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Increasingly unequal?

Convergence of real wages in the EU

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Abstract

The European Union has taken steps to remove obstacles for labor mobility and per economic theory this should lead to an equalization of real wages through an increase in labor mobility. The equalization of real wages is a process named convergence by economists. This thesis looks closer at the convergence process in the European union during 1997 to 2015 for the EU-27. The main questions are; have real wage convergence taken place, is this process affected by the Eurozone crisis and do real wage growth similarities cause countries to group up in so called "Convergence clubs". Classic convergence measurements such as σ-convergence and β-convergence is used to measure the reduction of income disparities and the "Catch-up" process of weaker economies. Cluster analysis is employed to identify "convergence clubs" and the more modern time-series approach is used to determine the convergence properties of these clubs. The results indicate that real wage convergence has occurred in the European Union during the period. The convergence process was negatively affected by the Eurozone crisis as a result of stalled labor mobility. Two convergence clubs are identified and they are separated into a high income club and a lower income club. The lower income club will not "catch-up" to the real wage level of the high income club.

Keywords: real wage, sigma-convergence, beta convergence, european union, economic growth

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1 Introduction

"The Community shall have as its task, by establishing a common market and an economic and monetary union and by implementing the common policies or activities referred to in article 3 and 3a, to promote throughout the community a harmonious and balanced development of economic activities, sustainable and non-inflationary growth respecting the environment, a high degree of convergence of economic performance, a high level of employment and of social protection, the raising of the standard of living and quality of life, and economic and social cohesion and solidarity among Member States" (EEC, 1992).

One of the fundamental objectives of the European Union is to improve the social welfare of its citizens. The treaty on the European Union, which was signed by the European Economic Community in 1992 to form the European Union, stipulates that the "working conditions" of the workers in the EU is to be improved (EEC, 1992). In order to improve the working conditions, The European Union has abolished multiple barriers that hinder worker mobility and amplify capital allocation. According to the treaty of the functioning of the European Union, it should promote overall harmonious development and reduce economic and social disparities between the regions. One such aspect would be the disparities of worker earnings between the different member states. One of the attractions of joining the EU for new candidates is to "catch-up" with EU living standards. This includes both social protection and economic integration. Neoclassical economic theory argues that when trade barriers disappear, prices should converge to the same level across the different parties involved. To improve living standards, wages must also increase for citizens to maintain their purchasing power (Mankiw, 2016, p. 165). Convergence analysis focuses mainly on reducing of disparities and the "catching up" of weaker economies, and using this as the main methodology the question arises; Do the economies in the European Union converge in terms of real wages?

1.1 Thesis purpose

This thesis aims to investigate if real wage convergence occurs between the member states of the EU during the period 1997 and 2015. To answer this main question, the following subset of questions are investigated;

1. *Do disparities in real wages decrease over the period 1997-2015, across the EU?*

2. *Do the "weaker" economies catch up to the "stronger" ones, in terms of real wages?*

3. *Has the financial crisis distorted the convergence process of real wages?*

4. *Do "convergence clubs" exist and what are the properties of these clubs?*

Question 1 and 2 refers to the neoclassical measurements of convergence originating with Robert Solow (1956) and the convergence concepts stated by Barro and Sala-i-Martin (1990). A decrease in disparities would, in general, mean a decrease in inequality as wages across countries converge on each other. If weaker economies catch up, then this could also be regarded as an increase in equality as the weak catch up to the strong. Question 3 focus on the effect of macro-shocks on the process of convergence. Question 4 looks more closely at the possibility that some countries might enjoy a higher level of real wages than other countries.

1.2 Previous Research

Several authors have made contributions to the convergence debate over the years. The foundation was laid down by Robert Solow in "a contribution to the theory of economic growth" (Solow, 1956). Solow formulated a model which predicts capital stock and economic output based on the exogenous variable - savings rate. Solow stated that, assuming certain similarities between countries, poor economies grow faster than rich economies and that convergence to a steady state occurs in the long run. The model was later augmented to include technological growth and population growth by economists Mankiw, Romer and Weil (1992). The Solow model is highly influential up to this day. Robert Barro and Xavier Sala-i-Martin (1990) used this model to investigate if the different states in America converged in terms of GDP per capita between the 1840s to 1988. Barro and Sala-i-martin found evidence of convergence and used two concepts of convergence previously minted by Barro (1990, p. 11), Baumol (1986) and others. The two concepts are σ-convergence and β-convergence, which describe the reduction of disparities between economies and the "catching up"-process respectively. The measures are strongly related to Robert Solow's model, but Barro and Sala-i-Martin use statistical techniques to estimate effect sizes (1990, pp. 12-13). The negative relationship between initial income and growth rates is regarded as evidence of convergence. Bernard and Durlauf (1995) argued that the cross-sectional approach pioneered by Barro and

Sala-i-Martin is flawed and that a time-series approach is more adequate. This convergence approach rests on the properties of time-series of economies. Two economies converge if their long run forecasts of output are equal (Durlauf & Bernard, 1995, p. 99).

Both described techniques of convergence analysis have been used by a variety of modern day economists. Examples of work using Barros method include Lund, Schön and Svensson (2005) along with Siljak (2015). Economists that used Bernard's approach include Carlino and Mills (1987) and Kane (2001).

Analysis of convergence has been done on the countries of the European Union in other dimensions than real wages. An analysis of price convergence has been undertaken by Cuaresma Et al. (2007). Analysis of inflation convergence has been done by Busetti Et al. (2006).

The conclusions on price convergence in the EU points towards a process of price convergence that is occurring across different time periods. Cuaresma Et al. (2007) found that prices converged at the beginning of the 1990s. The analysis of Allington Et al. (2005) suggest that prices converged in the EU over the period 1992 to 2002.

The general confirmation of price convergence is the foundation of this thesis, which will focus on real wages. If we assume that price convergence is occurring in the EU according to Allington (2005) among others and we know that real wages is the ratio of wages to prices, then if wages do not increase with the price increase, then the real wage ratio might decrease for some countries and workers lose purchasing power.

1.3 Definitions

A short description of the abbreviations frequently used in this thesis follows in this chapter, the definitions are commonly used and described briefly for clarity;

- *EU-15.*

Defined as the 15 EU member states prior to the "Enlargement" of the additional countries in 2004. The EU-15 consist of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

- *Accession countries*

The 10 countries joining the EU in 2004. These 10 countries are Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia.

- *EU-27*

This group is the majority of EU-members, excluding Croatia that were formally introduced in 2013. The EU-27 consist of EU-15 and the ascension countries plus Romania and Bulgaria.

- *Schengen members*

The Schengen area enhances the ability of citizens to travel internally in the EU. This might affect the labor mobility in a positive way. Most EU-members are a part of Schengen. Countries that are not EU but a part of Schengen and will be included in this thesis analysis are Norway and Iceland.

- *GIIPS-countries.*

GIIPS stands for Greece, Ireland, Italy, Portugal and Spain. These countries were grouped together using this acronym after the Eurozone crisis in 2008 when it became evident that their economies were unstable in terms of debt to GDP ratios.

2 Theoretical framework

The theoretical foundation of this thesis is described in this chapter. In chapter 2.1 I will discuss the concept of convergence. Chapter 2.2 to 2.5 focus more closely at wage convergence and labor market theory. Chapter 2 ends with growth theory and the Solow model which is the foundation of the methodology chapter that follows in chapter 3.

2.1 Convergence and Dimensions of Convergence

Economic convergence has for decades been a hotly debated topic of interest for economists. The reasons might be apparent, mostly because the conclusions drawn from convergence analysis have the potential for enormous economic and political impact. All around the world, variation in living conditions can be seen. Poor countries have on average one tenth of the world´s rich countries, in terms of income per person. Income differences have direct effects on life expectancy, education and infant mortality, to name a few. Economists have shown interest in measuring how economies affect one another and whether they grow more alike over time. It follows that poor countries might grow faster than rich countries If this is the case, inevitably over time, poor countries will catch up with rich countries - a process that economists call *convergence* (Mankiw, 2016, p. 248).

The concept of convergence originates back to Robert Solow and his neoclassical growth model which states that, assuming similar starting points, countries will reach the same long run equilibrium in terms of output. The Solow model results in a globally stable state, thus economies either currently exist in their steady state or converge towards this state (Solow, 1956, p. 70). If economies have similar starting points in terms of savings rate, population growth and labor efficiency, then they should reach the same steady state. If they have different capital stocks, the country with the lower capital stock will grow faster and thus "catch-up". This is called *absolute convergence* (Barro & Sala-i-Martin, 2004, pp. 44-45). If two countries have different starting points, for instance different savings rates, then one could not assume that the countries reach the same steady states. Rather, it will result in two separate steady states. This is called *conditional convergence* (Mankiw, 2016, p. 248).

When analyzing convergence, one is interested in two main questions. Firstly, will countries' income equalize to a similar value over time and secondly, will countries which are further behind in economic development catch up to those whom are further progressed. Convergence analysis is applicable in different dimensions such as inflation, welfare state indicators and price levels.

2.2 Wage Convergence

Wage convergence implies that wages between two regions should equalize, assuming that markets are competitive and that workers and firms may enter and leave the market. The starting point for market integration for workers, and thus for wage equalization, is the single market competitive equilibrium. According to theory, workers prefer to work where wages are high and firms prefer to hire labor where wages are cheap. In the single market context, this will lead to an equilibrium in the wage employment plane, as displayed in figure 1;

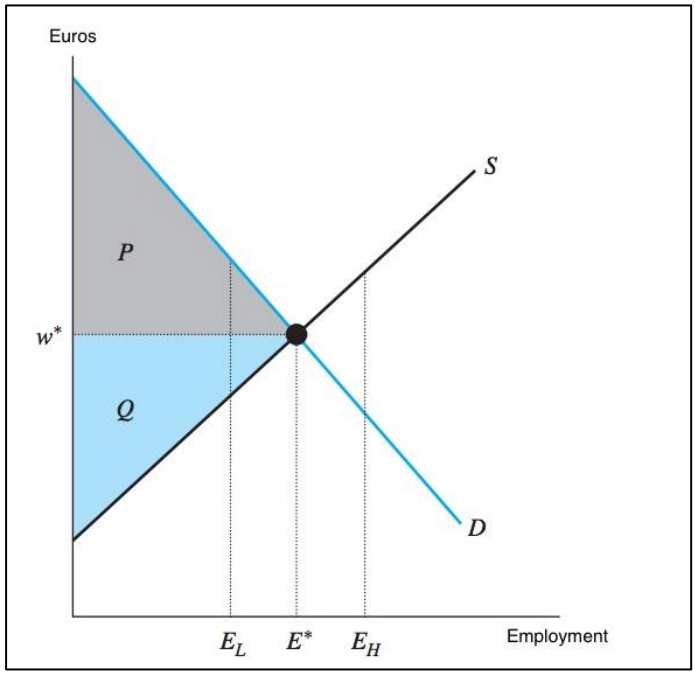


Figure 1 Equilibrium in a single competitive labor market. (Borjas, 2013, pp. 145-146)

Here firm demand of labor equals the workers supply, and thus we have a market clearing wage w^* and an equilibrium employment E^*. If we would have any wage that is either larger or smaller than w^*, then this would create downward or upward pressure on wages and we would end up in w^*. Firms then hire all available workers until the number of workers equals w^*. Now E^* workers are employed at wage w^*. The outcome of this equilibrium is efficient since the gains from trade, P and Q, are maximized and all labor resources are efficiently allocated.

However, in reality, there are multiple labor markets. Suppose that there are two regions with workers, region A and region B. The workers perform the same work in both regions. Suppose now that the regions differ in remunerations to the worker, so that region A have higher wages

than region B. If free worker mobility exists, then the workers will move from region B to region A. This creates an influx of labor in region A, which allows for firms to reduce wages due to a larger labor force. Firms in Region B must pay a higher wage to attract workers. This process of workers moving and wages being pressured either up or down reaches a point where wages in region A equals the wages in region B. This single equilibrium wage is the same as in the single competitive equilibrium, w^*. Note that if firms also have free mobility, then this process of equalization should also take place as firms in region A move to Region B to employ cheaper labor. This process is illustrated in figure 2;

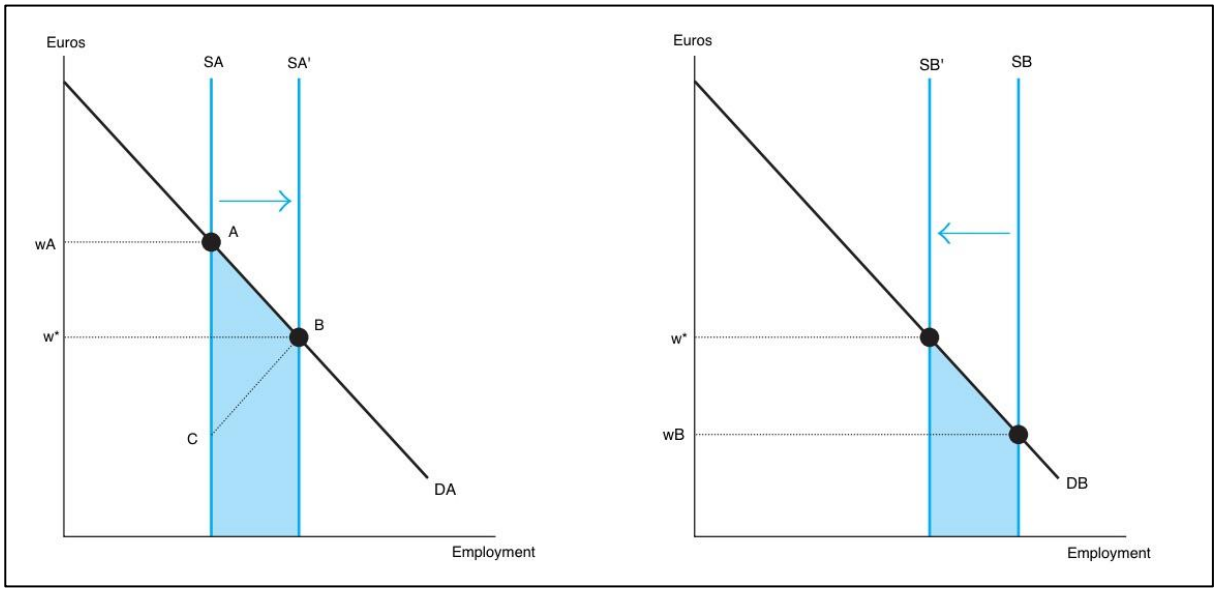


Figure 2 Competitive equilibrium in two labour markets linked by migration. (Borjas, 2013, pp. 147-148)

In figure 2 workers from region B moves to region A, pressuring wages in region A from wA to w^*. Since workers are relatively scarce in region B due to this migration, wage rise from wB to w^*. Both region A and B now reside at equilibrium wages w^*.

Classical wage theory literature defines the process of wage convergence as a reduction of wage dispersion, measure with the decline of standard deviation over time with an absolute rigid structure of relative wages (Dunlop, 1957, p. 223). Barro (2004, p. 492) also states that migration between labor markets should speed up the convergence process.

2.3 Labor mobility

John Hicks (1932, p. 76) stated that "differences in net economic advantages, chiefly differences in wages, are the main causes of migration". If a worker should decide to migrate

from one country to another, then the economic gain must be sufficient. Theory formulated after this statement says that workers calculate expected gains in all potential labor markets available, factoring in the costs of moving, and then choose the labor market that maximizes the net present value of lifetime earnings (Borjas, 2013, p. 319). Suppose that a worker in Estonia has the opportunity of migrating to a labor market in Germany. Assume that this worker is 30 years old and that she earns w_{30}^{ES} euros currently in Estonia. The potential wage in Germany she would earn w_{30}^{GE} euros. The cost for migrating to Germany is given by M which are migration costs. The present value of earnings in Estonia is then amounts to:

$$PV^{ES} = w_{30}^{ES} + \frac{w_{31}^{ES}}{(1+r)} + \frac{w_{32}^{ES}}{(1+r)^2} + \cdots + \frac{w_{n}^{ES}}{(1+r)^n} \quad (1)$$

where r is the discount rate and n is the retirement age of the worker. The present value of earnings in Germany is given by:

$$PV^{GE} = w_{30}^{GE} + \frac{w_{31}^{GE}}{(1+r)} + \frac{w_{32}^{GE}}{(1+r)^2} + \cdots + \frac{w_{n}^{GE}}{(1+r)^n} \quad (2)$$

The net gain of the migrating is then given by:

$$Net\ gain\ of\ migration = PV^{GE} - PV^{ES} - M \quad (3)$$

if equation 3 is positive, then the worker will move to Germany. Three testable facts arise from equation 3. Firstly, if economic opportunities improve in Germany, there is an increase in likelihood that the Estonian worker moves. Secondly, if the economic opportunities in Estonia worsens, the likelihood of migrating also increases. And thirdly, if costs of migrating are reduced, then the likelihood of migrating increases (Borjas, 2013, pp. 319-320)

When a country joins the EU, then per the "Treaty on the European Union" (1992) the costs of moving labor is abolished. Thus, the M term in the equation should decrease. As a result, the likelihood of moving should increase. If workers then are expected to move between markets due to reduced costs, then according to the theory of equilibrium wages described earlier, wages should converge across the Union. This works under the assumption that wages differ in the first place.

For wages to converge over time, there should be a negative relationship between initial wage levels in an economy and the rate of wage growth. Thus, wage convergence is a result of efficient allocation of workers across different labor markets and market integration (Lundh, et al., 2005). The wage gap across countries should decrease over time, and if we assume that the economies in question have similar endowments, this leads to unconditional, or absolute, convergence of wages.

A research paper from Eurofound (2014) found that labor mobility was negatively affected by the Eurozone crisis in 2008, the effect of the Eurozone crisis on the convergence of wages is thus also of interest in the coming analysis.

This thesis focuses on the convergence of real wages, which is the ratio of nominal wages and a deflator. The deflator is typically an index of inflation and I choose to use the "harmonized index of consumer prices". This measure allows for comparison across countries in the economies of interest. The inflation is measured as a standardized basket of goods, and the price of these goods is used to establish the rate of inflation over time. Similar to wages the prices of goods in different areas should also converge as stated by the theory of the "law of one price".

2.4 Law of one price

The law of one price states that a good cannot sell for different prices in different locations. Should these discrepancies in an economy exist, then arbitrage opportunities arise and individuals will buy a good cheaply in one location and then sell the same good in a different location at a higher price and make a profit. Using the same logic as in discussion on wage equalization above, this will cause prices to have a ratio of one between regions. This theory applies in the context of real wage equalization in the EU. When joining the EU, countries should adopt the same currency and trade barriers are reduced. This should in turn allow for prices to equalize across member countries (Dreger, et al., 2007, pp. 22-24). For instance, an apple sold in Germany should sell for the same price in Estonia, per the "law of one price" (Mankiw, 2016, p. 165). If prices in Estonia and Germany converge over time, then the wages must also converge at the same rate in formula 4:

$$Real\ wage = \frac{Nominal\ wages}{Price\ index} \quad (4)$$

Suppose that the formula 4 describes real wages in Estonia. If Estonia joins the EU, and thus reduce trade barriers, then per the law of one price the prices in Estonia should converge towards the EU average. But if nominal wages do not increase at the same rate, then the denominator in formula 4 becomes larger and thus real wages in Estonia decrease. If prices adjust quicker than wages in a country, the purchasing power of the workers decreases.

So, we have two theories working in tandem, firstly, the labor mobility increase should allow wages to converge. Secondly, the law of one price suggest that prices should converge. And, in conclusion, the real wages in the EU-countries should converge to a similar equilibrium real wage.

2.5 Determinants of real wages

There are several determinants of real wage development. A report from the EU Commission in 2003 described these determinants as the following (2003, pp. 76-77, 95-96);

1. *Labor productivity.*

An increase in labor productivity has a positive effect on real wage development, here productivity is measured as GDP per person employed. The greater the differences between markets, the greater the differences in wages will be. The report finds that there are significant differences between countries in the EU, these differences can be found in figure 3;

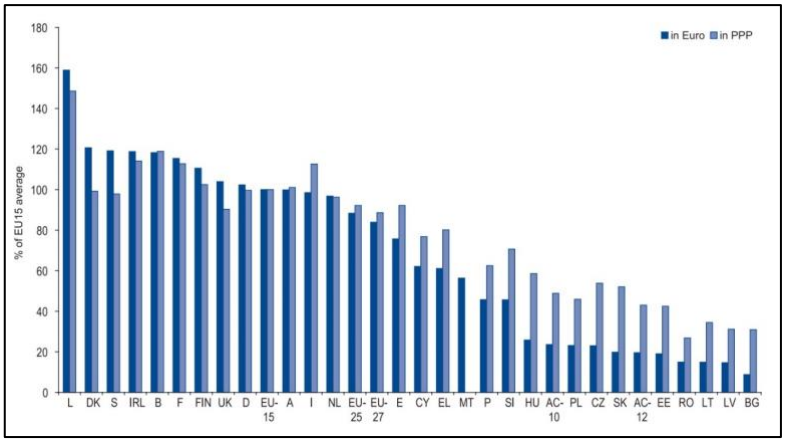


Figure 3 Labor productivity in EU-countries (European Commission, 2003, pp. 94-95)

The EU-15 countries and the Nordic countries exhibit higher levels of labor productivity according to figure 3. Theoretical literature argues that real wage developments for the most part move in step with productivity (Dunlop, 1957, p. 48). The specific country codes can be found in the appendix in table 20.

2. *Workers' rights*

Collective bargaining agreements and unions that protect the rights of the workers in the different workers are of importance to the wage formation. This is computed as the proportion of workers that have their pay and working conditions set to some extent by collective agreements. The report by the commission provides the following figure 4 depicting coverage of collective bargaining in the different EU member countries;

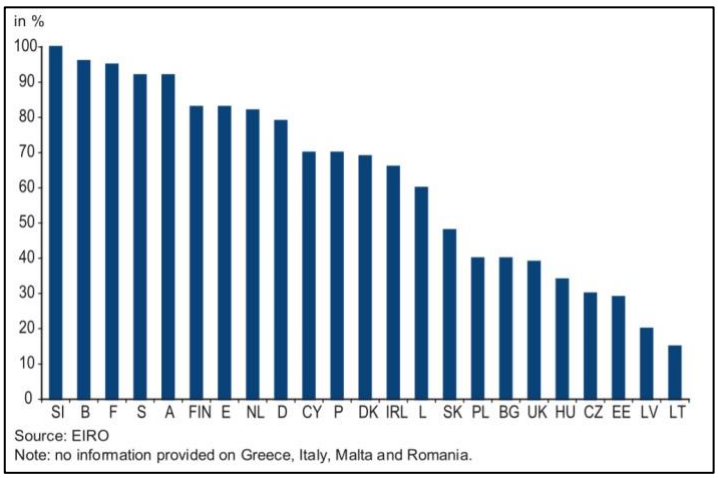


Figure 4 Collective bargaining coverage in % in EU-countries. (European Commission, 2003, p. 115)

Most accession countries have lower collective bargaining coverage. This might influence wage formation and thus wage differentials between countries. The report concludes that higher coverage rates correlate positively with higher wage levels. Theory also supports the coverage rate effect on wages, as the narrowing of wage differentials is quicker under collective bargaining then under perfect competition (Dunlop, 1957, p. 220).

In addition to the two determinants above, the price levels are an obvious determinant of real wages based on equation 4. The deflator used is the "harmonized index of consumer prices" or HICP, so differences in HICP lead to different levels of real wages.

2.6 Growth theory

As previously mentioned, the foundation of the methodology in this thesis is the work of Robert Solow. The simplest version of the Solow-model is the one of "one-sector"-model. The underlying assumptions is that each region produces one good using a combination of inputs. The inputs are a combination of labor and capital and the produced good can either be saved for future consumption or consumed immediately. The production function is identical across regions and the function exhibits constant returns to scale and diminishing marginal products (Mankiw, 2016, pp. 212-213). The general production function is as follows:

$$Y_{i,t} = F(K_{i,t}, L_{i,t}), \tag{5}$$

where $Y_{i,t}$ is output in region i at time t. This output is function of $K_{i,t}$ and $L_{i,t}$ which is the physical capital and labor force in region i at time t respectively. Since this function assumes constant returns to scale, we can analyze output per worker by dividing equation one with $L_{i,t}$ to gain a function describing the output per worker:

$$y_{i,t} = f(k_{i,t}), \tag{6}$$

where $y_{i,t}$ is equal to $Y_{i,t}/L_{i,t}$ and $k_{i,tt}$ is equal to $K_{i,t}/L_{i,t}$. It is further assumed that the labor force is growing at a constant rate, n, according to:

$$n = \frac{\dot{L}_{i,t}}{L_{i,t}}, \tag{7}$$

where $L_{i,t} = L_0 e^{nt}$ and $n \geq 0$, we assume full employment so labor supply is always equal to labor demand.

The source of growth in this model is the accumulation of physical capital, this process occurs over time through investment (I). It is assumed that all savings are automatically invested so $I \equiv S$. It is furthermore assumed that the aggregate savings in the region is a constant proportion of the region output such that:

$$S_{i,t} = sY_{i,t}, \tag{8}$$

where $0 \leq s \leq 1$

The net increase in the capital stock is given by:

$$\dot{K}_{i,t} = sL_{i,t}f(k_{i,t}) - \delta K_{i,t}, \tag{9}$$

where $sL_{i,t}f(k_{i,t})$ is equal to the investment *I* and δ is capital depreciation, a constant fraction of capital that is destroyed each time period. Dividing both sides of equation 9 with $L_{i,t}$:

$$\frac{\dot{K}_{i,t}}{L_{i,t}} = sf(k_{i,t}) - \delta k_{i,t}, \tag{10}$$

and knowing that the capital labor ratio can be written as follows:

$$\dot{k}_{i,t} \equiv \frac{\dot{K}_{i,t}}{L_{i,t}} - nk_{i,t}, \tag{11}$$

we can substitute equation 10 into equation 11 and get:

$$\dot{k}_{i,t} = sf(k_{i,t}) - (n + \delta)k_{i,t}, \tag{12}$$

Setting $\dot{k}_{i,t} = 0$ allows for an equation to be formulated that must hold in order for an steady state to be achieved:

$$sf(k^*) = (n + \delta)k^*, \tag{13}$$

equation 13 states that investment equals capital depreciation, this is called the steady state of capital and can be showed in the classical Solow diagram in figure 5:

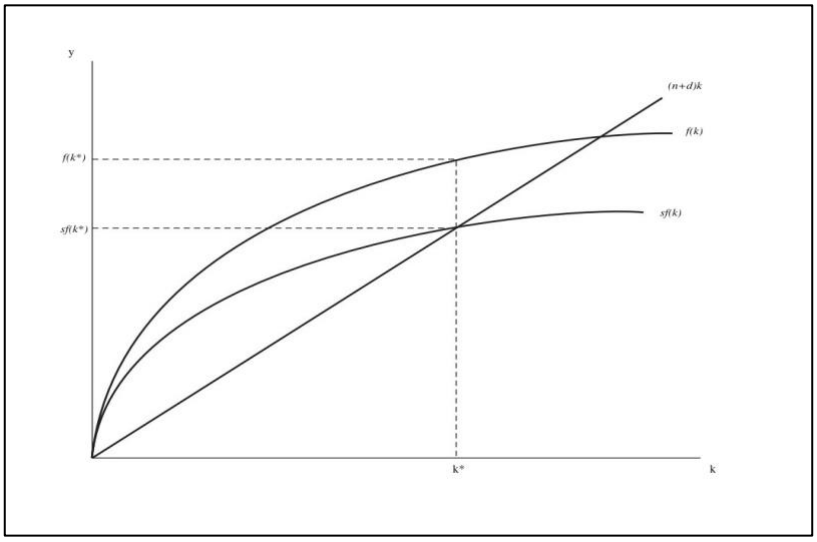


Figure 5 Steady state in the Solow model.

This model was later augmented to account for technological progress so equation 13 becomes:

$$sf(k^*) = (n + \delta + g)k^*, \tag{14}$$

where g is the labor-augmenting technological progress. The key aspect of the Solow model is its production function, which assumes constant returns to scale, diminishing returns and positive elasticity of substitution between the different inputs. Solow then adds a constant-saving-rate to generate the equilibrium state of the model. This model has in turn generated the conditional convergence hypothesis. This hypothesis states that the lower starting point of GDP per capita of an economy in relation to its steady state, the faster the growth rate. This hypothesis is conditional on the growth rate of the population and savings rate along with the exact similarity of the production function (Barro & Sala-i-Martin, 2004, p. 17).

Mankiw et al. (1992, p. 408) argued that the disparities between countries could be attributed to differences in educational skill level of the labor force. The key insight from Mankiw is that countries have different output per worker equilibrium levels due to differences in capital invested in human capital. In other words, the educational skill of the labor force.

The underlining assumption in the Solow model is that, due to diminishing marginal returns, an economy will reach a steady state where capital per capita, output per capita and consumption per capita grow at a constant rate which is equal to the rate of technological progress. This in turn leads to convergence, in two ways. The first notion of convergence is that if countries are similar in technology and preferences, then the countries in question should

reach the same steady state in time. The second notion of convergence is that growth rates between countries should be equalized over time, since technology is exogenously given in the Solow model.

For the sake of the analysis in this thesis we must make certain assumptions in relation to the Solow model. It should be noted that if this model were to be applied to a set of countries, then for these countries to converge to the same level they should all be characterized by the same production function and same preferences for savings. Even if capital stocks are different in the starting point, these economies should converge on the same equilibrium point (Alexiadis, 2013, p. 16)This thesis will focus on this method for convergence which is called unconditional convergence, meaning that convergence is unconditional on other variables that might differ between countries such as unemployment levels and saving rate differences.

Unconditional convergence say that countries should reach the same steady state in the long run, however, countries are subject to different macro shocks constantly. Thus, different economies are not in an equilibrium. So, when steady states do not appear, how can convergence be measured? For this empirical exercise, one must measure the underlying process of convergence, instead of the equilibrium "end-state". This leads us to the most common measures of convergence; σ-convergence and β-convergence.

3 Methodology

This chapter describes the methods developed by economists to empirically measure the convergence process. σ-convergence and β-convergence is described and then the more modern time-series convergence approach follows.

3.1 σ-convergence

The concept of σ-convergence appeared early in Barro and Sala-i-Martin (1990) amongst others. The process of convergence occurs when the dispersion of the logarithm of income per capita decline over time for a group of countries. It follows that;

$$\sigma_{i,T} < \sigma_{i,0}, \tag{15}$$

in the inequality 15 above, the dispersion is measured with the standard deviation in country i, today, and country i in some point in the future. In general, we say that $\sigma_{i,t} \to 0$ as $t \to T$, for σ-convergence to occur. In other words, as time approaches terminal time T the standard deviation tends to zero. The standard deviation is given by equation 16:

$$\sigma_{i,t} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[log\left(\frac{y_i}{y^*}\right)\right]^2}\ , \tag{16}$$

where $log\ y^* \equiv \frac{1}{n}\sum_{i=1}^{n} log\ y_i$ and y_i is the income per capita for instance (Alexiadis, 2013, p. 90). In the statistical program employed in this thesis, σ-convergence is calculated as follows:

$$\sigma_{i,t} - \sigma_{i,t+T} = \sigma_i', \tag{17}$$

where $\sigma_{i,t}$ is the standard deviation at initial time t and $\sigma_{i,t+T}$ is the standard deviation at time $t + T$ where T is some terminal date. σ_i' is the difference in dispersion. It follows from equation 17 that if the differences are positive, then $\sigma_{i,T} < \sigma_{i,0}$ as is stated in equation 16 and the dispersion of income has decreased between the countries and thus σ-convergence has occurred. Thus σ-convergence occurs when disparities between different regions is reduced over time. Another way of assessing σ-convergence is to calculate the coefficient of variation (henceforth CV). This is done via the following simple formula in equation 18:

$$CV = \frac{\sigma_{i,t}}{\mu_{i,t}}, \tag{18}$$

thus, the CV is the ratio of the standard deviation to the mean (Alexiadis, 2013, p. 90). This thesis will utilize both difference in standard deviation (eq 17) and CV (eq 18) as measurements of dispersion and thus as proxies for σ-convergence.

3.2 β-convergence

The second concept of convergence, β-convergence, says that when countries are poor, they will tend to "catch-up" to the richer countries in terms of income per capita. This view of convergence stems from the Solow model, but was formulized by Barro and Sala-i-Martin in

1990. β-convergence is defined as an inverse relationship between the growth rate during a period and the starting level of income per capita.

A contribution to the convergence literature was given by Baumol (1986), here the author uses regression to estimate beta convergence per the simple regression in formula 19:

$$g_i = a + by_{i,0} + \varepsilon_i, \tag{19}$$

where $y_{i,0}$ is the natural logarithm of output per worker at time 0 for country i, a is the constant, b is the proxy of β-convergence and ε_i is the residuals or random error. The growth of output per worker can represented by:

$$Y_{i,T} = e^{g_i} Y_{i,0}, \tag{20}$$

taking logs and solving for g yields:

$$g_i = y_{i,T} - y_{i,0}, \tag{21}$$

so, the growth rate for some period is given by the difference between the natural logarithm of output per worker at time T and the natural logarithm of output per worker at some initial time 0, where T is the terminal time. The estimate b indicates the partial correlation between growth and the start value of output per worker. The sign of the parameter b indicates whether economies are converging or not. The condition for convergence is that the first derivative of equation 19 is negative, as such:

$$\frac{\partial g_i}{\partial y_{i,0}} \equiv f'_{g_i, y_{i,0}} = b < 0\,, \tag{22}$$

furthermore, Alexiadis (2013, p. 94) describes that when $b = -1$ perfect convergence is present. Perfect convergence indicates that the countries are on a strictly balanced rate of convergence. A value of $b = 0$ leads to $g_i = a$ in equation 19 and this can be considered as an autonomous growth that does not allow for income differences between countries to disappear. Thus, the following is condition for β-convergence emerges:

$$-1 < b < 0, \tag{23}$$

if the beta estimate is within this range and statistically significant, we conclude that β-convergence is present (Barro & Sala-i-Martin, 2004, p. 467). The reader should note that *b* is the estimate for the β parameter. When β-convergence is present, one can calculate the speed of convergence λ and the half-life of this speed. The beta parameter may be expressed as follows:

$$b = -\left(1 - e^{-\lambda T}\right), \tag{24}$$

Where *T* is the range of years that is being analyzed (Barro & Sala-i-Martin, 2004, p. 462). Following equation 24, the expression for the speed of convergence is formulated:

$$\lambda = -\frac{\ln(b+1)}{T}, \tag{25}$$

It follows from equation 25 that if $-1 < b < 0$ then the parameter λ will be positive and a larger value of λ will lead do a faster average rate of convergence. The speed of convergence is reasonable to look at in a comparative sense, i.e. when we have two time periods or two groups of countries. When looking at one sample of countries, the half-life is more intuitive. The half-life measure is calculated per the following:

$$HalfLife = \frac{\log(2)}{\lambda}, \tag{26}$$

The half-life measure indicates the amount of time, in years, that it would take for the quantity measured to reduce to half of its initial size. When measuring this "catch-up" process we thus have three interesting parameters b, which determines β-convergence along with λ, which is speed of convergence and half-life.

The regression models used in this thesis is based on function 19. This is a simple linear regression with one explanatory variable as is described in the neoclassical model. The following general regression model is used;

$$\log(Real\ wage\ growth)_i = \alpha + \beta \log(Real\ wage\ in\ initial\ year)_i + \varepsilon_i, \qquad (27)$$

where i is country and ε_i is the error term. Thus, the real wage growth is depended on the real wage in the starting year, which varies depending on what period is under focus.

3.3 Club convergence

Convergence between countries might occur if one looks at a larger dataset of countries, here β-convergence and σ-convergence could be statistically significant. But some countries inside this analysis might experience convergence towards one equilibria, whilst other countries converge toward another steady state. This phenomenon is called club convergence and is of importance when measuring equality across countries. Economies might polarize into different clusters, for example poor and rich clusters. Identifying these could give insights into which countries have specific and different equilibria in terms of real wage convergence (Alexiadis, 2013, p. 61). For this thesis, there is an a priori assumption that "core"-economies of the EU might differ from peripheral economies. Should these clusters of countries emerge, it is also vital to verify if these clusters are transitory or permanent, i.e. are the clusters converging towards each other or towards separate steady states for the period measured.

Club convergence is when a subset of economies exhibits certain similarities, in this case real wages properties. Thus, absolute convergence might be restricted to this club and other economies outside of the club might experience different convergence patterns (Alexiadis, 2013, p. 61). Since real wage properties are similar it is assumed that propensities to save differ between the populations in the different countries. Another reason that countries might form convergence clubs is due to technological gaps (Alexiadis, 2013, p. 88)

3.4 Clustering EU countries

A hierarchical clustering method is employed to outline different clusters, and possibly convergence clubs based on the dissimilarities between countries in the EU.

Clusters are defined as k entities where the k consists of n observations. Here n is the total of countries in the EU and k are the clusters formed. A cluster needs to exhibit internal cohesion, homogeneity, and external separation from other possible clusters in the dataset (Everitt, et al.,

2011, p. 7). The method used in this thesis is that of the agglomerative hierarchical clustering. Applying this method, a computer program starts with $k = n$ clusters, so that all observations form separate entities. Then the program fuses different clusters together to form bigger clusters containing a larger quantity of observations. This process is repeated until one single cluster remains containing all the observations the process is shown in figure 6 below:

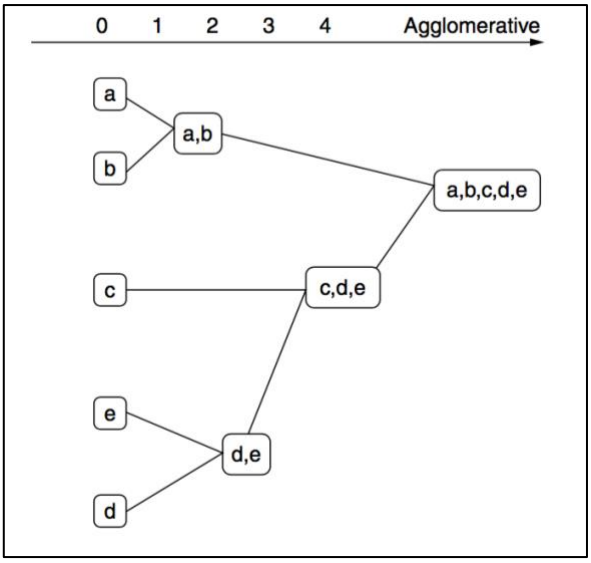


Figure 6 Example of dendogram (Everitt, et al., 2011, p. 71)

As we can see in figure 5, at step 0 each observation is in its own cluster. As the steps increase, new clusters are formed according to the complete linkage measure. This linkage measures the distance between groups as defined by their two most distant pair of observations per function 28:

$$D(X,Y) = \max_{x \in X, y \in Y} d(x,y), \tag{28}$$

where $d(x,y)$ is the distance between two observations x and y and $D(X,Y)$ is the distance between cluster X and Y, where x and y is a sub-observation in the respective cluster. This method will be applied on the panel data for the economies in the EU and the results will be visualized with a dendogram like the one in figure 6. Should different clubs be found in this analysis, then the clubs need to be homogenous to each other in respect to the variable used to perform the clustering. The statistical software will partly account for this question as it determines the farthest, most similar neighboring observation.

To further test this homogeneity, I will perform an analysis of convergence within the clusters. Should the analysis show that β-convergence occurs within the clusters, then they are not

homogenous, as some economies are catching up to each other instead of remaining on similar levels of real wage. If σ-convergence occurs within the clusters then disparities, in this case real wage differences, is reduced over the period.

3.5 Time-series convergence

Once the convergence clubs have been established, it is of further interest to verify if these clubs converge on each other or if the different clubs converge on different equilibria. A time series approach might be adopted to test for convergence between the different clubs. Here convergence tests are based on if the dispersion between the clubs have narrowed across all the available observations. Thus, convergence is defined as the long run forecasts of the time series in real wages between the groups of countries (Durlauf & Bernard, 1995, p. 99). it should be noted that time series convergence tests lack theoretical background, it has nevertheless been applied multiple times by economists such as Greasley and Oxley (1997) along with Kane (2001). When testing the convergence between two time-series, the following convergence property must hold:

$$\lim_{k\to\infty} E\left(y_{i,t+k} - y_{j,t+k} \middle| I_t\right) = 0\,, \tag{29}$$

where $y_{i,t+k}$ is equal to the logarithm of the real wage of economy i at time $t+k$ and $y_{j,t+k}$ is the logarithm of real wages in economy j at time $t+k$. I_t is the information available at time t. Equation 29 states that if the expected difference in real wages between the two economies are equal, in other words zero, in the long run, then we have unconditional "catch-up"-convergence. Equation 29 is then extended to include n economies in the different clubs according to:

$$\lim_{k\to\infty} E\left(y_{1,t+k} - y_{i,t+k} \middle| I_t\right) = 0 \;\; \forall i \neq 1, \tag{30}$$

Equation 30 states that the economies specified will converge if the long run forecasts of real wages for all economies are equal (Durlauf & Bernard, 1995, p. 99). A simple method of testing this empirically is to test for unit roots in the stochastic process, a test used frequently for this is the Augmented Dickey Fuller test (ADF-test). The ADF-test utilizes formula 31:

$$\Delta(y_{i,t} - y_{j,t}) = \mu + \alpha(y_{i,t-1} - y_{j,t-1}) + \beta t + \sum_{k=1}^{n} \delta_k \Delta(y_{i,t-k} - y_{j,t-k}) + \varepsilon_t, \qquad (31)$$

where μ is a constant, βt is the time trend and ε_t is the error term. α is equal to (1-ρ) where ρ is the unit root. If ρ=1, i.e. the stochastic process contains a unit root, then α=0 and the economies will not experience absolute convergence. If the stochastic process does not contain a unit root, then α<0 and the economies specified will experience convergence. (Durlauf & Bernard, 1995, pp. 98-100). When performing an ADF-test, the null hypothesis is that the time series contain a unit root and the alternative hypothesis is stationarity. In our situation, this means that if we cannot reject the null then no convergence takes place and if we accept the alternative hypothesis, then the time-series exhibit absolute convergence.

3.6 Data

In order to verify convergence over time, data on multiple countries spanning over several years is required. Panel data have thus been collected from Eurostat in the form of two different data sets. The first dataset describes nominal earnings over the period 1997 to 2015. The second dataset describes the annual average "Harmonized index of consumer prices" (from now on HICP) which will be used as a deflator when calculating real wages. The total list of countries that have been included in this analysis can be found in the appendix in table 20. Some countries have been excluded due to data availability as it would not be meaningful to keep them in the analysis since they would bias the results. These countries are Cyprus, Romania and Switzerland. A couple of countries that are not a part of the EU have been included since they enjoy the benefits of free mobility across EU borders and have access to the internal market. These countries are Norway and Iceland. Real wages are calculated as the ratio of nominal wages to HCPI and a third panel data set is produced for all countries using the datasets previously gathered. This dataset is then used in the convergence analysis described in chapter 3.1 and 3.2.

For the analysis described in chapter 3.3 I divide the data into different clusters using the clustering method described in chapter 3.4. Therefore, I have clusters with multiple time series, since there are several countries in each cluster. Then I take the mean of the time series in the

different clusters, this way I get three different time series describing the mean real wages. This will allow me to perform the time series convergences tests previously described in chapter 3.5.

4 Empirical results

This chapter contains the empirical findings of this thesis. The first section contains the results of the convergence analysis for the entire European Union during the period 1997 to 2015. In the second section I divide the data into two sub-periods, 1997-2007 and 2008-2015, to estimate the effect of the Eurozone crisis on the convergence process. The two last sections focus on the cluster analysis and convergence clubs, testing the convergence hypothesis using unit root tests on time-series.

4.1 Convergence across the EU

Table 1 shows the regression results for the aggregated data in the EU between 1997 and 2015. Table 2 shows the parameters of interest for the convergence analysis.

Table 1. Regression table for real wage convergence in EU-27 during 1997-2015

EU 97-15	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	8.17784	0.70390	11.62	1.43e-11 ***
ln_initial	-0.81155	0.07519	-10.79	6.71e-11 ***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*
Residual standard error: 0.6259 on 25 degrees of freedom
Multiple R-squared: 0.8233, Adjusted R-squared: 0.8163
F-statistic: 116.5 on 1 and 25 DF, p-value: 6.712e-11

Table 1 shows that the estimated slope is statistically significant at the 99% level, furthermore the slope is negative and within the bound specified in inequality 23. This indicates that β-convergence is occurring at a rate of -0,81% per year. The model is statistically significant at the 99% level.

Parameters of interest from this regression are:

Table 2 Parameters of interest for real wage convergence in EU-27 1997-2015

	σ-convergence	β-convergence	λ	Half-Life
EU 97-15	0.10574	-0.81155	0.09272	7.4757

According to table 2, we have σ-convergence since 0.10574 is larger than zero, which was the prerequisite for σ-convergence specified in equation 17. The real wage gap will be reduced by 50% in 7.47 years. β-convergence have occurred across the period since the estimate is within the range defined in inequality 23. The relationship is illustrated in figure 7.

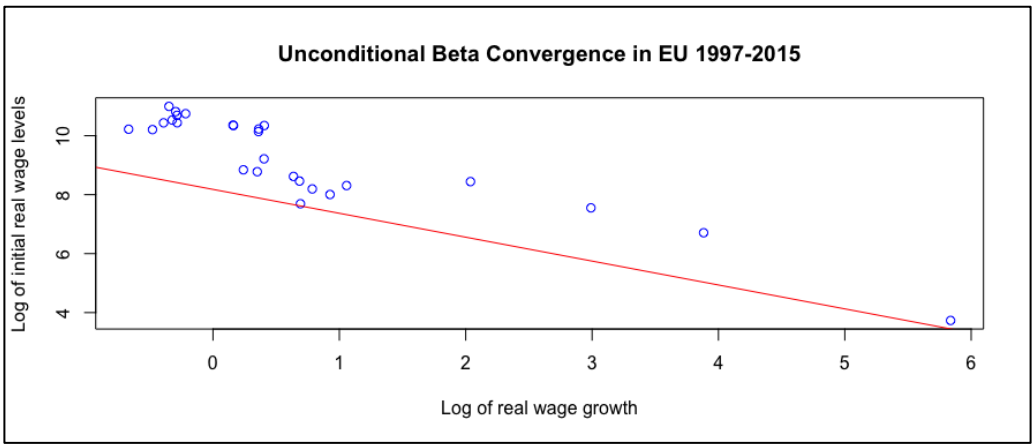


Figure 7 Graph depicting unconditional β-convergence in EU 1997-2015

The red regression line in figure 7 shows the negative relationship between initial real wages and real wage growth, this is considered evidence of β-convergence. Since the σ coefficient in table 2 is positive, this is evidence that σ-convergence has occurred in the period specified. To graphically show this, we can plot the coefficient of variation for each of the years in the period in figure 8;

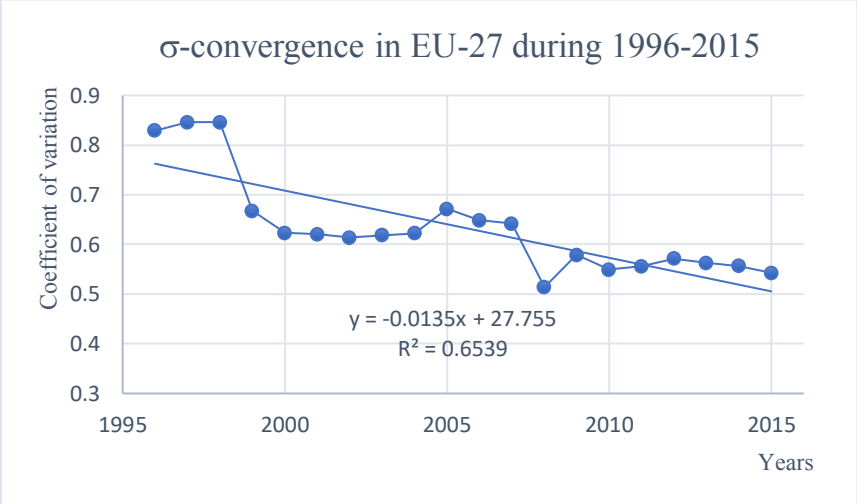


Figure 8 Graph depicting σ-convergence in EU-27 between 1996-2015

According to figure 8, the coefficient of variation decreases over the time period, so the disparities of real wages have decreased over time in the EU, due to data availability the CV is calculated for 1996 to 2015.

4.2 The effect of the Eurozone crisis on real wage convergence

According to previous research, the labor mobility was negatively affected by the financial crisis in 2007 (Eurofound, 2014). Since real wages equalize due to increased labor mobility and market integration, it is of interest to investigate the effect of the Eurozone crisis on real wage convergence. I therefore divide the data into two sub-periods; one for 1996-2007 and one for 2008-2015. The first hypothesis is that β-convergence is non-existent or that it is reduced in the aftermath of the crisis. The second hypothesis is that σ-convergence is non-existent or reduced in the aftermath of the crisis. The simple linear regression estimates for the period 1997-2007 are summarized in table 3;

Table 3 Regression table for real wage convergence in EU-27 during 1997-2007.

EU 97-07	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	7.89567	0.85304	9.256	1.49e-09 ***
ln_initial	-0.78824	0.09112	-8.651	5.48e-09 ***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*
Residual standard error: 0.7585 on 25 degrees of freedom
Multiple R-squared: 0.7496, Adjusted R-squared: 0.7396
F-statistic: 74.84 on 1 and 25 DF, p-value: 5.482e-09

According to table 3 we have a negative, statistically significant, estimated slope. Thus β-convergence is occurring at a rate of -0,79% per year before the crisis. The variables of interest from this regression are reported in table 4:

Table 4 Parameters of interest for real wage convergence in EU-27 1997-2007

	σ-convergence	β-convergence	λ	Half-Life
EU 97-07	0.09196	-0.78824	0.15523	4.46529

According to table 4, we have σ-convergence before the crisis. The real wage gap will be reduced by 50% in 4.47 years. β-convergence has occurred before the Eurozone crisis and the negative relationship is illustrated in figure 9:

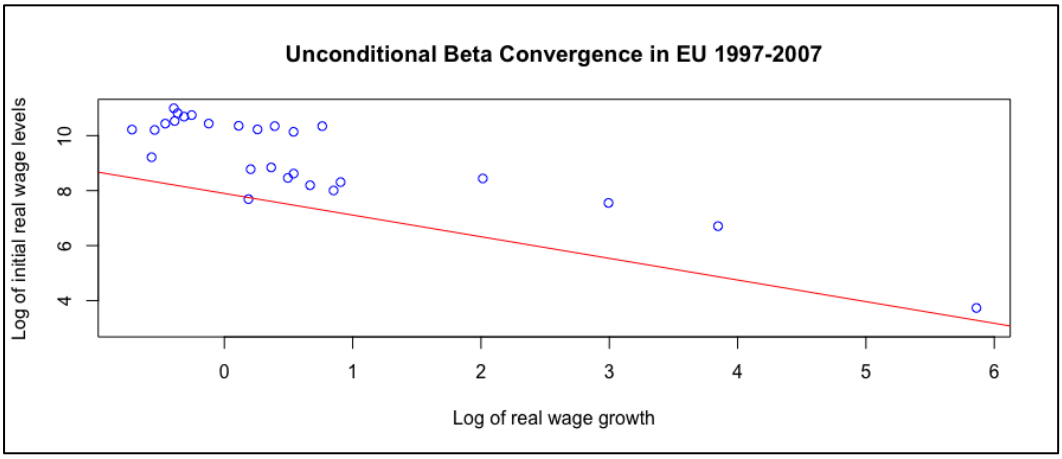


Figure 9 Graph depicting unconditional β convergence in EU 1997-2007

The relationship in figure 9 is similar to the relationship in figure 7. This is due to the fact that the initial values and b-estimates are alike in of both of the regressions. Since we have a downward sloping red regression line, we conclude that β-convergence has occurred before the crisis. Since the value of the estimated σ-convergence is positive, we conclude that real-wage disparities declined before the Eurozone crisis. This relationship is shown graphically by plotting the coefficient of variation in the figure 10;

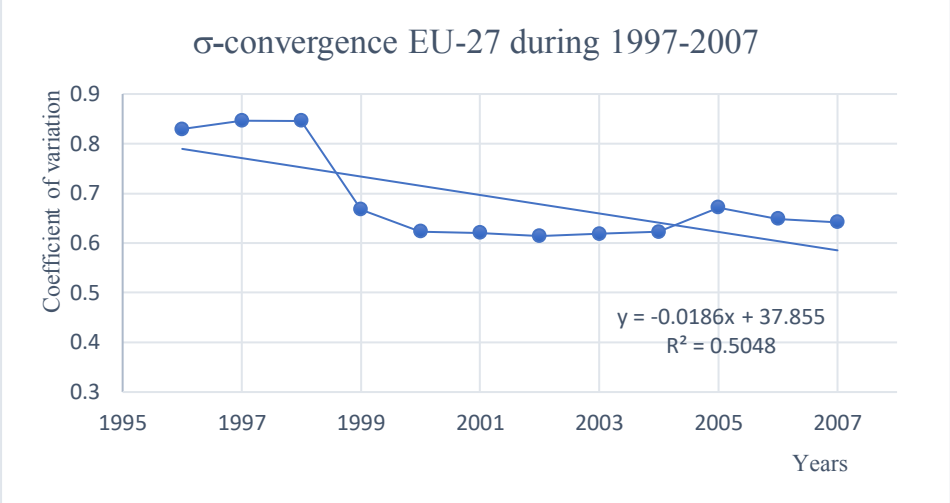


Figure 10 Graph depicting σ-convergence in EU-27 between 1996-2007

According to figure 10 the coefficient of variation has decreased before the crisis, and as a result, disparities of real wages have decreased in the EU. Due to data availability, the CV is calculated for the period 1996 to 2007. An a priori reflection is that the Eurozone crisis negatively affected the convergence process. If this were true, there should be a slower or non-existent convergence. The "After the crisis" linear regression results are summarized in table 5;

Table 5 Regression table for real wage convergence in EU-27 during 2008-2015

EU 08-15	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.60445	0.26247	2.303	0.0307 *
ln_initial	-0.05716	0.02636	-2.169	0.0407 *

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*
Residual standard error: 0.0931 on 23 degrees of freedom
Multiple R-squared: 0.1698, Adjusted R-squared: 0.1337
F-statistic: 4.703 on 1 and 23 DF, p-value: 0.0407

The variables of interest from this regression are reported in table 6;

Table 6 Parameters of interest for real wage convergence in EU-27 2008-2015

	σ-convergence	β-convergence	λ	Half-Life
EU 08-15	NA=0	-0.05716	0.00841	82.4194

β-convergence has occurred after the Eurozone crisis since the estimate is within the range defined in inequality 23. This process is happening at a rate of $-0{,}06\%$ per year. The relationship can be illustrated in figure 11;

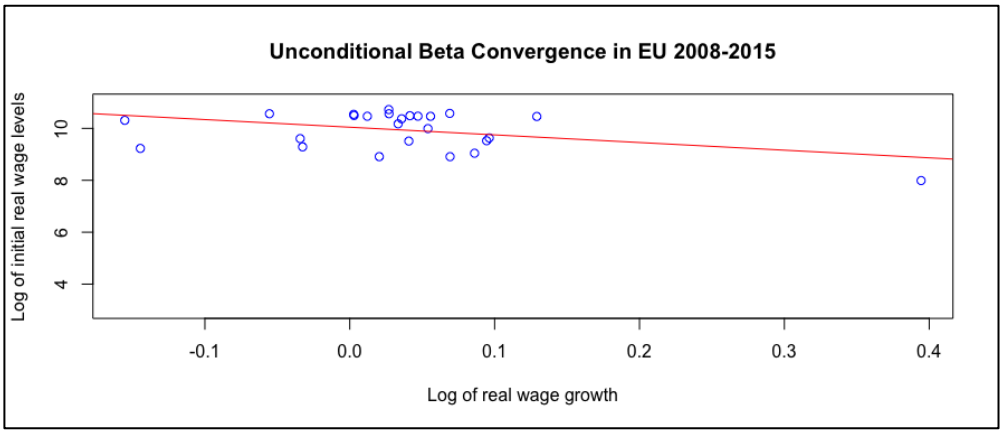


Figure 11 Graph depicting unconditional β convergence in EU-27 2007-2015

It is apparent that since the b coefficient is negative and statistically significant, the period after the crisis also exhibits β-convergence. It should be noted that the β-convergence was impaired because of the Eurozone crisis since the β-convergence estimate decreased. The estimate of σ-convergence in table 6 is not computed, this is since the statistical program deems these differences to be insignificant. Thus, we conclude that σ-convergence does not occur. However, this could mean that σ-divergence exists, and to examine this possibility we plot the coefficient of variation after the crisis in figure 12;

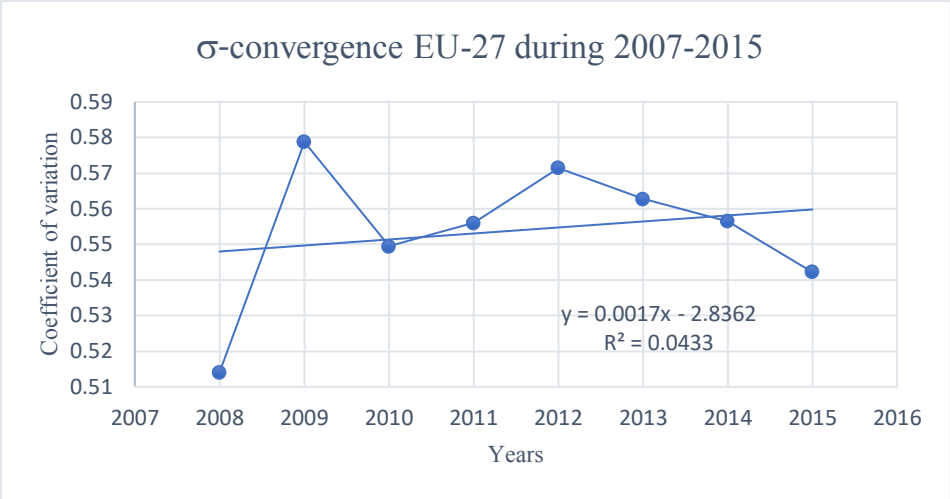


Figure 12 Graph depicting σ-convergence in EU-27 between 2008-2015

In figure 9 we can see that the trend is positive, which indicates that the disparities of real wages have increased after the crisis. The overall results are summarized in table 7;

Table 7 Summary of parameters for real wage convergence in EU-27 before and after the Eurozone crisis.

Time period	σ-convergence	β-convergence	λ- conv.speed	Half-Life
Before crisis	0.09196	-0.78824	0.15523	4.46529
After Crisis	0	-0.05716	0.00841	82.4194

From table 7 we see that the hypothesis that the real wage convergence process was affected by the Eurozone crisis is confirmed. The disparities of real wages have increased according to figure 12 and the *b* estimate is smaller after the crisis. The speed of convergence also drastically decreased. We can conclude that the Eurozone crisis affected real wage convergence, possibly through a decreased labor mobility.

4.3 Cluster analysis

According to the methodology in chapter 3.4, three clusters are formed. These are represented in figure 13:

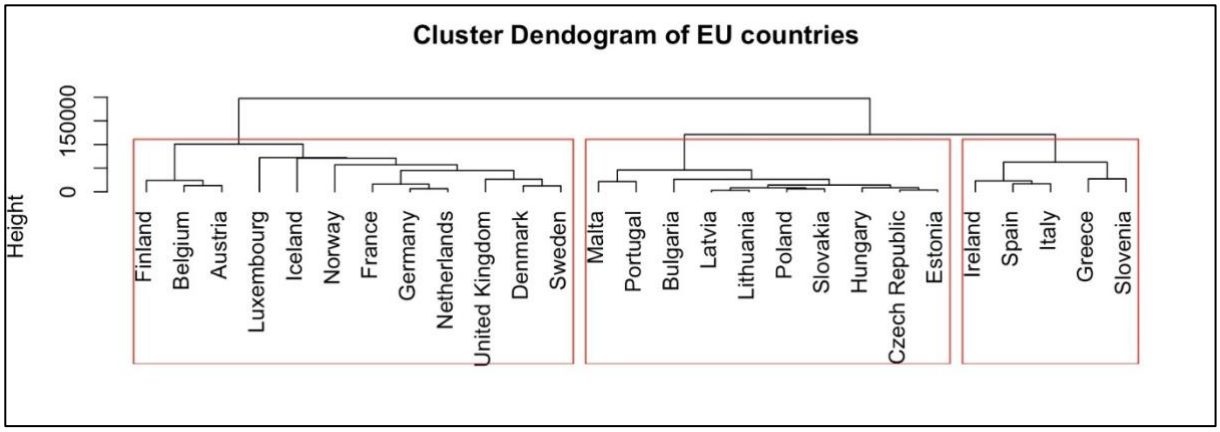


Figure 13 Dendogram depicting the emerging clusters from EU-27 and schengen countries.

The clusters are summarized in table 8-10.

Table 8 Cluster 1. Nordic countries and the majority of EU-15 countries.

Finland	Austria	Iceland	France	Netherlands	Denmark
Belgium	Luxembourg	Norway	Germany	U.Kingdom	Sweden

Cluster 1 contains what is considered strong economies, traditionally the Western countries of Europe and the Nordic countries.

Table 9 Cluster 2. The majority of the accession countries.

Malta	Portugal	Lithuania	Slovakia	Czech.Rep
Bulgaria	Latvia	Poland	Hungary	Estonia

Cluster 2 contains the accession countries that joined the EU in 2004, these are traditionally considered peripheral economies.

Table 10 Cluster 3. GIIPS-countries

Ireland	Italy	Slovenia
Spain	Greece	

Cluster 3 shows what is commonly referred to as the GIIPS countries, apart from Slovenia. Portugal is traditionally a part of the GIIPS countries but has been shown to belong to cluster 2 in this analysis. First and foremost, I verify the σ-convergence and β-convergence within each of the clusters. The hypothesis is that β-convergence does not exist since that would indicate that some countries are catching up to others in the cluster, making the cluster in question heterogeneous. The second hypothesis is that σ-convergence occurs within the different clusters, so they are converging to different real wage steady-state levels.

4.3.1 Cluster 1 results

Table 11 Regression table for real wage convergence in Cluster 1 during 1997-2015

Conv.Club 1	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	10.55363	0.19558	53.96	1.16e-13 ***
ln_initial	-1.00054	0.01981	-50.51	2.24e-13 ***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*
Residual standard error: 0.0925 on 10 degrees of freedom
Multiple R-squared: 0.9961, Adjusted R-squared: 0.9957
F-statistic: 2551 on 1 and 10 DF, p-value: 2.237e-13

Variables of interest from this regression are:

Table 12 Parameters of interest for real wage convergence in Cluster 1 1997-2015

	σ-convergence	β-convergence	λ	Half-Life
Cluster1 97-15	0.12981	-1.00054	-	-

According to inequality 23 no β-convergence has occurred since b<-1. Since no countries are catching up to the others in cluster 1, it is redundant to calculate speed of convergence and half-life. It is however noteworthy that the b-estimate is close to -1 indicating perfect convergence in cluster 1. Since the value of σ-convergence is positive, then according to inequality 15 we have σ-convergence in cluster 1. So, the disparities of real wages between the countries in cluster 1 are decreasing. This can be shown, as before, in a figure depicting the decrease of coefficient of variation over the period:

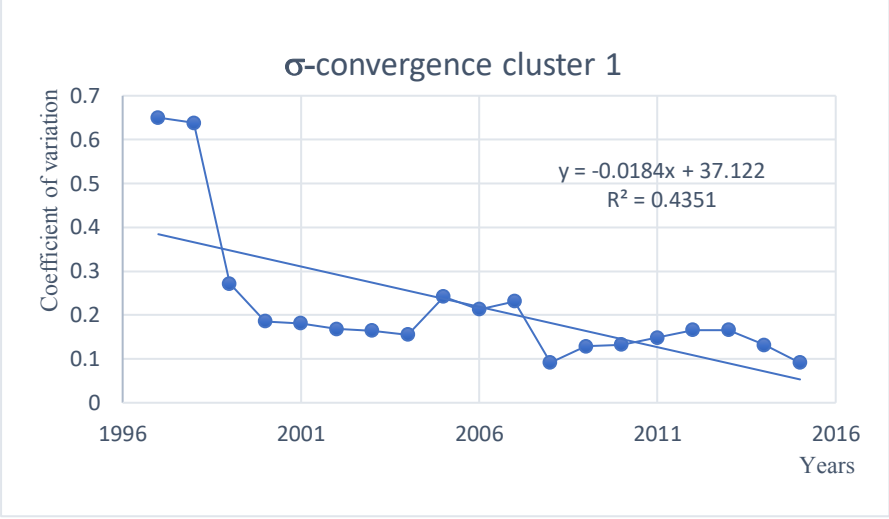


Figure 14 Graph depicting σ-convergence in Cluster 1 between 1997-2015

4.3.2 Cluster 2 results

Table 13 Regression table for real wage convergence in Cluster 2 during 1997-2015

Conv. Club 2	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	9.50033	0.63900	14.87	4.13e-07 ***
ln_initial	-1.04430	0.07869	-13.27	9.92e-07 ***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Residual standard error: 0.3676 on 8 degrees of freedom
Multiple R-squared: 0.9566, Adjusted R-squared: 0.9511
F-statistic: 176.1 on 1 and 8 DF, p-value: 9.918e-07

Variables of interest from this regression are:

Table 14 Parameters of interest for real wage convergence in Cluster 2 1997-2015

	σ-convergence	β-convergence	λ	Half-Life
Cluster2 97-15	0.14833	-1.0443	-	-

According to inequality 23 no beta convergence has occurred since b<-1. Since no countries are catching up to the others in cluster 2, it is redundant to calculate speed of convergence and half-life. Since the value of σ-convergence is positive, then per inequality 15 we have σ-convergence in cluster 2. So, the disparities of real wages between the countries in cluster 2 are decreasing. This is shown in figure 15, which depicts the decrease of coefficient of variation over the period:

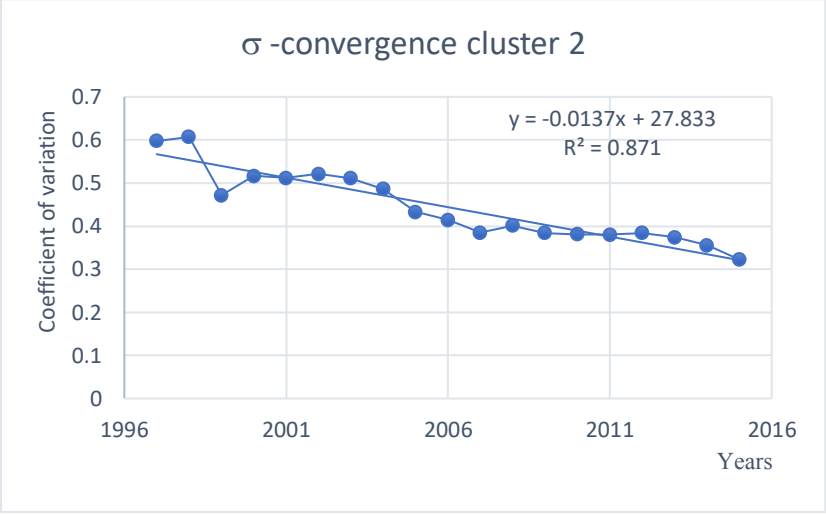


Figure 15 Graph depicting σ-convergence in Cluster 2 between 1997-2015

4.3.3 Cluster 3 results

Table 15 Regression table for real wage convergence in Cluster 3 during 1997-2015

Cluster3 97-15	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-9.4765	3.5135	-2.697	0.0740 .
ln_initial	0.8728	0.3389	2.575	0.0821 .

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*
Residual standard error: 0.09842 on 3 degrees of freedom
Multiple R-squared: 0.6886, Adjusted R-squared: 0.5847
F-statistic: 6.632 on 1 and 3 DF, p-value: 0.08211

Variables of interest from this regression are:

Table 16 Parameters of interest for real wage convergence in cluster 3 1997-2015

	σ-convergence	β-convergence	λ	Half-Life
Cluster3 97-15	-0.01312	0.87278	-	-

According to inequality 23 no β-convergence has occurred since b>0. Since no countries are catching up to the others in cluster 3, it is redundant to calculate speed of convergence and half-life. It should be noted that the regression in table 15 is not statistically significant. Since the value of σ-convergence is negative, then per equation 15 the initial standard deviation is larger than the standard deviation at terminal time T. So, the disparities of real wages between the countries in cluster 2 have increased and we have σ-divergence. This can be shown in figure 16:

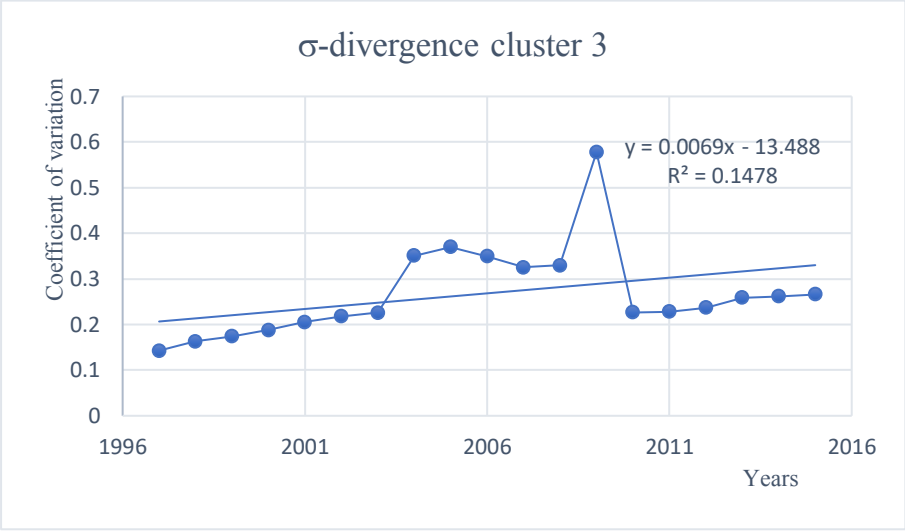


Figure 16 Graph depicting σ-divergence in Cluster 3 between 1997-2015

The results for all three clusters are summarized in table 17;

Table 17 Summary of parameters for all clusters 1997-2015.

Cluster	σ-convergence	β-convergence	λ- conv.speed	Half-Life
1	0.12981	-1.00054	-	-
2	0.14833	-1.04430	-	-
3	-0.01312	0.87278	-	-

Per table 17 no β-convergence has occurred in any of the clusters, σ-convergence is present in clusters 1 and 2, meaning that they converge on different steady state levels of real wages. Cluster 3 exhibits σ-divergence, which mean that the disparities in real wages increased over the period. It is now appropriate to label cluster 1 and 2 "Convergence Club 1" and "Convergence Club 2" respectively. Cluster 3 will not be relabeled since it exhibits sigma divergence and not convergence.

4.4 Convergence tests using time-series

We have concluded that different convergence clubs / clusters exist and that they seem to be converging on different steady state levels. The next question is, are the clubs in a transitory state, i.e. are they moving towards each other or are they stagnant at their individual real wage levels. The first hypothesis is that cluster 2 catches up to the real wage levels of cluster 1. The second hypothesis is that the countries in cluster 3 catch up to the real wage levels of either cluster 1 or cluster 2. This assessment is based on previously described time-series differences and the utilization of unit root tests. The results are presented in table 18 below;

Table 18Time-series convergence tests using augmented dickey fuller tests for unit roots in all clusters.

Time series difference	A.Dickey-fuller estimate	P-value
Cluster 1 – Cluster 2	-1.0837	0.9083
Cluster 2 – Cluster 3	-2.4299	0.4086
Cluster 1 – Cluster 3	-3.0915	0.1566

Since we cannot reject the null hypothesis in any of the time series, neither of the clusters are converging on each other. This means that the clusters are not transitory, but rather remain on separate levels of real wages. The time series of the three clusters are depicted in figure 17;

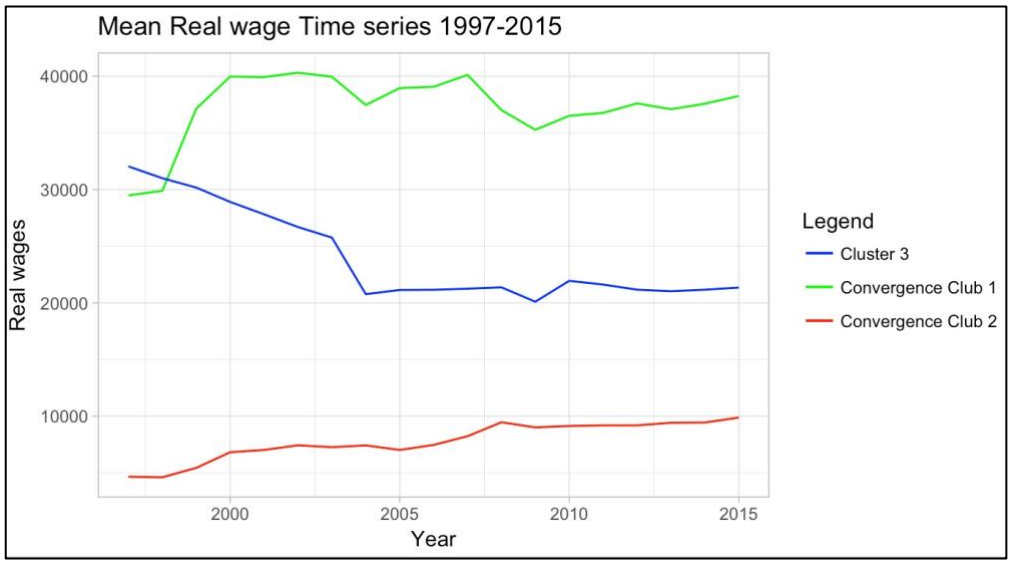


Figure 17 Time-series depicting the mean real wages in all convergence clubs and clusters.

According to the results, Convergence Club 2 will not converge on Convergence Club 1. It should be noted that Convergence club 1 has 3.9 times higher real wages than convergence club 2 in 2015. Cluster 3 is undetermined in terms of convergence, and thus, I have looked at each of the countries in cluster 3 individually. Cluster 3 consists of countries that one might assume would belong to either convergence club 1 or 2. It is therefore of interest to verify if the separate countries in cluster 3 converge on the real wage levels in convergence clubs 1 or 2. The result of this analysis follows in table 19 below:

Table 19 Time-series convergence tests using augmented dickey fuller tests for unit roots for cluster 3 countries.

Time series difference	A.Dickey-fuller estimate	P-value
Ireland – Cluster 1	-2.4452	0.4028
Ireland – Cluster 2	-3.2978	0.09198*
Greece – Cluster 1	-1.9119	0.606
Greece – Cluster 2	-1.5998	0.7248
Spain – Cluster 1	-2.9346	0.2164
Spain – Cluster 2	-1.505	0.761
Italy – Cluster 1	-3.5834	0.0523*
Italy – Cluster 2	-1.6653	0.6999
Slovenia – Cluster 1	-1.833	0.636
Slovenia – Cluster 2	1.4345	0.99

From table 19 we learn that Ireland is expected to converge to the real wage levels of Convergence Club 2 and Italy is converging towards the real wage levels of convergence club 1. Both unit roots tests are statistically significant at the 90% level. Greece, Spain and Slovenia are not converging towards either Convergence Club 1 or 2.

5 Analysis and discussion

5.1 Analysis

We can conclude that unconditional β-convergence and σ-convergence has occurred in the aggregate investigation presented in table 2 and figure 8. The disparities of real wages have decreased over the period and the "poorer" countries experience a more rapid growth than the "rich" countries. The β-convergence is happening at a rate of -0,81% per year, which is consistent with earlier research in growth empirics. The results indicate that real wages across the EU are converging on each other to some future real wage mean. This result is in accordance with what the theory in chapter 2.3 predicted, that when labor mobility increases, the wage differentials should decrease.

Earlier reports indicated that labor mobility was impeded by the Eurozone crisis, and thus to a certain extent, the process of real wage convergence should be affected in a negative fashion. The results from table 7 confirm that the rate of real wage convergence was changed from -0,79% before the crisis, to -0,06% after the crisis. Thus β-convergence was stalled by the Eurozone crisis. σ-convergence was also affected by the crisis. Before the crisis, the disparities were decreasing. After the crisis, we have mixed results. Table 7 indicates that σ-convergence was non-existent - in other words, the disparities were constant in the period. Figure 12, however, shows a slight increase in the coefficient of variation in the period after the crisis. I conclude that the disparities of real wages increased after the Eurozone crisis and we have σ-divergence.

It could be so that countries with similar real wage growth over the period, form specific convergence clubs due to similar characteristics. The EU countries were formed into clusters using a hierarchical clustering method. In Convergence Club 1 we have the main body of the EU-15 along with Norway and Iceland; Belgium, Germany, Finland, Austria, Luxembourg, France, Netherlands, United Kingdom, Denmark and Sweden. Convergence Club 2 contains

most of the EU countries that joined the union in the 2004 enlargement; Malta, Bulgaria, Latvia, Lithuania, Slovakia, Hungary, Czech Republic and Estonia. Portugal is also a part of Convergence club 2. Cluster 3 consist of GIIPS-countries apart from Portugal. Slovenia is also included in cluster 3.

No β-convergence can be found within the clusters. I view this as a positive; the clusters are homogenous enough so that no country in any of the clusters can be viewed as "poor" in relation to the other countries within the respective cluster. Thus, no "catching-up" process is occurring. The disparities of real wage decrease in both Convergence Club 1 and 2. So these clubs might be converging to some future "Convergence club-specific" real wage mean. Cluster 3, however, is experiencing divergence in real wage disparities. This leads to the suspicion that cluster 3 might be in a transitory state. The countries in cluster 3 might be converging to either Convergence Club 1 or 2. So, cluster 1 and 2 form separate convergence clubs, and cluster 3 countries could belong to either of these convergence clubs, or neither. Using time series analysis, I conclude that Convergence clubs 1 and 2 do not converge to each other, further establishing the conclusion that they form convergence clubs. Cluster 3 does not seem to be converging on either of the convergence clubs. When analyzing the disaggregated countries in cluster 3 separately, I find that Ireland is converging on Convergence club 2. Italy is converging on Convergence club 1. Spain, Greece and Slovenia does not appear to be converging on any of the convergence clubs. Thus, only parts of cluster 3 converge on the convergence clubs.

In conclusion, the real wages in EU are converging over the period, a process which was negatively affected by the Eurozone crisis. When dividing the countries into different clusters, it seems that a certain group of countries converge to one level of real wages whilst another group of countries converge to a separate, lower level, of real wages. In addition to this, there are a few countries that are in a transitory state towards these groups of countries and a few that seem to be converging towards some other real wage level entirely.

5.2 Discussion

At first glance, the theory of labor mobility in chapter 2.3 appears to hold. As countries join the EU and its citizens gain better mobility opportunities, the real wages tend to equalize as the labor markets becomes more integrated. The theory also holds when looking at the difference

of real wage equalization before and after the Eurozone crisis. Previous research tells us that labor mobility abilities were worsened after the crisis, and the theory says that this should stall the convergence of real wages. The results of this investigation are consistent with this fact.

Some countries group up in their progress and form convergence clubs. When determining why these clubs have formed, I refer to the key determinants of the wage structure described in chapter 2.5 of this thesis. The convergence clubs might have formed because they differ in their characteristics in the different determinants of wages. The key determinants of wages, which can be found in chapter 2.5 is the following;

1. *Differences in labor productivity.*

Convergence club 1 exhibit larger labor productivity. This might be one reason that wage development is similar and thus why the countries cluster together. Convergence club 2 is comprised of countries which, on average, have lower labor productivity.

2. *Stronger labor laws and policies.*

Convergence club 1 consist of countries that has a higher proportion of workers that are covered by collective bargaining per figure 4. Convergence club 2 have lower coverage rates on average. This could lead to a higher real wage in convergence club 1 than in convergence club 2.

3. *Price levels*

In the appendix, we find the HCPI levels from 2000 to 2002. We see that the accession countries experience higher inflation rates than the EU-15. According to the real wage equation, the higher HCPI equals a lower real wage, all else equal. Thus, the price levels could lead to different real wage levels.

The final part of the analysis concludes that the clubs that have formed does not converge to each other. Thus, the consequence is that different real wage levels in Europe will persist. These countries might remain at these real wage levels, as suggested by the data used in this thesis. A third cluster of transitory countries have crystalized in the analysis; Italy, Spain, Ireland, Greece and Slovenia. Out of these five countries, only Italy and Ireland converge to the real wage levels of the clubs. Italy is moving towards club 1 and Ireland is moving towards club 2. Spain, Slovenia and Greece does not converge to either club. The reason for the behavior of the third cluster is beyond this thesis, but does compel for further research.

There might be several causes that real wages do not converge in the EU, one reason for wage differential remaining stagnant could be that even though the EU promotes labor mobility, other factors than physical costs might be included when deciding to migrate. The *M* term in equation 3 might be quite large due to the fact that cultural- and language barriers hinders labor mobility. Other reasons for this *M* term to be large might be strong family ties in the home country or lack of social networks in the country where one might migrate to.

Policy makers should focus on recognition of professional qualifications for certain professions. Public sector jobs such as teaching or nurses should also become less restricted in terms of access for other EU-nationals. In Sweden, for instance, there is a lack of the supply of teachers. This causes wages for teachers to increase on average in Sweden. The supply of teachers in Europe might be of use in this problem if the Swedish labor market is open to foreign labor supply.

Insurance systems in the country where one might be inclined to migrate to must be able to cover the EU-national that is considering a relocation. If the benefit of unemployment protection is not given to the migrant, then they might deem the risk in the new country to high since they might end up unemployed.

Language barriers is considered one of the largest hurdles for migrants. Policy makers should make language courses free and provide ample information on where and how such courses might be undertaken. One problem that might cause the M term to be inflated is the lack of information of job vacancies. Migrants might face a mismatch problem where they search for work in the new country but do not know how to find one. This might cause them to not risk moving to the new country at all. Here it is of importance that that public information is accessible for migrants.

The last problem that might not allow the market to function properly is that which is caused by the perceived “brain drain”. Countries which find their most driven and educated workforce leaving the country might set up policies that hinders this to some extent. Countries that receive educated migrants on the other hand might set up policies that protects the domestic labor market and hinders these migrants to properly integrate into the market.

6 Concluding remarks

The attractions of an EU-membership for a candidate country are several. Increasing living standards is a commonly referred to argument when rallying public opinion prior to entry referendums. A specific measure of such welfare is the real wages of workers. Therefore, the analysis that this thesis has undertaken, could well be argued to be of high political interest for many parties. Both those with an agenda to welcome more member states, as well as the movements opting for "Brexits", will find their arguments nuanced here and questioned beyond feelings and values – this analysis shows that an EU membership does not necessarily equal growth and convergence, and that it definitely does not hold the same development promises for each member state. Will real wages of a candidate country increase to the levels of more productive EU states? This analysis shows that it is likely that the real wages of a candidate country will grow more similar, or converge to, the economies of a club of newer members of the union, i.e. not the countries with the strongest or best growth rates.

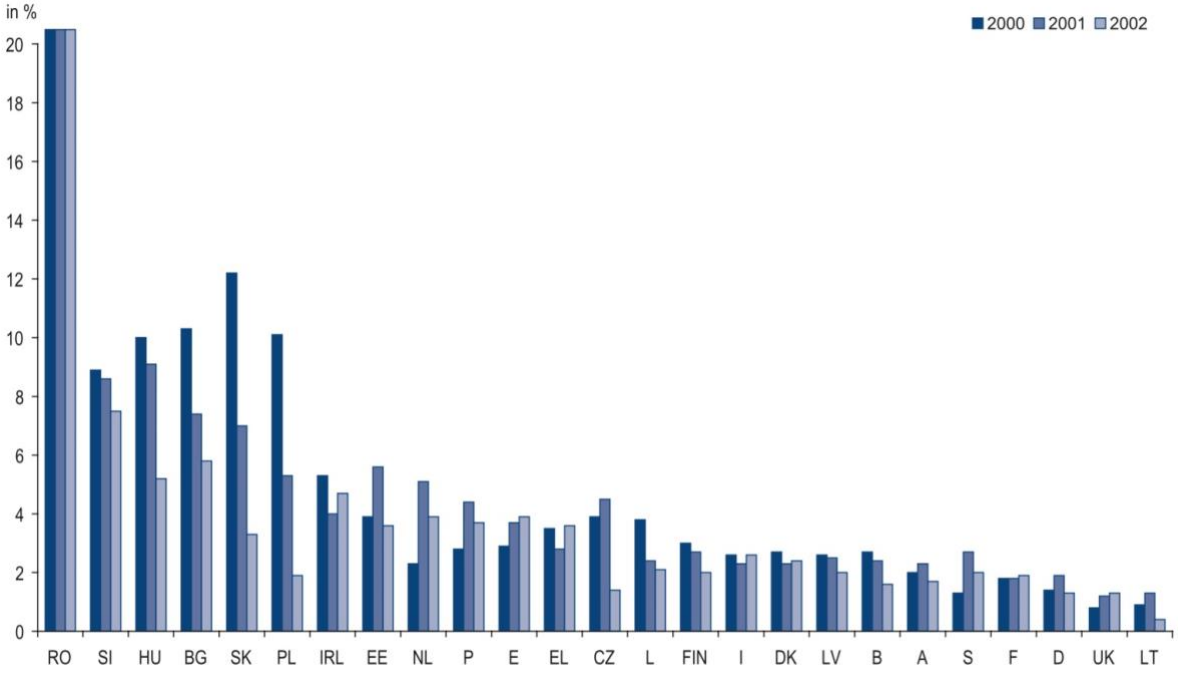
The more advanced members of the EU will remain on a higher level of real wages, which appears to be out of reach for the newer and prospect member states. Previous research has shown that real wage development is due to certain determinants, and future research could direct its attention towards the two different real wage clubs outlined in this analysis, and investigate *why* they differ, as this thesis merely concluded that they do.

7 Appendix

Table 20 Countries and country specific codes.

Countries	Country code
Belgium	BE
Bulgaria	BG
Czech Republic	CZ
Denmark	DK
Germany	DE
Estonia	EE
Ireland	IE
Greece	EL
Spain	ES
France	FR
Italy	IT
Latvia	LV
Lithuania	LT
Luxembourg	LU
Hungary	HU
Malta	MT
Netherlands	NL
Austria	AT
Poland	PL
Portugal	PT
Slovenia	SI
Slovakia	SK
Finland	FI
Sweden	SE
United Kingdom	UK
Iceland	IS
Norway	NO
Croatia	HR
Cyprus	CY
Romania	RO
Switzerland	CH

Table 21 Harmonized index for consumer prices between 2000 and 2002 in the European Union. (Eurofound, 2014, p. 106)



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