LABOUR MARKET ADJUSTMENT IN THE EUROZONE: BEFORE AND AFTER THE GREAT RECESSION

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1 | Introduction

The success of the European Monetary Union (EMU) is often evaluated with respect to the Optimal Currency Area criteria, that cites the necessity of factor and price mobility across the region, a risk sharing system, and a synchronized business cycle, in order to absorb asymmetric shocks (Mundell, 1961). Before the implementation of the Euro, labour mobility was found to be much lower within the EMU than in the US, which is often used as the benchmark for a currency union. In early papers such as Blanchard and Katz (1992) and Decressin and Fatás (1995) it was predicted that labour mobility would play a minor role in the adjustment process to asymmetric shocks in a European Currency Union. Despite this predicted weakness of the common currency, the EU and Euro-zone countries trusted the OCA criteria would be 'self-fulfilling', and that with the help of EU and national level policies labour mobility would increase. When the asymmetric shock arrived, in the form of the Great Recession, unemployment rates began to diverge across Europe, Government debt began to increase, and the ability of Euro Area states to pay back their debts was questioned, resulting in the Sovereign Debt Crisis. Given the ability of labour mobility to cushion negative impacts of labour demand shocks on unemployment, and redistribute workers to countries with higher labour demand, it has once again become an important policy topic within the European Monetary Union, and EU (Bayer & Smets, 2015).

This paper will analyse adjustment mechanisms to asymmetric labour demand shocks in European Currency Union member countries, comparing the differences between the pre-Great Recession and post-Great Recession samples. The analysis will consider only the Original EMU members (EMU-11) and Greece in order to have sufficient data of EMU countries before, and after the crises, and the sample time period begins in 1996 due to data availability to ensure a balanced panel. This group of countries will be referred to throughout the paper as the EMU-12. The paper will use Vector Autoregression Analysis following the model first used in Blanchard and Katz (1992) as a baseline model. This model is often used in the labour mobility literature as it estimates the response of migration to shocks without the need for data on migration which is often quite limited, and is still used often in current investigations (Arpaia, Kiss, Palvolgyi, & Turrini, 2016), (Bayer & Smets, 2015) (Dao, Furceri, & Loungani, 2014). This paper also incorporates real wages into the analysis, which allows the paper to test empirically the optimal currency area criteria (Mundell, 1961), and also an assumption of the Blanchard and Katz (1992) model, that assumes that relative real

wages remain unchanged after a shock. Country level data is used as opposed to region due to a lack of data availability of real wages at the regional level.

The key finding of the analysis is that in the period after the onset of the crisis, the responsiveness of labour mobility to an employment shock increased. When adjustment through labour mobility was needed most in the EMU-12, it improved. After 1 year, labour mobility is estimated to absorb approximately 33% of an asymmetric shock when considering the 1996-2008 period, compared to 35% in the post crisis period. The big difference is seen in the medium term. After 5 years, labour mobility is estimated to absorb approximately 92% of an asymmetric shock in the post crisis period, compared to 44% in the 1996-2008 period. This indicates that in the period after the onset of the financial crisis, labour mobility became much more responsive to asymmetric labour demand shocks.

The paper is organized as follows. Section 2 covers the importance of labour mobility as an adjustment channel, and a brief summary of the findings of past papers that have looked at Labour Mobility in Europe. Section 3 discusses the observed data regarding mobility and the labour market dynamics in the EMU-12 countries. Next, in parts 4, and 5, the method of evaluation and data sources used in this paper will be examined. Part 6 will show and discuss the findings from the models, before conclusions and a brief word on the impact on mobility as an adjustment channel of COVID-19.

2 | Labour Markets and Mobility in Europe

2.1 | Net Migration in the EMU-12

When evaluating whether or not the EMU does meet the Optimal Currency Area (OCA) criteria, it is often compared to the USA. Although labour mobility within the EU is increasing, the research consistently finds that labour mobility in the EU is much lower than the USA, and well below mobility within countries (Farhi and Werning, 2014; Dijkstra and Gáková, 2009; Arpaia, et. al., 2016). Figure 1 is taken from Arpaia et al. (2016) and highlights this consistent difference (Note: Data for the EU series excludes Germany, since no time series is available about the breakdown of foreigners living in Germany by country of origin. Source: Eurostat population statistics and Eurostat special extraction from the Eurostat LFS; US Census Bureau, Census and American Community Survey).

Figure 1 shows the relative net migration (net migrants per 1000 inhabitants) for the for the selected countries from the EMU-12. The graph highlights that the countries that were hit hardest by the Great Recession and debt crises saw a sharp decrease in net migration, with Spain, Greece, Portugal and Ireland all experiencing multiple years of negative net-migration during the crisis years. Contrarily, countries such as Germany and Austria, that were less affected by the crises saw an increase in net migration after the initial shock of the Great Recession, however this increase is much smaller in magnitude than the declines in net migration seen in hard hit countries. Zivot and Andrews Structural Break tests estimate structural breaks the series for Greece, Ireland and the Netherlands around the great recession as well as structural break in the EMU-12 aggregate net migration (test results included as appendix 1).

A decrease in net migration can be seen for almost all countries in 2020 from the sample which is almost certainly a result of COVID-19 and the associated economic impacts, especially job losses, however the impact of COVID-19 on labour mobility in Europe is outside the scope of this paper, and thus, 2020 is excluded from the sample.

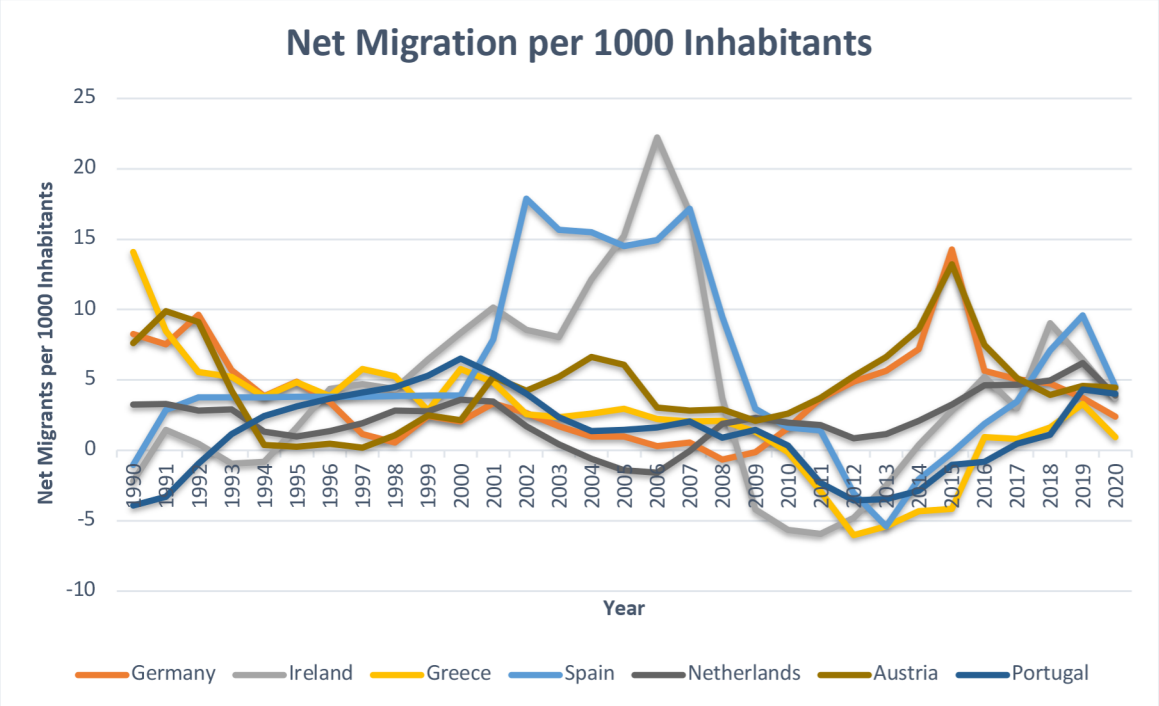

Figure 1: Net migration, 1990–2020: EMU-12. Note: Statistics on net migration include statistical adjustment by national statistical offices.. Source: Eurostat, own calculations.

2.2 | Labour Markets in Europe

Labour market conditions in both the home and destination countries are key factors in the decision to migrate (Mcauliffe & Khadira, 2019), and without differences between labour market conditions there would no need for the labour mobility adjustment channel in the Optimal Currency Area theory (Mundell, 1961). Figures 2, 3, 4, and 5 compare selected EMU-12 member country's employment growth, unemployment rates, participation rates and real wages relative to aggregate EMU-12 values for each time period. Looking at the relative rates with respect to the combined EMU-12 rates allows the removal of common trends and shocks that effect all countries in the sample from the analysis. The data used in the following graphs is the same used in the model estimations in section 5 of this paper.

2.2.1 | Relative Employment Growth

Figure 2 shows the relative log employment levels in first differences, and it can be seen visually that the same countries that experienced negative migration around the crises experienced negative relative employment growth, namely Greece, Spain, Ireland and Portugal. Spain and Ireland in particular show positive relative employment growth before the crisis, which coinsides with periods of sustained net inward migration as shown in Figure 1. The countries that experience net migration during the crisis as seen in Figure 2 (Germany and Austria) saw positive relative employment growth in the same period. Structural break tests suggest both Ireland and Austria experienced structural breaks in 2008 (see appendix 2, at the end of the paper).

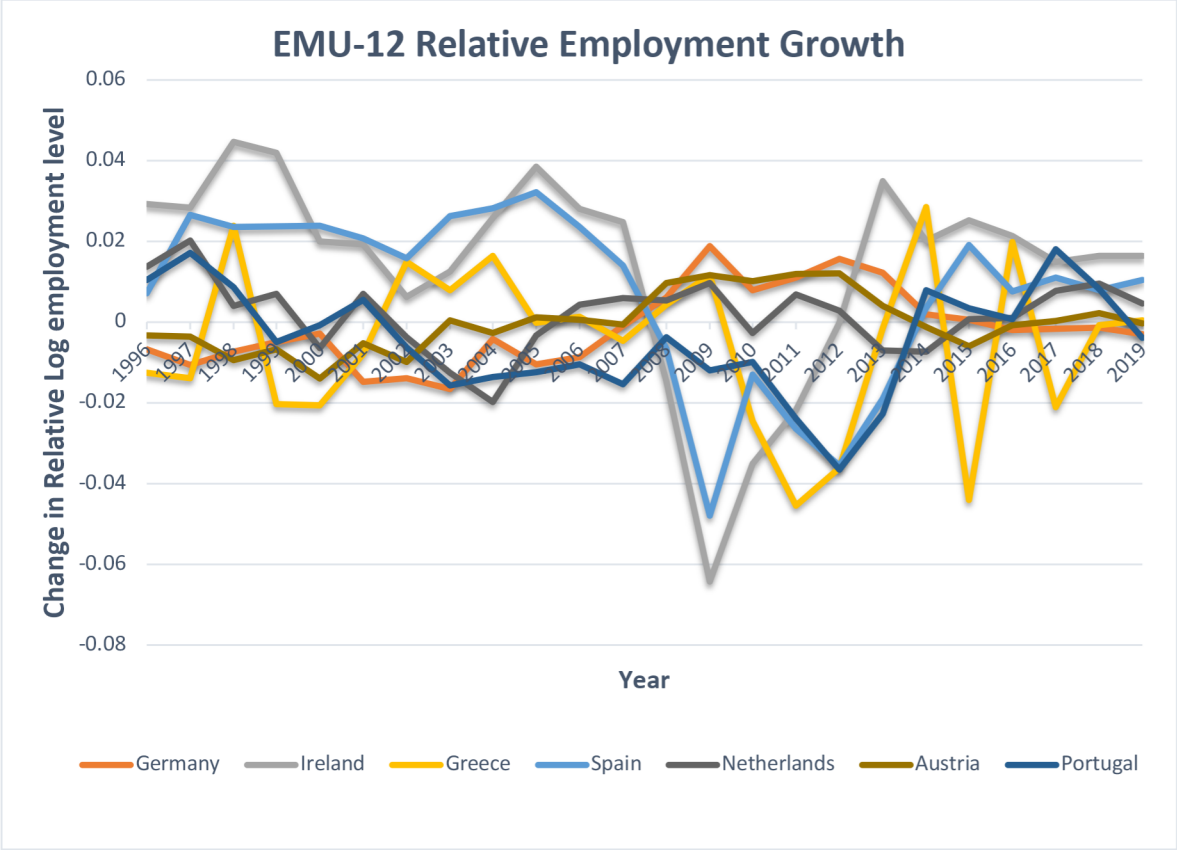

Figure 2: Employment Growth Relative to the Combined EMU-12 Employment Growth, 1996–2019: EMU-12. Source: AMECO Database, own calculations.

2.2.2 | Relative Unemployment Rates

Figure 3 shows relative employment rates, which are calculated as the inverse (multiplied by -1) of the unemployment rate. Unemployment rates within the Eurozone had been converging between the introduction of the Euro until the crisis. Would analyzing all EMU-12 countries It can also be seen that the same countries are persistently slightly above or below the combined EMU-12 unemployment rate. This is to be expected and reflects structural differences in labour market conditions across different countries, such as differing worker protection, minimum wages and industrial bargaining structures. Ireland, Portugal, Greece and Spain all experienced increases in the relative unemployment rate between 2007 and 2012, at slightly different times. The relative unemployment rate in Portugal and Ireland eventually returned to roughly pre-crisis levels, however Spain and Greece continue to experience high unemployment rates. This could be evidence of a persistent, asymmetric, negative labour demand shock, or perhaps is reflective of structural problems in the labour market.

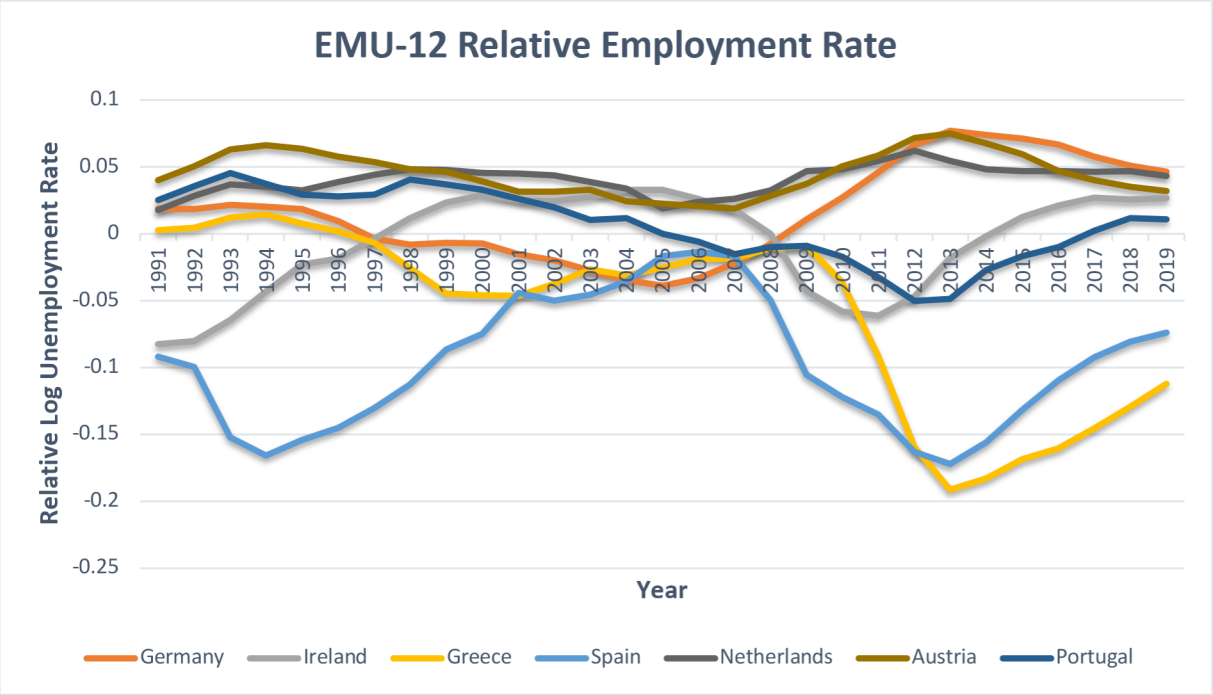

Figure 3: Unemployment Rate Relative to the Combined EMU-12 Unemployment Rate, 1991–2019: EMU-12. Source: AMECO Database, own calculations.

2.2.3 | Relative Participation Rates

Figure 4 shows obvious differences in participation rates among EU-12, however the correlation between poorly performing countries and net outward migration is not as strong as in the employment growth and unemployment rate data. . The participation rates relative to the combined EU-12 participation rate are reasonably steady, with the exception of Greece that experienced a large increase in its participation rate relative to the combined Euro-zone participation rate during the crises, and Ireland, which experienced a decrease in the relative participation rate. Both of these countries experienced negative relative employment growth in this period, therefore the change in participation rate is more likely due to structural and societal factors. Karamessini and Koutentakis' 2014 paper contributed Greece's increasing relative participation rate to Women, predominately mothers, joining the labour force, and Barret and McGuiness (2012) suggest structural factors around recruitment and the hiring process in Ireland discouraged the working age population from searching for work. Although not obvious in the graph, France also experienced a structural break in relative participation rate in 2008 (see appendix 4).

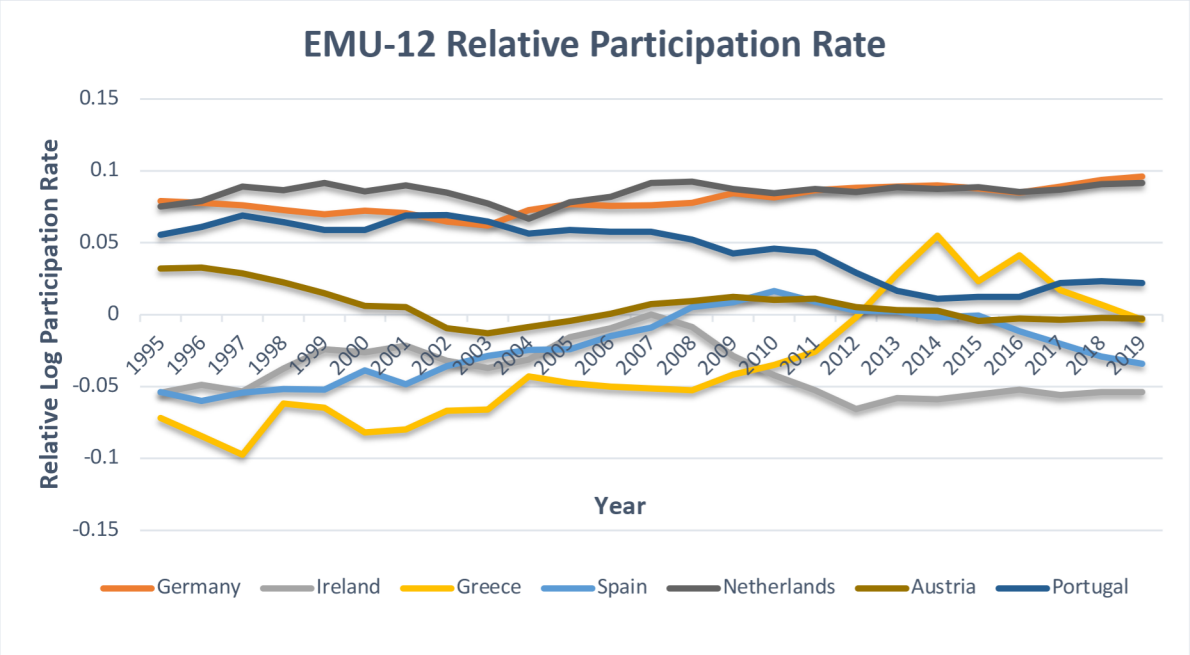

Figure 4: Participation Rate Relative to the Combined EMU-12 Participation Rate, 1995–2019: EMU-12. Source: AMECO Database, own calculations.

2.2.4 | Wages

Figure 5 shows the patterns of relative real wage growth in the EMU-12 countries between 1990 and 2020. It can be seen that the included countries generally oscilate around the average EMU-12 Growth Rate (as do the exlucede EMU-12 countreis), Wage growth in countries such as Greece, Portugal and Ireland being particularly volatile. Negative relative wage growth in Greece around the crisis is likely a 'readjustment' after the credit-fuelled relative wage-growth increase that Greece experienced in the early years after the introduction of the Euro. The same can be said, albeit to a lesser extent, about Ireland. For the remaining countries, this implies that labour market developments in unemployment rate, participation rate and employment growth do not have major, or long lasting effects on the relative real wage rate, and that adjustments to assymetric shocks do not occur via changes to wages.

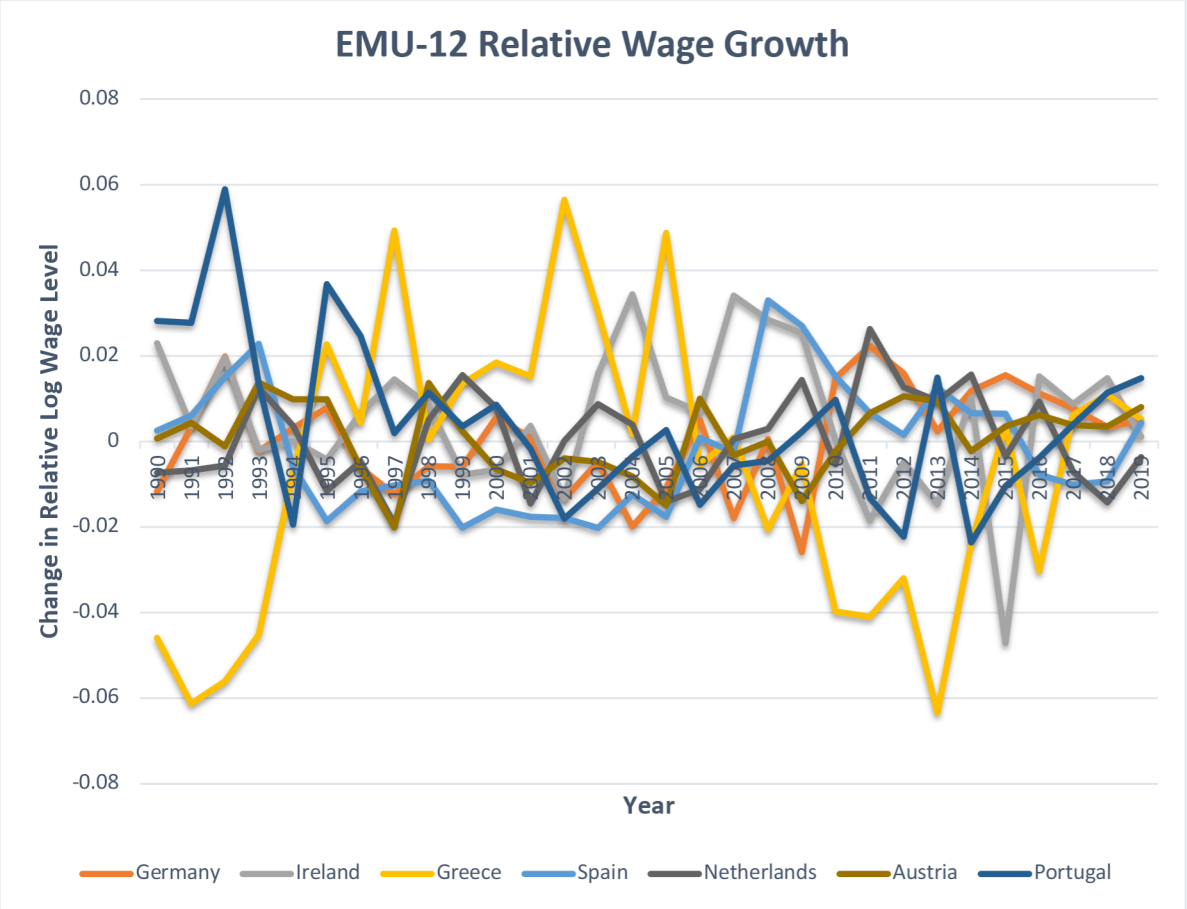

Figure 5: Wage Growth Relative to the Combined EMU-12 Wage Growth, 1990–2020: EMU-12. Source: AMECO Database, own calculations.

3 | Labour Mobility as an Adjustment Channel in a Currency Union

3.1 | Importance of Labour Mobility

By joining a currency union, countries (or regions) lose the ability to manipulate balance of payments through the exchange rate mechanism, and furthermore lose the ability to practice independent monetary policy. In the event of asymmetric economic shocks (i.e. shocks affecting some members but not others) it is expected that members will consequently encounter unequal unemployment and activity rates. Without the possibility of currency appreciation (or depreciation) in the event of a shock, these differences can be absorbed over time via the adjustment of real wages and via the geographical movement of factors, away from regions experiencing negative shocks, and towards regions experiencing positive shocks (Mundell, 1961). In this sense, labour mobility acts as a real stabilizer within the currency union. Countries experiencing a recession will (in theory) experience net emigration,

reducing the labour supply, and maintaining the country's real wage. Countries experiencing a boom should experience net immigration, increasing labour supply, and maintaining the country's real wage (Mundell, 1961). Adjustment through labour mobility is particularly important if the asymmetric shock effects labour demand, and is persistent. Without migration, a persistent negative labour demand shock leads to persistent unemployment due to the rigidity of real wages (Arpaia, Kiss, Palvolgyi, & Turrini, 2016).

This rigidity of real wages, due to factors such as minimum wages, salary contracts, and political pressures, makes the option of absorbing a given shock through the adjustment of real wages a very difficult and slow process. It is however possible, as noted by Hans-Werner Sinn in his book 'the Euro Trap' (2014) ; Germany's 'Hartz reforms' were a series of labour market reforms that, in short, increased labour market flexibility by simplifying and reducing the welfare system, and shifting power in the labour market towards employers. These reforms are widely credited as the main reason from the performance of the Germany's economy since the early 2000's (including through the great recession), however the number of people in insecure jobs and at risk of poverty increased during this period (Odendahl, 2017).

From the onset of the monetary union, it was noted that that labour mobility would likely be a weakness of the EMU, with papers such as Blanchard and Katz (1992) and Fatás (1995) highlighting the lack of labour mobility in Europe compared to the USA. Blanchard and Katz (1992) stated that the labour mobility channel would only play 'a minor role' in any necessary adjustment to an asymmetric shock to the currency union. More recent papers such as Arpaia et. al., (2016) indicate that labour mobility absorbs approximately 25% of asymmetric shocks after one year, and about 60% after 10 years. Both of these studies also include non-Eurozone, EU member countries in their analyses and thus do not completely disentangle labour mobility within the EMU-12, from labour moblity the EU as a whole.

The EU has implemented various policies over the years that have aimed to increase mobility within the European Monetary Union (and the EU as a whole), by reducing both administrative, and cultural barriers. The first, and perhaps the most significant in terms of legislation precedes the EMU by more the 50 years, the Treaty of Rome, which enshrined the free movement of labour between European Council countries. Freedom of movement and residence has been a right for EU citizens since the Maastricht Treaty, and social security

systems for all of the basic benefits (health, pensions, unemployment) have been coordinated since 2004, such that the various national systems do not deprive mobile workers of the benefits they have accumulated in another member state. Research has shown that the introduction of the Schengen Area, and the introduction of the Euro itself has led to increased mobility within Europe (Beine, Bourgeon, & Brincogne, 2013) Despite these advancements, the European Commission's 2013 survey (included in the Commission's paper "Strengthening the Social Dimension of the Economic and Monetary Union") shows that the main barriers to mobility are related to cultural and linguistic diversity.

Barslund and Busse (2014) report that the increase in EU labour mobility is principally due to the EU enlargement to include eastern countries such as Poland and Romania. This acted as a rapid removal of barriers to entry to the EMU-12 country labour markets for a large number of workers. The result of this can also be seen in Figure 6 by comparing the dotted and large-dash blue lines that represent the pre-enlargement countries (EU15, which includes the EU-11 + Greece, and the UK, Denmark and Sweeden) and enlargement countries respectively. The enlargement increased the EU population by 120 million, and given the income differences between the EU15 members and the new EU countries, and relatively low unemployment rates across Europe, citizens of the new EU countries migrated to earn higher wages (Barslund & Busse, 2014; Bayer & Smets, 2015; Beine, Bourgeon, & Brincogne, 2013).

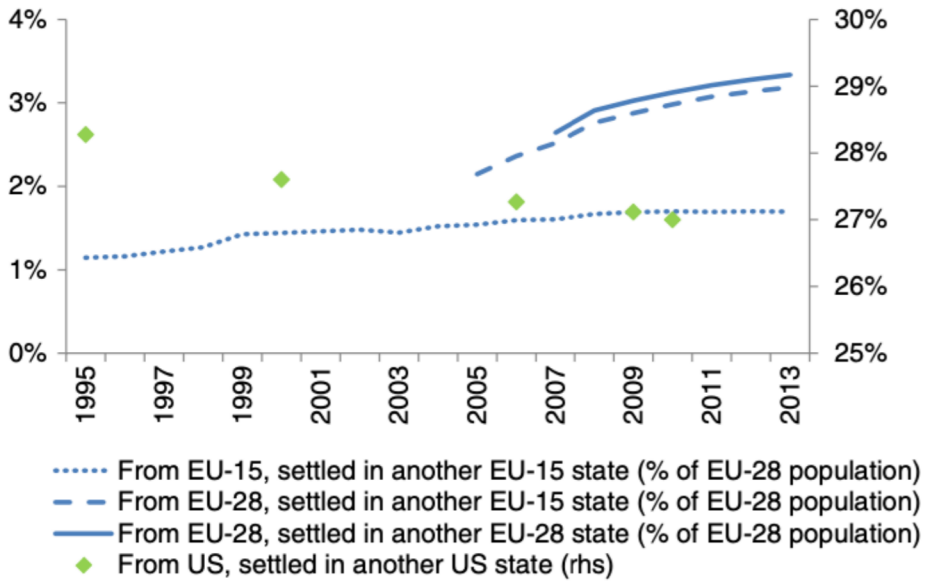

Figure 6: Share of EU working-age population born in other EU countries and share of US population born in a different US state

Optimal Currency Area Theory discusses the need for mobility between currency union members, however the effect on the labour market of one member state experiencing net-immigration, and another net-emigration in equal amounts, is the same regardless if the migration occurs directly the two member states, or via a third country. The important point is the adjustment in the labour supply to maintain the real-wage rate. This report does not distinguish whether the migration occurs completely within the Euro-zone (between EMU-12 countries), or includes third countries (which in this paper is defined as all countries other than the EMU-12).

3.2 | Previous Research Summary

As mentioned, Labour Mobility within the EMU, and the EU as a whole has been widely studied due to its importance to the European Economy. The following table shows results from four important papers that focus on labour mobility in Europe, that all use the Blanchard and Katz (1992) model, however differ in sample size and time, as well as two studies of US labour mobility. The table shows how much of the initial labour demand shock is absorbed after one year by changes to the unemployment rate, the participation rate and labour mobility. The US is often used as a 'benchmark' when judging the merit of the

Eurozone as an optimal currency area, as the US is a similar size economy with a relatively homogenous labour market. All results discussed are reported in Table 1 below.

Decressin and Fatás (1995) was one of the first papers to apply the Blanchard and Katz (1992) model to the estimate the role of labour mobility in the adjustment mechanism in response to an asymmetric shock in Europe, using regional data from Spain, Germany, France, Italy and the UK, as well as national data for Belgium, Ireland, Greece, Netherlands, Denmark (countries and regions all treated equally in the model). The use of regional data allows analysis of labour market adjustment mechanisms to regional specific shocks, and is useful when economies within Europe can differ dramatically within countries (e.g., Industrial Lombardy and Agricultural Sicily, in Italy). Using a sample from 1975 to 1987, the paper estimates that labour mobility accounts for just 4% of the labour market adjustment to a regional asymmetric labour demand shock.

L'Angevin (2007) uses a sample from 1970 to 2005, and aims to test the impact of the introduction of the Euro on Labour Mobility in the EMU-12 countries. The model uses national data and is estimated twice, using the entire sample period as well as a shorter sample from 1990 to 2005. The paper finds an increased importance of the role of labour mobility to the adjustment mechanism in response to an asymmetric shock in the shorter sample period. Furthermore, L'Angevin (2007) compares the results to the US, and concludes that although mobility in the EMU-12 improved, there was still a significant difference between mobility in the EMU-12 and in the US.

Bayer and Smets (2015) use the same regions as Decressin and Fatás (1995), and utilize more recent data and a larger sample, from 1977 to 2011. The larger sample makes their results more robust, and also allows for a comparison over time. Further more, Bayer and Smets (2015) provides estimates the model in the with the states of the USA over the same time period as a comparison. The paper concludes that the importance of labour mobility as an adjustment mechanism to asymmetric regional labour demand shocks increased after 1987 (the sample used in Decressin and Fatás (1995)), however it was still less than in the US in the same time period.

Dao et. al (2014) use regional data (as done in Bayer and Smets (2015) and Decressin and Fatás (1995)), however they makes use of the Eurostat NUTS-1 data, available from

1998, that includes data on all regions in the EU-21. The sample specification allows a more complete analysis of regional specific shocks, as all sample members are regions (except for small countries such as Denmark, Malta, Ireland etc.). The sample time period used in Dao et. al (2014) is similar to that used in the sub-sample of L'Angevin (2007). This allows the comparison between the estimations using national and regional data, where it can be seen that when regional data is used, the estimated role of labour mobility as an adjustment method is decrease.

	Unemployment	*Participation*	*Mobility*
Euro area (12 Member States 1973–2005) (1)	33	44	23
Euro area (12 Member States 1990–2005) (1)	31	40	29
EU (51 regions 1975–1987) (2)	21	74	4
EU (47 regions 1977–2011) (3)	30	40	31
EU (NUTS1 regions 1998–2009) (4)	16	60	24
USA (51 States 1976-2005) (1)	22	34	44
USA (51 States 1977-2011) (3)	14	43	43

Table 1: Decomposition of the response of labour market variables after 1 year to an asymmetric labour demand shock. Source: (1) L'Angevin (2007); (2) Decressin and Fatás (1995); (3) Beyer and Smets (2015); (4) Dao et al. (2014); Blanchard and Katz (1992)

It can be seen that both US models shown estimate a greater contribution of labour mobility than any EU estimate, regardless of the time period. Within the models looking at Europe, the papers that use more recent data show a higher estimated contribution of labour mobility within the EU, but do not formally distinguish between before and after the Great Recession. It can also be seen that results differ when using national and regional data, and thus it is important to choose the right time of data dependent on the relevant research question. This paper looks at the impact of the Great Recession, which had asymmetric effects based on mostly national factors, such as debt-levels (private and public) and financial regulation (Bénassy-Quéré, et al., 2018).

4 | Estimation Framework

4.1 | Blanchard and Katz (1992) Model

Blanchard and Katz's seminal paper (Blanchard & Katz, 1992) proposed an innovative method to indirectly measuring migration flow as the residual of employment growth, that is not explained by a change in employment (1 – unemployment) rate or participation rate. Given the scarcity of direct information of international labor mobility, it provides a good approximation using accessible data. The paper also designs a corresponding vector autoregression model (VAR), derived from the theoretical model. The VAR model does not include migration as a variable, and instead measures migration as employment change unaccounted for by the participation or the employment rate.

The empirical specification of Blanchard and Katz (1992) relates wages to employment and labour demand, where each variable changes across countries (represented by 'i') and over time (t). Production factors are mobile across countries, and each country produces a bundle of products. Differing bundles of products require different inputs, and thus shifts in labour demand will effect some countries more than others, asymmetrically.

To allow for the focus on asymmetric (rather than common) shocks, all variables are expressed as relative to the aggregate of the countries in the sample. In doing this, any common trends are removed, leaving only country specific shocks. All variables are in logarithms to allow a linear formulation.

The internal labour demand of country 'i' and time 't' is expressed as;

Equation 1

$$w_{i,t} = -dn_{i,t} + z_{i,t}$$

where 'w' is wage, 'n' is employment, and 'z' is labour demand. 'd' is positive and reflects the negative slope of demand for a country's output. Relative labour demand is affected by relative wages, as well as time constant country-specific characteristics (x_d) that affect firms' locational decisions, and thus act as a source of permanent differences in employment levels between countries.

Equation 2

$$z_{i,t+1} - z_{i,t} = -aw_{i,t} + x_{di} + \varepsilon^{d}_{i,t+1}$$

where '$\varepsilon_{i,t}^{d}$' is a country specific labour demand shock, and 'a' represents the responsiveness of wages to a change in labour demand.

The labour supply is driven by the difference in wages, local unemployment (u), as well as country specific factors (x_s).

Equation 3

$$n_{i,t+1}^{s} - n_{i,t}^{s} = bw_{i,t} - gu_{i,t} + x_{si} + \varepsilon_{i,t+1}^{s}$$

where '$\varepsilon_{i,t}^{s}$' is country specific labour supply shock, 'b' represents the responsiveness of wages to a change in labour supply, and 'g'represents the responsiveness of unemployment to a change in labour supply . The relationship of wages to unemployment is shown by 'c'

Equation 4

$$w_{i,t} = -cu_{i,t}$$

and unemployment is defined as the difference between labour demand and labour supply (equation 5).

Equation 5

$$u_{i,t} = n_{i,t}^{s} - n_{i,t}$$

Using equations 1 to 5, it can be shown that the long run relative employment growth (Δn_i) is determined by the following equation;

Equation 6

$$\Delta n_i = \frac{cax_{si} + (cb + g)x_{di}}{ca + d(cb + g)}$$

such that the long run change in employment is determined by country specific factors 'x_{si}' and 'x_{di}'. The long term relative unemployment is determined by;

Equation 7

$$u_i = -\frac{w_i}{c} = \frac{dx_{si} - x_{di}}{ca + d(cb + g)}$$

which also is dependent on country specific factors 'x_{si}' and 'x_{di}'.

Intuitively, if there is a positive shock to a country's 'country specific factors' such as an increase in productivity through an innovation, the country will attract more firms, and in turn more labour demand, resulting in lower unemployment and higher wages. This will encourage foreign workers to the country, increasing labour supply, and resulting in increased unemployment and decreased wages, cancelling out the initial effect of the shock.

Therefore, according to the model a shock to labour demand has no long term effects on unemployment and the participation rate, but it does affect the employment level.

Relative variables to the weighted sample average mean that a shock to any country in the sample will affect sample average, and thus the relative variables of all countries. Thus, if one country is affected by a negative demand shock, such that wages and employment decrease, workers will emigrate, which reduces the labour force and in turn mitigates the effects of on wage and employment in the country. The lower wages and unemployment will also attract firms to the country, creating new jobs and increasing wages. The overall effect depends on the elasticity of relative labour demand ('a' in the model), and relative labour supply ('b').

4.2 | VAR Estimation Specification

Using this empirical specification Blanchard and Katz (1992) proposed the following panel, structural VAR model that can be used to assess the response of a shock to labour demand on employment, unemployment, and participation rate, expressed as deviations from the sample (EMU-12) average (pre-shock conditions). To implement the theoretical framework it is necessary to use a VAR model as each is dependent on lagged values of itself, all other variables and an error term. The proposed model implies that change in employment level comes from distinct, uncorrelated, independent sources. The VAR model should be estimated with the (relative) employment level in first differences in order to measure the employment level change, and the employment rate (1-unemployment rate), and participation rate in levels. The VAR model is estimated as follows;

Equation 8

$$v_{it} = A + A_1(L)v_{it-1} + f_i + \varepsilon_t$$

where the vector (v_{it}) encompasses $\Delta n_{it}, le_{it}, lp_{it}$. Δn_{it} is the first difference of the logarithm of employment minus the logarithm of aggregate employment in the EU (employment is non-stationary in levels, and stationary in first-differences, as confirmed by unit-root tests); le_{it} is the logarithm of the employment rate minus the logarithm of the employment rate in the EU; and lp_{it} is the logarithm of the participation rate minus the logarithm of the participation rate in the EU. f_i represents the constant differences in labour market conditions across countries as fixed effects. By construction, f_i is correlated with v_{it} through the lagged variables. These

fixed effects are removed by estimating each variable as deviation from their (country-specific) mean. In order to remove country fixed effects from the analysis, a VAR with two lags for each variable is estimated, with OLS pooling the sample countries, after removing the country fixed effects via demeaning.

The identifying assumption to the Blanchard and Katz (1992) model is that '$\varepsilon_{i,t}^{d}$' in equation 2 represent exogenous labour demand shocks. If the correlation between employment rates and employment growth is positive, this hypothesis is reasonable (Arpaia, Kiss, Palvolgyi, & Turrini, 2016). In the sample used in this paper of EMU-12 countries since 1996, a (fixed effects) panel regression of unemployment rate on employment growth gives a positive slope of 0.81 (appendix 2). This hypothesis is applied to the model through the Cholesky decomposition, that ensures the estimated error terms (that represent the labour demand shocks) are orthogonal (uncorrelated).

The Cholesky decomposition is an important feature of structural VAR models, that use uncorrelated error terms to represent distinct shocks. The decomposition functions by constructing a matrix that is used to cancel correlated error terms, resulting in an orthogonal error term matrix (Pfaff, 2008). In practice, it is implemented by ordering the VAR such that shocks to the variables that come earlier affect the following variables contemporaneously, and shocks to the later variables affect the previous variables only with a lag (Pfaff, 2008). This is known as the recursive identification method. Based on the empirical specification, a labour demand shock affects the unemployment rate and the participation rate contemporaneously, and the effect on employment growth in the following period. Therefore it can be inferred that changes in the relative employment growth in the same period reflect asymmetric (country-specific) labour demand shocks.

Using the impulse response functions from the estimated Panel VAR model, the importance of labour mobility to the adjustment can be calculated by the difference between employment, and the employment and participation rates. The activity rate is expressed as $a = L/P$ and the unemployment rate is expressed as $u = 1 - E/L$, where 'a' and 'u' are the activity rate and the unemployment rates, E is employment, L the labour force, and P is the working age population, then, denoting growth rates by a dot, and using logs to calculate growth rates,

it can be shown that $\dot{E} - \dot{a} - 1 - u = \dot{E} - (L - \dot{P}) - (\dot{E} - \dot{L}) = \dot{P}$, where $\dot{P}$ is assumed to be labour mobility.

4.3 | Inclusion of Real Wages

In addition to the standard Blanchard-Katz approach, real wages are included in the VAR model to analyse the impact of a labour demand shock on wages. Theoretically, if the OCA criteria is (completely) satisfied, relative real wages will not change in a country experiencing a positive shock, as the increase in labour demand will encourage migration, increasing labour supply, such that the real wage remains unchanged, and the employment level increases. In practice this does not occur due to labour market frictions and lags involved in migration, thus it is expected that in the short term real wage growth will increase, until labour supply increases sufficiently to ease the upward pressure on the real wage rate. Furthermore, the inclusion allows the model to better identify the origin of the shock to labour; for a positive labour demand shock, the response of wages should be positive, and for a positive labour supply shock; negative.

Real wages are assumed to respond contemporaneously to labour demand shocks and to affect contemporaneously the labour supply through changes in the employment or in the participation rate. Given these assumptions, it is important that the real wage variable is placed after the employment growth variable, but before the other variables. The log of relative real wages is included in the VAR as first differences it is non-stationary.

5 | Data Sources

The following analysis' data source is the 'AMECO' Database from the European Commission and Eurostat. The data set contains data for the EU, the euro area, EU Member States, candidate countries and other OECD countries, for a total of over 40 countries, however only the data of the EMU-12 countries, and the EMU-12 aggregate data is used here. The analysis is conducted using the time from 1996 to 2019, to allow for a balanced panel, and utilizes the data on employment, employment rate (1-Unemployment rate), participation rate, and real wages (nominal wages adjusted using the GDP deflator). The use of a balanced panel is particularly important as each used in the model is relative to the EMU-12 aggregate, thus, without a full panel the relative variables cannot be correctly

calculated. 2008 is considered the break year based on the graphs and structural break tests provided in section 2, that indicated multiple country's experienced a distinct change in labour market dynamics in (or close to) 2008.

The unemployment rate is defined as the proportion of the labour force without employment, the employment data is measured as net jobs created, the participation rate data is calculated the Labour Force divided by 15-64 years population. The real wage data is calculated using the GDP deflator. The variables are all calculated as logs relative to the EMU-12 country aggregate. Employment and real wages are both non-stationary, while unemployment and participation rate are stationary (confirmed using several unit-root tests that consider cross-dependence across the panel units).

6 | Results

Results from the VAR model are shown in Figures 7 & 8, show the impulse response functions for the models using the pre-crisis sample (1996-2008), and the post crisis sample (2009-2019). The impulse is a 0.01 log point (or 1%) positive labour demand shock, and the shock has a symmetric effect, such that the results of a 0.01 log point negative demand shock 'flips' the graph. In both sample periods, all eigenvalues lie inside the unit circle and VAR system is stable

The model assumes, as per Blanchard and Katz (1992), that the reaction of employment to an asymmetric shock is the same for all EMU-12 countries, and it's important to consider that the variables relative unemployment rate, relative participation rate and relative real wages return to country specific pre-shock levels (as explained in section 2.1), which vary across the EMU-12 based on country-specific factors, which are removed from the model through the use of time constant fixed effects with 2 lags.

Table 2 shows the impulse response results from both the pre-crisis and post-crisis VAR models. The regression output from the estimation of two models is presented in the appendix (6 and 7). One year after a shock, the pre-crisis predicted contribution of Mobility, Unemployment Rate and Participation rate are not significantly different from the post-crisis predicted values. However, after five and years the difference between the estimated values for the two sample periods is large. Five years on from the shock, the mobility adjustment

channel contributes for 44% of the labour market adjustment in the pre-crisis sample, compared to 92% in the post-crisis sample. This indicates that in the period after the onset of the Great Recession (which includes the great recession, and the sovereign debt crises) the speed of adjustment via labour mobility doubled. As a result, the reliance on adjustment through the unemployment rate and participation rate is substantially less. After 10 years the post-crisis sample estimation suggests the labour market has approximately returned to the pre-shock relative employment, and participation rates, and the increase in employment is accounted for solely by migration (mobility). In comparison when only the pre-crisis sample is considered, after ten years the unemployment rate has still not returned to pre-shock levels, and accounts for approximately one quarter of the adjustment.

The lagged values of wages do not significantly affect any variables, including current period (t=0) wages, nor do any other lagged variables affect wages (appendices 6 and 7). This can also be seen in the impulse response functions in Figures 7 and 8, where the effect of the labour demand shock on wages is (approximately) 0 in all periods. This indicates that real wages are not effected by shocks to labour demand, and the labour market adjustment process occurs through other channels (participation rate change, unemployment rate change, labour mobility). A VAR model was estimated for both sample periods excluding wages from the analysis and the estimated VAR covariates were not significantly different from the models including wages. This finding is consistent with the theoretical framework proposed by Blanchard and Katz (1992), that relative real wages remain unchanged, and also satisfies the OCA criteria proposed by Mundell (1961).

Time after Shock		Mobility	Unemployment Rate	Participation Rate
1 Year	Pre-Crisis	33%	41%	26%
	Post-Crisis	35%	35%	30%
5 Years	Pre-Crisis	44%	32%	24%
	Post-Crisis	92%	7%	1%
10 Years	Pre-Crisis	74%	23%	3%
	Post-Crisis	95%	5%	0%

Table 2: Contribution of Mobility, Unemployment Rate, and Participation Rate to Labour Market Adjustment after an Asymmetric Labour Demand Shock.

The overall results are consistent with findings from L'Angevin (2007), that used the same sample countries to analyse any the effect of the introduction of the Euro on labour mobility. L'Angevin (2007) used almost the same sample period used in here in the 'pre-crisis' sample, and attained (approximately) the same results, and concluded that the introduction of the euro had significantly improved labour mobility within the sample countries, such that the Euro-area was converging to the mobility levels seen in the US. After five years, the contribution of labour mobility to the US labour market response to a asymmetric regional labour demand shock (taken from the Bayer and Smets (2014)) is approximately the same as the result found in the post-crisis model. The results in this paper suggest that the role of labour mobility in response to an asymmetric shock to labour demand has continued to increase in the EMU-12 countries perhaps partly due to necessity when responding to the great recession, but also to due policy initiatives to reduce barriers to intra-EU migration.

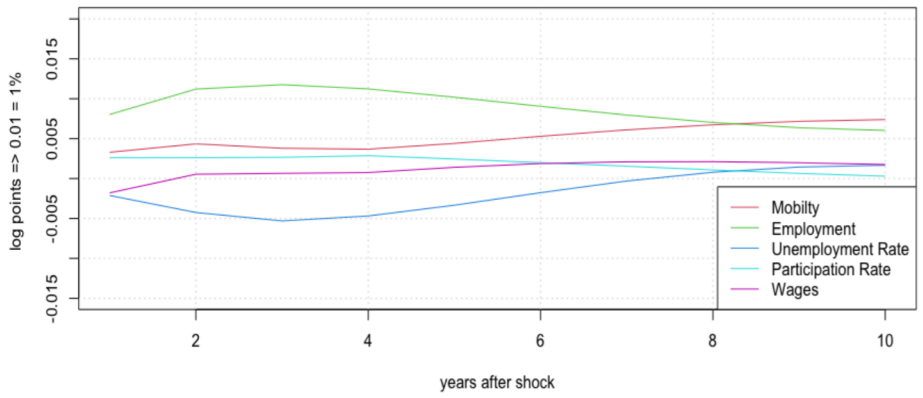

Figure 7: Impulse Response Function to a 1% Asymmetric Shock to Labour Demand (Employment), Sample Period 1996-2008. Data Source: AMECO Database

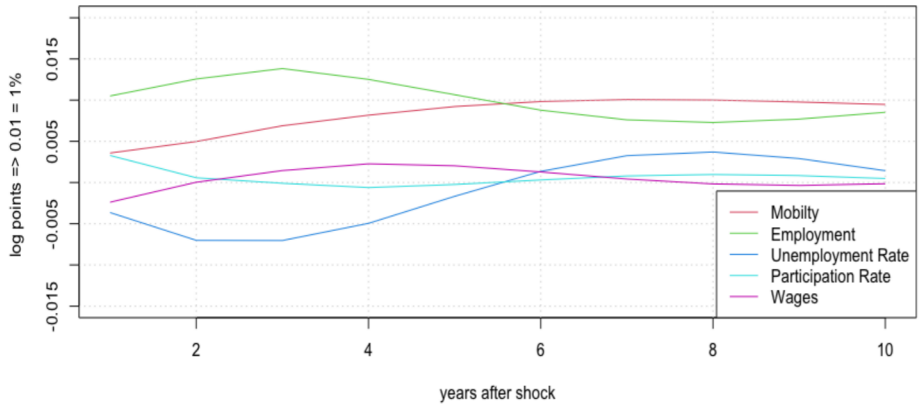

Figure 8: Impulse Response Function to a 1% Asymmetric Shock to Labour Demand (Employment), Sample Period 2009-2019. Data Source: AMECO Database

The increase in the speed of the labour mobility adjustment, indicates efforts by the various EU bodies and member states to decrease barriers to migrating are having the desired effect. In the case of negative labour demand shocks, this results in shorter periods of increased relative unemployment as seen when considering the inverse ("flipped") of Figures 7 and 8, which is costly for both the home country, and inefficient in terms of labour allocation within the currency union.

Beyer and Smets (2015) use a similar sample time period (1994-2011) concluded that adjustment through labour market mobility in EU regions has fallen since the introduction of the Euro. The key difference between the analysis here and the analysis by Beyer and Smets (2015) is the use of regions rather than countries which suggests country specific asymmetric shocks have a greater impact on labour mobility between countries, than region-specific shocks have on labour mobility between regions.

As seen in figure 1, almost all EMU-12 member countries have consistently experienced net inward migration, implying that this labour mobility adjustment is not necessarily occurring between member countries. However as previously mentioned, when considering the effect on the vigor of currency union, the origin of the worker is not important as long as relative net migration is responding to the asymmetric shock (i.e. relative net migration increasing as a result of a positive labour demand shock).

7 | Conclusions

The Blanchard and Katz model provides a good approximation on a complex subject with a lack of lack of available data. As a tool to compare different currency unions, or in this case the same currency union in different sample time periods it provides a useful approximation about the importance of labour mobility. As mentioned, an improvement in the available data would allow the use of more accurate econometric methods that would allow for more freedom in the model specification, and enable more detailed research into specific types of shocks and policies, and there effects on specific countries.

Although the inclusion of wage in the model was not significant, this in itself is an important result as it tests the assumption of the model that in response to a labour demand

shock, relative real wages remain unchanged and adjustment occurs through the unemployment rate, participation rate, and mobility.

The continued improvement of labour mobility within the EMU-12 (and thus the eurozone as a whole) can play an important part in creating a more resilient common currency area. As per the OCA theory, increased labour mobility is one important factor in ensuring the stability of the eurozone, reducing the risk of sovereign debt crises, and protecting the credibility of the currency, as well as the economies of fellow currency union members. Further analysis is needed to identify the effect of particular policies, or particular aspects of shocks that have improved labour mobility, as well if there is a specific 'type' (i.e., male vs female, high-education vs low-education) of worker that is more likely to migrate within the EU, and what effects specific migration of particular workers has by the destination country, as well as the country of origin.

Finally a brief comment on the implications of the results for the labour market adjustment to the economic effects of the COVID-19 pandemic. The decrease in economic activity associated with COVID-19, and the accompanying restrictions can be classified as a common shock to the EU-12 countries with asymmetric effects, with countries relying on industries such as tourism and hospitality being particularly hard hit by a negative labour demand shock. The workers in these countries are either unable, or have less incentive to relocate due to current implicit restrictions as well as the uncertainty around future restrictions, as well as unintended consequences of furlough schemes that may prevent workers relocating to where there is greater labour demand . This impact on net migration can already be seen in Figure 1, with all countries experiencing decreased net migration in 2020. If and when net-migration will return to pre-pandemic levels is uncertain, and if the current situation persists the trend of increasing labour mobility in the EMU-12, and the EU in general may go into reverse.

8 | References

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9 | Appendix

9.1 | Appendix 1 – Zivot-Andrews Structural Break Tests on Net Migration Series

Country	Structural Break Specification		
	Both	Trend	Intercept
Belgium	2012	2010	2012
Germany	2004	2005	2011
Ireland	2008**	2005	2008***
Greece	2011***	2015**	2016
Spain	2003	2003	2008
France	2012	2010	2006
Italy	2013	2014**	2017
Netherlands	2009***	2011***	2013**
Luxembourg	2020	2016	2020
Austria	2014	2020	2012
Portugal	2011	2015	2017
Finland	2015	2012	2015
EMU-12 Aggregate	2009*	2005	2009**

*** denotes significance at 1%, ** at 5%, and * at 10%

9.2 | Appendix 1 – Zivot-Andrews Structural Break Tests on Relative Employment Growth Series

Country	Structural Break Specification		
	Both	Trend	Intercept
Belgium	2009	2012	2008
Germany	2009	2013	2007
Ireland	2008***	2014	2008***
Greece	2010	2003	2010
Spain	2008	2010	2008
France	2009	2013	2009
Italy	2019	2019**	2019
Netherlands	2002	2004	2004
Luxembourg	2011	2014	2008
Austria	2008**	2012**	2008
Portugal	2011	2013*	2014
Finland	2015	2019	2014

*** denotes significance at 1%, ** at 5%, and * at 10%

9.3 | Appendix 3 - Zivot-Andrews Structural Break Tests on Relative Unemployment Rate Series

Country	Structural Break Specification		
	Both	Trend	Intercept
Belgium	2000	2004	2011
Germany	2001*	2004*	2001*
Ireland	2008	1998	2008
Greece	2005	2009	2015**
Spain	2017	2019	2009*
France	2009	2011	2016
Italy	2013	1992	2008***
Netherlands	2003	1997	2003
Luxembourg	2009	1992	2009***
Austria	2004	2005	2008
Portugal	2012	2014	2017
Finland	2012***	2014	2017

9.4 | Appendix 4 - Zivot-Andrews Structural Break Tests on Relative Participation Rate Series

Country	Structural Break Specification		
	Both	Trend	Intercept
Belgium	2011	2015	2011
Germany	2019	2019	2007
Ireland	2005	2006	2004*
Greece	2019	2019	2019
Spain	2013	2011	2017
France	2008***	2009***	2014
Italy	2004	2005	2003
Netherlands	2003	2005	2003*
Luxembourg	2004	2005***	2001
Austria	2002**	2003*	2002***
Portugal	2001	2002	2012
Finland	2012	2014	2017

*** denotes significance at 1%, ** at 5%, and * at 10%

9.5 | Appendix 5 – Fixed Effects Pooled OLS of Relative Employment Growth on Relative Unemployment Rate

plm(formula — employmentrate ~ employment)				
Signif. codes: *** p < 0.001, ** p < 0.01, * p < 0.05				
Total Sum of Squares = 0.28219	Coefficients			
Residual sun of Squares = 0.24843		Estimate	Std.Error	p-val
R-Squared = 0.11964	Employment	0.8149	0.1333	0.0796
Adj. R-Squared = 0.081227				
F-statistic: 37.3732 on 1 and 275 OF, p-value = 3.3318e-09				

9.6 | Appendix 6 – 1996-2008 Fixed Effects OLS Panel VAR estimation

	employment	wages	participationrate	employmentrate
employment (-1)	0.406 ***	0.2367	0.0481	0.2061 *
	(0.1097)	(0.1779)	(0.1100)	(0.0891)
wages (-1)	0.0708	-0.0318	0.0889	-0.056
	(0.0584)	(0.0946)	(0.0585)	(0.0474)
participationrate (-1)	-0.2095 *	0.0915	0.7499 ***	-0.0837
	(0.0961)	(0.1559)	(0.0964)	-0.078
employmentrate (-1)	0.301 *	0.0648	0.2017	1.2799 ***
	(0.1186)	(0.1922)	(0.1189)	-0.0962
employment (-2)	-0.1509	-0.1617	-0.0099	0.0295
	(0.0960)	(0.1557)	(0.0963)	-0.0779
wages (-2)	-0.0464	-0.13	0.1258 *	-0.109
	(0.0601)	(0.0974)	(0.0602)	-0.0488
participationrate (-2)	0.0835	-0.0947	0.0266	0.0322
	(0.0998)	(0.1618)	(0.001)	-0.081
employmentrate (-2)	-0.3356 **	0.1069	-0.1334	-0.4509 ***
	(0.1095)	(0.1776)	(0.1098)	-0.0889
*** p < 0.001, ** p < 0.01, * p < 0.05				

9.7 | Appendix 7 – 2009-2019 Fixed Effects OLS Panel VAR estimation

	employment	wages	participationrate	employmentrate
employment (-1)	0.3325 **	0.1957	-0.1496	0.2193 **
	(0.1247)	(0.1450)	(0.1031)	(0.0806)
wages (-1)	-0.0604	0.1928	-0.0273	0.0753
	(0.0861)	(0.0110)	(0.0712)	(0.0557)
participationrate (-1)	-0.3838 **	0.1012	0.8145 ***	-0.0489
	(0.1353)	(0.1573)	(0.1119)	(0.0875)
employmentrate (-1)	-0.088	0.1347	-0.1617	1.3852 ***
	(0.1495)	(0.1737)	-0.1236	(0.0966)
employment (-2)	0.1609	-0.0139	0.1096	-0.1011
	(0.1007)	-0.1171	-0.0833	(0.651)
wages (-2)	-0.0896	0.0584	-0.0157	-0.1139
	(0.086)	(0.1)	(0.0711)	-0.0556
participationrate (-2)	0.093	0.0742	-0.1929	-0.0177
	(0.1285)	(0.1493)	(0.1062)	-0.083
employmentrate (-2)	-0.1761	-0.1138	0.1072	-0.6685 ***
	(0.1228)	(0.1428)	-0.1015	-0.0794
*** p < 0.001, ** p < 0.01, * p < 0.05				