly positive, but the link with industry was nevertheless compelling, and was consistent with historical examples of countries that arose and became wealthy via strong industrial sectors.

The results from the 1996 data do give an idea of core and peripheral status of the different parts of Europe in one point in time, but they do not give any idea of processes, only states. It could easily be argued, for example, that high agricultural employment causes peripheralization, rather than a lack of employment in other sectors. Therefore, examining the data, or similar data, over a span of years is necessary to obtain an idea of causality between the variables.

Therefore, the heart of this thesis is the Eurostat data of variables for the 11 years from 2000 to 2010 and at the NUTS2 level if possible. Variables examined include GDP, fixed capital investment and employment by six economic sectors — breaking out parts of the service sector in particular, which showed no results as a whole in the 1996 data, for further examination — current account trade balance, and male and female unemployment.

A descriptive analysis of these variables was first done. Examining the NPCGDP of the NUTS2 regions in 2000 and 2010 does show a contagion effect of rising NPCGDP in the former Eastern bloc countries, especially hierarchically, with the populous capital regions rising the most toward the European average, but also spatially, as is evident by examining Poland. At the same time, certain parts of Western Europe, in particular in France, Italy, and the UK, regressed downward.

Examining the other variables economic sectors was also instructive. Agricultural employment, as one might expect, is very much a peripheral activity, highest in Eastern and Southern Europe, but does not correlate with growth. Manufacturing (Ba) does appear strongest in Central and Eastern Europe, and shows the strange regional effect in Spain, Italy, France, and Portugal where it is concentrated in the north or northeast of each country, and sparse in the south or southwest. Construction (Bb) is high in Spain, southern Italy, and parts of Central Europe; commerce (Ca) is fairly evenly distributed around the continent; finance (Cb) is highest in major urban or capital centers, and other services (Cc) is concentrated in Britain, France, and Scandinavia. Noting the centers of high employment is important when OLS regressions are done later in the analysis. (As an interesting aside, the countries with high Cc employment also seem to be more or less the same ones to have relatively high birth rates; if a country is interested in pronatalism — and most European countries are at the present moment — increasing investment in the Cc sector may be one way to do so.) Meanwhile, unemployment was highest in Spain, the Baltics, and eastern Slovakia, although it was also particularly bad for men in Ireland and women in Greece. Interestingly, the areas with high male unemployment — Ireland, Spain, and the Baltics — also seem to be the same areas that had burst real estate bubbles and/or banking crises, as opposed to sovereign debt crises due to excessive debt accumulated by governments. Why banking crises specifically should be particularly potent at worsening male unemployment is an interesting question that may merit further study.

Fixed capital formation figures were only available between 2002 and 2006, but they showed highly accelerating levels of industrial capital formation in Eastern European countries except for Hungary, which was also hardest-hit by the recession. Current-account export figures also appeared to increase more over the decade if fixed capital investment in industry was larger. The descriptive analysis thusly appears to show that investing more in manufacturing, especially for developing former Eastern Bloc economies, is a process crucial for keeping an economy healthy and weakens the impacts of recessions, whereas the actions of a reckless financial sector is a potentially and often catastrophically negative process. FCI was correlated strongly with economic growth, as were imports; however, a correlation between exports and growth was not immediately obvious. Import growth appears to be a process that results from economic growth, as one would intuitively expect, but export growth's causality of economic growth is much more subtle. Nevertheless, those countries that had the most positive current-account balance over the whole decade as seen in Figure 9, and also had no banking troubles (relevant here when considering Ireland and Hungary), were also the same countries that best maintained their economic position as seen in Figure 5. Therefore, whereas import growth is a good short-term indicator of economic health, a positive current-account balance with robust exports may prove to be a better long-term

indicator, and unlike with imports, one would intuitively expect the causality of such robust exports to precede economic growth. This suggestion merits further research. Arrighi (2010, pp. 226-246) suggests that export growth occurs in an environment of increasing returns to profit, and that as industry no longer becomes profitable, capital tends to shift more toward building up the financial sector. The low FCI levels in industry for the UK, for example, appear to be such a late-phase case where UK capital sees industry as unprofitable and avoids investing in it, at least within the UK. Profitability concerns thereby appear to be one rationale for industry locating where it does within Europe.

A univariate analysis of GDP was next done at the NUTS2 level from 2000 to 2010, featuring both a plain Moran's I figure and LISA. Interestingly, the NUTS2 level showed a Moran's I drop from 0.55 to 0.37 from 2000 to 2009, with a slight uptick in 2010. Moran's I was thus larger at the NUTS2 level than at the country level (described in the first paragraph of this discussion), but it also showed a steadier fall over the time period. In addition, within-country analysis shows that within the large countries, Moran's I has not changed all that much, and is in fact worst for Italy, not Germany as one might expect with the attention given to the failure of the former GDR to "catch up" to the rest of the country. Meanwhile, the univariate LISA (Figure 22d) highlights not only the rising areas of Eastern Europe, but the sinking areas of Western Europe, i.e., of France, Italy, and the UK mentioned before. In this case, manufacturing might not at first glance appear to have an effect one way or the other, as while UK FCI in industry was very weak in 2005-06, it was robust in Italy. However, if one returns to Figure 9, it should be noted that Italy, despite both apparently aggressive investment in industry along with high manufacturing employment in the north of the country, had a chronic trade deficit over the decade, showing that whatever it was manufacturing did not appear to translate into lucrative sales abroad and consequent repatriated wealth for the country.

Bivariate analysis OLS regressions between GDP and the variables described above were run. The employment by economic sector showed the most interesting results; whereas the 1996 Eurostat data did not break down services further, the 2000-2010 data did so, as described above in the Data section. The results show that agricultural employment is insignificant to economic growth, the Bb (construction) and Cb (financial) sectors showed a bubble and collapse, and Ba (industry) and Ca (commerce) showed more sustainable growth. The last sector, Cc, appeared to also help sustainable growth like Ba and Ca, although to a lesser extent. Thus, while industry and commerce, and investing capital in them, do not give very high levels of GDP growth, they appear to give more sustainable growth, and to help economies withstand recessions better than high investment in the financial (Cb) or construction (Bb) sectors.

The importance of industry to improving a country's maneuver has been postulated by Reinert, among others, and industrial protection has been used by the aspiring hegemons of the world-economy in the past few centuries during their rises to hegemony, as Arrighi has pointed out. The financial sector, meanwhile, arises when the economy becomes wealthy enough to support it, and an excess of capital builds up seeking rent. This financial sector may be used to buy influence elsewhere in the world, and is often seen according to the dictum "money is power". Unfortunately, if there is a lack of profitable enterprises in which to invest

capital, and especially if interest rates are low, this capital often ends up being used for speculation, which often builds a bubble that pops and causes widespread economic harm to those regions in which the bubble has occurred, as has been happening with real estate. It would seem that, if a country wishes to develop, it should do its utmost to attract investment in industry, and over time increasingly higher-value industry, increasing exports along the way.

In regards to the DSK and FKV models, these findings broadly support their theory. LISA results for NPCGDP appear to support the phenomenon of agglomeration in the core, and peripheral areas of Southern Europe continue to have high levels of agricultural employment. (It may be surmised that agriculture would be important in extreme Northern Europe as well if the terrain and climate was at all favorable, and it is interesting that Norway, despite its oil wealth, also boasts the largest fish catch in Europe.) Industrial employment (Figure 6a) appears to show the sharpest agglomeration effects, which is consistent with its being a close approximant to the "manufacturing" sector in the DSK model.

In addition, the LISA for NPCGDP change between 2000 and 2010, Figure 22d, shows an interesting cluster of significant NPCGDP drop in France, Italy, and the UK, almost as if these areas are left behind by the core of the European economy — exhibiting de-agglomeration, so to speak — as the core itself shifts to the east. Areas which are in the core in both 2000 and 2010, such as Germany, or in the periphery both years, such as Spain, are affected much less, apparently because their *relative* positions in the European economy have not changed all that much over the decade, unlike France, Italy, and the UK. Interestingly, the three countries have had considerably different levels of FCI in their industrial sectors over the decade, with industrial FCI being quite high in Italy and very low in the UK (Figure 7, top center), but the apparent de-agglomeration effects of geography appear to affect Italy just as much as the UK.

Conclusion

Over the decade since 2000, Eastern European economies have made great strides to achieving parity with Western Europe, as may be seen on Figure 22d. At the same time, banking and sovereign debt crises have brought economic pain to various countries, including Ireland, Spain, Greece, and the Baltics. Examination of the different economic sectors appear to suggest that a robust industrial and commercial sector, combined with an aggressive export regime, help to improve a country's maneuver, while at the same time, caution in regards to financial investment and speculation is crucial to stave off the danger of bubbles that can cause severe economic shocks and high levels of unemployment when they collapse.

LISA and descriptive analysis of NPCGDP over the decade makes clear that Eastern Europe has risen relative to the EU average both geographically and hierarchically, while the Western European economies of France, Italy, and the United Kingdom have suffered relative declines. An interesting question is if this is due to those countries being geographically in the core of the European economy before the collapse of the Iron Curtain, and more in the semiperiphery afterwards; in other words, if their economic maneuver has worsened. Another possibility, from looking at history and politics, may be that two of the countries, France and the UK, are on a downslope from being the foremost political powers in Western

Europe — both are the EU's only nuclear powers and permanent members of the UN Security Council.

Limitations of this research include a relatively short timescale, for FCI in particular, and a certain lack of sensitivity in capturing certain effects, such as the long-term correlation between a healthy current-account balance due to strong exports and reliable economic growth. In addition, OLS equations are limited in their explanatory power, especially as space is not explicitly included. While identifying processes as opposed to states is done by considering change over time (as with ΔGDP instead of GDP), a SAR model may prove even more effective toward this end by capturing spatial effects.

Incorporating space into the analysis, however, is not that difficult, and in fact will be the next step. Preliminary indications are that taking the OLS models created here, and supplementing them with a spatial lag function to create SAR models, increases the models' R^2 and thereby their explanatory power. For example, considering an OLS model of ΔGDP vs. ΔULF (2009-2010), the OLS model has an R^2 of only 0.066, but the corresponding SAR model using first-order rook connectivity has an R^2 of 0.210, with a ρ of 0.425. The OLS model of ΔGDP (2009-2010) vs. ELF (2009) has an R^2 of 0.586, while the SAR model improves to 0.656, with a ρ of 0.369. Explanation improves due to the fact that, as workers are mobile, especially within their own home countries, a statistically significant correlation between two variables would also apply to an extent across NUTS2 regions; SAR models are able to account for this in a way OLS models cannot. Further examinations of these OLS models with spatial error or GWR models may also be warranted to better ascertain which are most effective at improving R^2 and pulling all spatial effects out of the errors. Another area of potential future research would be bivariate LISA. The power of spatially-explicit models is barely touched on here, but it should be readily apparent that this geographic tool has the potential to contribute much to the understanding of economic processes.

The models here, as well as the SAR models planned in future, also should help contribute to world-systems theory by providing insights into the short-term economic cycles in operation in the region being studied, as well as hints of longer-term structural power shifts and cycles.

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