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UNDERINVESTMENT AND UNEMPLOYMENT: THE DOUBLE HAZARD IN THE EURO AREA

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ABSTRACT

An alarming legacy of the austerity programs in the euro area is the vast disinvestment that has taken place over the recent years, and especially so in the peripheral economies. Unless it is quickly reversed, disinvestment not only hinders long-term growth but also undermines the prospects of a gradual reduction of unemployment and risks further imbalances in, and threats to, the monetary union. Combining a neoclassical Diamond model with labour market imperfections, the paper shows that unemployment is a function of capital investment under either CES or Cobb-Douglas production functions. A cross-section estimate for the euro area economies confirms the theoretical findings.

Keywords: euro area, investment, unemployment, capital-labour substitution, production function

JEL classification: E22, E24

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1. Introduction

A worrisome characteristic of the euro area is the massive fall in overall investment activity. As Fig. 1 shows, gross fixed capital formation in the core euro area is nearly 20% below the share in GDP it had in 2007, the year before the global financial crisis erupted. In contrast, investment activity in other economies such as the US, Japan or the non-Euro Nordic countries has been steadily recovering since 2010. The fact that investment activity as a share of GDP is declining while the latter remained sluggish after the crisis implies that the reduction of capital investment in volume terms is even more pronounced in the euro area relative to the other economies. Moreover, the fact that investment in Germany is approaching its pre-crisis intensity means that the rest of the euro area economies suffer an even larger toll.

[Fig. 1, around here]

However alarming such developments might have sounded elsewhere, they failed to grasp the attention of European policy makers. Too preoccupied with stemming off the debt crisis as they were, European authorities insisted on the priority of fiscal rehabilitation across member states as a condition for the return of growth in the monetary union. But despite the fiscal progress achieved by the debt-stricken economies and the unprecedented monetary ease offered by the European Central Bank (ECB), the signs of recovery remained dim and this –at long last– led to a focus on the issue of underinvestment in the euro area.

A study published by the European Investment Bank (Kolev et al, 2013) admitted that the EU is experiencing “a historically unprecedented collapse in fixed capital formation” and describes a priority list –from the acceleration of reforms to industrial restructuring to financial support– to mitigate its impact. In a detailed study of capital formation in the European Union, Bardi et al (2014) find that its curtailment has dampened growth by 0.20% of GDP per year since 2010 and suggest an optimal level of investment that has to be attained in the near future. Others prioritize the much needed investment impetus in critical sectors. For example, Hirschhausen et al (2014) argue for the need of new investment in the energy sector, Buti and Mohl (2014) call for restoring public investment activity, while Fratzscher (2014) advises for keeping away from it.

The recent underinvestment notwithstanding, Gornig and Schiersch (2014) acknowledge that investment activity in the euro area was lagging far behind other advanced economies even before the financial crisis. For the euro area to have stayed at a par with other advanced economies, they estimate that that it should have invested more than €7. 5 trillion over the period 1999-2007. As a matter of fact, the gap not only didn't close but has since been further widened. The collapse of investment activity is found to be more worrisome in the debt-stressed countries of the euro area periphery as a result of falling demand and front-loaded fiscal consolidation. Agénor and Yilmaz (2006) noted before the crisis that subjecting public investment to the strict fiscal rules of the Stability Pact undercuts long-term growth in the euro area. Additionally, social tensions generated by the austerity programs create a multitude of political and economic uncertainties that hinder potential investment plans.

At the same time, an unprecedented rise in unemployment is ravaging the euro area. In comparison with the same group of countries as before, the euro area is found to be the only large economy, where unemployment has thus far exceeded the pre-crisis level by more than half, remains double-digit and is still rising; see Fig. 2. Again, the fact that unemployment is being reduced in Germany implies a much bleaker situation for the rest of the euro area members.

[Fig. 2, around here]

By juxtaposing developments in unemployment and net fixed capital formation over the period 1991-2014, an impressive mirror pattern emerges as shown in Fig. 3. A strong negative correlation between unemployment and total investment is established and the same holds for its components of the private sector or the General Government. This suggests that a deeper link might exist between the twin malaises in the euro area and is worth further investigation.

[Fig. 3, around here]

The issue is not a novel one and the relationship between capital investment and equilibrium unemployment has been extensively debated in the literature over the last two decades. A key reference point was the result derived by Layard, Nickel and Jackson (LNJ for short, 1991) in an economy with a wage-bargaining process between firms and labour unions, and a Cobb-Douglas production function so that the elasticity of capital-labour substitution is unity. In this setting, LNJ (1991, p. 107) found that equilibrium unemployment is increasing with union power and unemployment benefits, decreasing with product market competition, but remains totally unaffected by changes in the capital-labour ratio. The implication was that capital-inducing policies are ineffective in addressing high levels of unemployment, and it is only the implementation of labour market reforms that could bring it down in the long run.

Both the assumptions and the neutrality thesis were subsequently challenged by several empirical and theoretical studies that continue to the present day. For example, Rowthorn (1999a and 1999b) showed that with a CES production function and an elasticity of substitution below unity, weaker investment activity is associated with higher unemployment and a fall in wage share. In the same spirit, Alexiou and Pitelis (2003) found that the unemployment in 13 economies in the European Union is significantly affected by the process of capital accumulation. Karanassou et al (2008) found strong empirical support for the investment impact on unemployment in Denmark, Sweden and Finland, and provided a review of the capital-labour substitution literature. The above empirical findings did not go unchallenged. Driver and Munoz-Bugarin(2010) have shown that for a panel of European countries the labour share has decreased with capital investment, thus the assumption of a negative relationship between investment and equilibrium unemployment cannot be maintained.

The interactions between investment and unemployment became the subject of controversy in the US as well. Taylor (2011) produced a striking negative correlation between the two and suggested that "[e]ncouraging the creation and expansion of businesses should be the focus on government efforts to reduce unemployment." In contrast, Krugman (2014) argued that the finding is an artifact brought about by the bust in residential investment after the global crisis and asserted that causation more likely runs from unemployment to capital formation rather than the other way around.

Quite often, the debate was laden with theoretical or even ideological interpretations. For example, Alexiou and Pitelis (2003) assigned the neutrality assertion to "[t]he neoliberal tradition [that] considers unemployment to be invariable to the capital stock", while Kapadia (2005) argued that the existing literature "ignored any potential direct and permanent relationship between the capital stock and equilibrium unemployment", exactly because it adopts a framework similar to that used by LNJ. Stockhammer (2011) argues that the capital-deepening effect on unemployment can be interpreted only in a Post-Keynesian framework that "rejects the quest for micro-foundations of macroeconomics." For their part, however, LNJ had already noted that the neutrality outcome is conditional on the constancy of the wage share and warned that "[i]f … the elasticity of substitution is less than one, capital accumulation (with no technical progress) raises the share of labour and *reduces unemployment*", (emphasis added). Thus, the real issue is to investigate whether and to which extent unemployment can be influenced by investment activity.

[Table1, around here]

The outcome of the present research is broadly in the range obtained in similar existing studies; for a brief summary see Table 1. Nonetheless, the paper is differentiated in scope, structure and examination period. For example, Rowthorn (1995) includes only few euro area countries, while Alexiou and Pitelis (2003) provide estimates for the period 1961-1998, thus completely leaving out the effects brought about by the single currency. Both papers ignore labour market rigidities and leave out some of the peripheral economies.[1] Stockhammer and Klar (2008) include several labour market indices, but their estimates stop short of capturing the effects of the recent financial crisis. Moreover, the above estimates implicitly assumed that variables did not exhibit unit roots but this is no longer a valid hypothesis after the surging patterns of post-2008 unemployment.

The aim of the paper is three-fold: first, to show that the investment impact on unemployment holds not only under Post-Keynesian assumptions but in a representative agent framework as well, if some labour market frictions are introduced. Second, it shows that developments in the euro area do not support the assumption of wage share constancy. Hence, a unit elasticity of substitution cannot be taken for granted, the investment neutrality assertion does not hold and the direction of causality should be investigated. Third, estimates are obtained for the period 1990-2013, thus taking into account the consequences of the global financial crisis and the austerity programs applied thereafter in some member-states.

The rest of the paper is organized as follows: Section 2 describes a two-period Diamond model of overlapping generations, with a general production function and job-matching inefficiencies. Section 3 provides the cross-section estimates, while Section 4 concludes. Appendix A gives details of the theoretical model. Appendix B describes the data sources and presents a number of statistical and econometric properties of the time-series used in the estimation.

[1] Most studies leave out some southern European economies which experienced the worst surge in unemployment since 2008. An exception is Miaouli (2001) who finds a strong capital effect on employment in southern Europe but this covers only the period 1960-1997.

2. A Diamond model with CES production

The economy is described by a two-period Diamond model with a job-searching process similar to that derived by Azariadis and Pissarides (2007). The model is modified by adopting a production function with an elasticity of substitution (σ) not constrained to unity. The demand and supply curves in the labour market are derived along the following steps:

2.1. Production

Time-subscripts are removed for simplicity, unless necessary. At each period of time (t), a capital stock (K) is combined with employment (N) to produce output (Y), according to a production function $Y=F(K, N)$ which is linearly homogeneous and satisfies the Inada conditions. The labour force is (L) and for ($N<L$), the unemployment rate is given by $u=1-N/L$. Output per worker is $y=f(\kappa)$, where (κ) is capital stock per worker and is related to the capital stock per capita (k) by:

$$\kappa = \frac{K}{N} = \frac{K}{(1-u)L} = \frac{k}{1-u} \tag{1}$$

The elasticity of substitution is defined as

$$\sigma = \frac{\partial(K/N)\,/(K/N)}{\partial(F_K/F_N)\,/(F_K/F_N)} \tag{2}$$

If production is a linear homogeneous function and the wage rate is set equal to the marginal labour productivity, $w = f(\kappa) - \kappa f'(\kappa)$, and the following expression is obtained as in Klump and Preissler (2000):

$$\sigma = \frac{f'(\kappa)\cdot[f(\kappa)-\kappa f'(\kappa)]}{\kappa f(\kappa)[-f''(f(\kappa)]} = \frac{dy/y}{dw/w} = \frac{dlny}{dlnw} \tag{3}$$

Denoting the labour share as ω=w/y and solving the differential equation as in Klump et al (2011), output per worker is obtained as:

$$y = \Gamma w^{\sigma} = \Gamma^{\frac{1}{1-\sigma}} \cdot \omega^{\frac{\sigma}{1-\sigma}} \tag{4}$$

where (Γ) is an integration constant determined by initial conditions. Further details are given in Appendix A.

2.2. The demand curve

Combining (1) and (4), the demand curve of employment by firms is implicitly obtained by the expression for the wage share:

$$\omega^D = \Gamma^{-\frac{1}{\sigma}} \left[f(\frac{k}{1-u}) \right]^{\frac{1-\sigma}{\sigma}} \tag{5}$$

The total differential of (5) is obtained as:

$$d\omega^D = (1-\sigma) \left[\frac{k \cdot du}{(1-u)^2 \sigma} + \frac{dk}{(1-u)\sigma} \right] \Gamma^{-\frac{1}{\sigma}} \cdot f' \left(\frac{k}{1-u} \right) \cdot \left[f \left(\frac{k}{1-u} \right) \right]^{\frac{1}{\sigma}-2} \tag{6}$$

In order to examine comparative statics, the following properties are readily established:

Proposition 1. For elasticities of substitution lower (higher) than unity, the demand for labour locus gives a wage share that is increasing (decreasing) in the unemployment rate.

Proposition 2. With a rise in per capita capital stock *k*, the demand curve shifts upwards (downwards) for σ<1, (σ>1).

These results hold for any linear homogeneous production function and are qualitatively the same as that derived by Rowthorn (1999a) for a CES function. For σ=1, the demand curve becomes horizontal at $\omega^D = 1/\Gamma$.

2.3. The supply curve

To derive the labour supply curve, the following search process is considered: in each period t, a new labour force (L_t) enters the economy seeking for a job and (N_t) of them find one. If employed, workers receive the competitive wage rate (*w*); if not, they get an unemployment benefit which is set as a fixed proportion *(b)* of the take-home wage (1-τ) *w*. Employed or not, they retire at period t+1, and a new generation of young workers (L_{t+1}) comes in.

The Government taxes the income of those employed at a rate *(τ)* so as to fully finance the compensation for the unemployed, i.e. $N_t \tau w_t = (L_t - N_t) b (1-\tau)\, w_t$. Total labour income in each period is thus given as:

$$N_t (1-\tau)\, w_t + (L_t - N_t) b (1-\tau)\, w_t = N_t w_t \tag{7}$$

Two-period consumption (c_{1t}, c_{2t+1}) when young and old respectively, is chosen so as to maximize a logarithmic utility function:

$$J_t = \ln(c_{1t}) + \frac{1}{1+\rho}\ln(c_{2t+1}) \tag{8a}$$

where (ρ) is the subjective discount rate. The two-period budget constraint is given by:

$$c_{1t} + \frac{c_{2t+1}}{1+r} = \varepsilon(1-\tau_t)\, w_t \tag{8b}$$

where ε=1 or ε=b for the employed or unemployed respectively, and (r) is the interest rate. The solution of (8a) under (8b) yields $c_{1t} = (1-s)\,\varepsilon(1-\tau_t)\, w_t$ and $c_{2t+1} = s\varepsilon(1-\tau_t)\, w_t$. For a logarithmic utility function, optimal savings rate are found to be independent of interest rates, common for both types and equal to $s=1/(2+\rho)$; see Romer (1996, Ch. 2).

The capital stock is fully depreciated in each period, thus new investment equals the capital stock. At the end of period t, a new stock is purchased by the saved income (sN_tw_t) to be used in the beginning of the new period t+1. Suppose now that there are (H) firms in the economy, each one employing a fixed amount of capital stock (q) determined by technology, i.e. $K = qH$. At the beginning of each period t, there are (V) vacancies advertised by firms and (L) unemployed persons seeking for a job. The number of jobs finally matched is given by the well-known search function (e. g. see Romer, 1996, Ch. 10) with constant returns to scale:

$$N = L^{\delta} V^{1-\delta} \tag{9}$$

where $\delta<1$. With gross profit per worker denoted by $\pi=y-w$, firms stop searching in the job market when their average profits equal the average cost of matching, namely:

$$\frac{\pi N}{H} = \frac{hV}{H} \tag{10}$$

where (h) is the unit cost incurring to the firm for creating and advertising a job. In general, this may depend on the number of total vacancies as well as the number of firms sharing the burden, i.e. $h=h(V;\ K) =h(V;\ qH)$. It is assumed that h_V>0 denotes congestion effects as the number of vacancies increases, and h_K<0 denotes a lower average cost per firm as their number increases. A simple representation may take the form:

$$h(V;\, K) = \gamma \left(\frac{V}{K}\right)^{\theta} = \gamma \left(\frac{v}{k}\right)^{\theta} \tag{11}$$

where $v=V/L$ is a measure of the labour market tightness. Parameter (θ) expresses how the cost per job increases by the degree of tightness. This is a generalization of the constant cost assumption by Azariadis and Pissarides (2007) that is obtained as a special case by setting θ=0. The following property is established:

Proposition 3. For a medium sized elasticity so that $\omega<\sigma<1$, the supply curve is downward slopping.

Proof: The profit rate is obtained from (4) as:

$$\pi = y - w = y(1-\omega) = \Gamma^{\frac{1}{1-\sigma}} \cdot \omega^{\frac{\sigma}{1-\sigma}} \cdot (1-\omega) \tag{12}$$

Calculating the wage share from (4), and combining (10), (11) and (12) the following expression for the implicit supply curve as a function of the wage share is obtained: [2]

$$\Gamma^{\frac{1}{1-\sigma}} \cdot [\omega^s]^{\frac{\sigma}{1-\sigma}} \cdot (1-\omega^s) = \gamma k^{-\theta} \cdot (1-u)^{\frac{\theta+\delta}{1-\delta}} \tag{13}$$

Taking logs, differentiating and rearranging, we get:

$$d\omega^s = \frac{\sigma-1}{\sigma-\omega} \cdot \omega(1-\omega)\gamma \left[\frac{\theta}{k} dk + \frac{\theta+\delta}{(1-\delta)(1-u)} du\right] \tag{14a}$$

The slope in the ω-u plane is obtained as:

$$\frac{\partial \omega^S}{\partial u} = -\gamma \cdot \frac{1-\sigma}{\sigma-\omega} \cdot \frac{\theta+\delta}{1-\delta} \cdot \frac{\omega(1-\omega)}{1-u} < 0 \tag{14b}$$

[2] Superscript (s) is omitted here to avoid confusion with power expressions, but it is added later on.

and the proposition follows immediately.

The above result is a generalization of Rowthorn's (1999a), since it derived under competitive wage-setting and with a more general production function. The cases with a large elasticity ($\sigma>1>\omega$) or a low elasticity ($\sigma<\omega<1$) imply an upward supply curve and are examined in Appendix A.

2.4. The Cobb-Douglas case

For the Cobb-Douglas case, $\sigma=1$ and the following property is established:

Proposition 4. With $\sigma=1$, the supply curve becomes vertical and unemployment decreases with a rise in the capital stock.

Proof: With $\sigma=1$, expression (4) collapses to a labour share fixed at $\omega=1/\Gamma$. The profit rate becomes

$$\pi = (1-\omega)y = (1-\omega)f\left(\frac{k}{1-u}\right). \tag{15a}$$

Combining (10) and (11) as before, it gives:

$$\frac{\Gamma-1}{\Gamma}\cdot f\left(\frac{k}{1-u}\right) = \gamma k^{-\theta}\cdot(1-u)^{\frac{\theta+\delta}{1-\delta}}. \tag{15b}$$

Applying the implicit function theorem, the slope of unemployment to per capita capital stock is given by:

$$\frac{du}{dk} = -\frac{\theta f + kf'}{\theta f + k^2 f' + \Omega}. \tag{16a}$$

where

$$\Omega = \frac{k\Gamma}{\Gamma-1}\left(\frac{k}{1-u}\right)^{\theta}\cdot\frac{\gamma\delta(1+\theta)}{1-\delta}(1-u)^{\frac{\delta(1+\theta)}{1-\delta}} > 0 \tag{16b}$$

Details are given in Appendix A. It follows that $du/dk<0$ and unemployment decreases for a rise in k. Observe that the same holds even if $\theta=0$, thus capital-employment effects are preserved when search costs remain constant per firm. [3]

Neutrality is obtained only when $\delta \to 1$, leading to $\Omega \to \infty$ and $du/dk \to 0$. This happens only when all labour market frictions disappear and all existing labour force is recruited through the job-matching process, i.e. $N=L$ and $u=0$.

3. Reduced-form equations and estimation

3. 1. A linear approximation

To obtain a reduced-form equation and still keep the elasticity effect, a linearization of (6) and (14a) around some base levels $(\bar{\omega}, \bar{u}, \bar{k})$ is considered. Setting differentials as deviations from base levels, a linear approximation of the aggregate demand curve is obtained in the form:

$$\omega^D - \bar{\omega} = (1-\sigma)\cdot\varphi_1\cdot(u-\bar{u}) + (1-\sigma)\cdot\varphi_2\cdot(k-\bar{k}) + z^D. \tag{17}$$

Similarly, the reduced-form supply curve is:

$$\omega^S - \bar{\omega} = \psi_1\frac{\sigma-1}{\sigma-\omega}(u-\bar{u}) + \psi_2\frac{\sigma-1}{\sigma-\omega}(k-\bar{k}) + z^S. \tag{18}$$

In the above expressions, coefficients $\{\varphi_i, \psi_i, i=1, 2\}$ are non-linear expressions of base values and structural parameters. They remain unambiguously positive as can be seen from the r. h. s. of original equations (6) and (14a). Demand and supply shocks are represented by z^D and z^S respectively. At labour market equilibrium we have that $\omega^S = \omega^D$, thus equilibrium unemployment is obtained as:

$$u^* = -\frac{(\sigma-\omega)\varphi_2+\psi_2}{(\sigma-\omega)\varphi_1+\psi_1}\cdot k^* + \frac{\sigma-\omega}{1-\sigma}\cdot\frac{z^S-z^D}{(\sigma-\omega)\varphi_1+\psi_1} + const \tag{19}$$

The constant term is an expression of the base levels, and a star denotes equilibrium levels. Unemployment clearly falls with a rise in capital accumulation, as long as $\sigma>\omega$. An increase in aggregate demand or a negative supply shock brought about by labour market

[3] In Azariadis and Pissarides (2007) employment is found to depend positively on the capital stock, and this is due to the existence of the job-matching process.

reforms reduce unemployment as long as $\omega<\sigma<1$. If $\sigma<\omega$, the effect on unemployment depends on the relative slopes in the demand and supply curves. Figures 4(a, b) and 5(a, b) illustrate the various cases.

[Fig. 4, around here]

[Fig. 5, around here]

3. 2. Data

All data are from the AMECO data base and listed in Appendix B. Unemployment rate (u) is measured on total civilian labour force in the twelve euro area economies. The capital intensity variable (k) is approximated by the ratio of total investment to GDP. Since gross capital formation is calculated in several countries by applying technical rules, total net fixed investment is preferred as more accurately reflecting the investment flows in the economy. Demand shocks are represented by the GDP growth rate (g) and the inflation rate (p). Supply shocks are represented by changes in the employment protection legislation (Δe), expressed by the relevant OECD indices with a reduction implying higher mobility in the labour market.

A statistical analysis is conducted in Appendix B and the main findings are summarized as follows:

(i) The wage share is not stationary across euro area countries and, thus, the elasticity of substitution cannot be assumed as being unity.

(ii) The unemployment rate and the investment share are not stationary and the assumption of a common unit root cannot be rejected at the 5% and 1% levels.

(iii) The two variables are cointegrated.

(iv) Granger causality runs both ways from investment to unemployment and vice versa. A more detailed analysis shows that causality seems to be stronger from investment to unemployment.

3. 3. Estimation

Taking into account the above findings, the unemployment equation is specified as a cross-sectional error-correction mechanism of degree one for the twelve euro area economies as follows:

$$\Delta u = c(j) + \beta_0 u_{-1} + \beta_1 g_{-1} + \beta_2 p_{-1} + \beta_3 k_{-1} + \beta_4 e_{-1}$$

$$+\delta_1 \Delta g + \delta_2 \Delta p + \delta_3 \Delta k + \delta_4 \Delta e + \xi_t \tag{20a}$$

Coefficients (β_i, δ_i, i=1 . . 4) denote long and short-term effects respectively, while country fixed effects are denoted by (*c(j)*, j=1, . ., 12) and $\{\xi\}$ is the error term. The disturbance term in (20a) may follow an AR(1) structure with coefficient ρ,

$$\xi_t = \rho \xi_{t-1} + \eta_t, \tag{20b}$$

where $\{\eta_t\}$ is an i.i.d. with zero mean. Then (20a) is rewritten as:

$$\Delta u = (1-\rho)c(j) + (1-\rho)\beta_0 u_{-1}$$

$$+(1-\rho)\beta_1 g_{-1} + (1-\rho)\beta_2 p_{-1} + (1-\rho)\beta_3 k_{-1} + (1-\rho)\beta_4 e_{-1}$$

$$+\delta_1 \Delta g + \delta_2 \Delta p + \delta_3 \Delta k + \delta_4 \Delta e - \rho(\beta_0 - 1)\,\Delta u_{-1} - \rho(\beta_1 + \delta_1)\,\Delta g_{-1}$$

$$-\rho(\beta_2 + \delta_2)\Delta p_{-1} - \rho(\beta_3 + \delta_3)\Delta k_{-1} - \rho(\beta_4 + \delta_4)\Delta e_{-1} + \eta_t \tag{20c}$$

Equation (20a) with autoregressive disturbances (20b) is estimated by cross-section OLS over the period 1993-2013as follows (standard errors in parenthesis):

$$\Delta u = \underset{(1.02)^{***}}{7.39} - \underset{(0.08)^{***}}{0.520} u_{-1} - \underset{(0.045)^{***}}{0.121} g_{-1} - \underset{(0.07)}{0.083} p_{-1} - \underset{(0.07)^{***}}{0.418} k_{-1}$$

$$-\underset{(0.03)^{***}}{0.093}\Delta g - \underset{(0.04)^{***}}{0.139}\Delta p - \underset{(0.05)^{***}}{0.321}\Delta k + \underset{(0.30)}{0.20}\Delta e \tag{21}$$

$$\tilde{R}^2 = 0.75, SER = 0.65, F - stat = 36, DW = 2.00, AR(1) = 0.813(0.06), nobs = 234$$

The *level* of labour market protection was found insignificant and wrongly signed, so it was omitted from the final estimation. All other coefficients are found to be correctly signed. However, the level of inflation rate as well as labour market characteristics are not found to be significant at the 10% level, when the OECD index on either individual or collective dismissals is used. [4] All other terms are significant at the 1% level. Estimation reveals a strong capital-

[4] Note, however, that the employment protection index may not be a good description of the overall tightness in the labour market as that examined in Section 2. Hence, its statistical insignificance should not be interpreted as a rejection of all possible effects that rigidities may exert on unemployment.

labour substitution effect: a rise in the investment ratio by 1% of GDP would reduce unemployment by 0.32% in the short run and 0.418/0.52=0.80% in the medium run.

The above results broadly confirm similar findings on the investment impact on unemployment by other studies summarized in Table 1. Regarding the Okun's Law coefficient, Ball et al (2013) provide individual estimates for ten euro area countries within the range [0.137, 0.923][5] and an average value of 0.381, without taking into account any other factor. The common growth-rate coefficient in the medium run (0.121/0.52=0.232) in (21) is close to the lower end. However, if one takes into account that a rise in demand causes a further rise in the investment ratio, the total effect comes closer to the higher end of the interval.

The disturbance term in (21) is found to be highly autoregressive, with a positive and statistically significant first-order coefficient equal to 0.8, in line with the assumption made in (20b). The reported dynamic structure in (21) is further supported empirically by additional specification tests shown in Appendix B. 3, where the model (20c) is generalized to any finite number of lags for the system variables.

Appendix B. 4 contains a brief note on the interpretation of the reported estimation results together with an econometric extension of model (20c), in which the assumption of investment's exogeneity is left aside. Estimation results with endogenous investment, confirm the negative cointegrating relationship between unemployment and investment already estimated in (21). With endogenous investment, the contemporaneous effect of investment changes on unemployment changes is decomposed into a 'partial' (i.e. from investments to unemployment) and a 'feedback' effect (i.e. from unemployment to investments). Unlike (21), it is possible to estimate these effects consistently; implementation of 'Three Stage Least Squares' on the extended model (shown in Appendix B. 4) produces negative estimates for both effects, a finding that remains in line with (21). It also reveals that the 'partial' effect is stronger from investment to unemployment rather than the other way around.

[5] The coefficients on Portugal and Spain are surprisingly large (-0.463 and -0.923, respectively) and this is attributed to ignoring strong labour market imperfections (op. cit.).

4. Conclusions

The paper shows that equilibrium unemployment is affected by capital investment as long as the elasticity of substitution between capital and labour is not too low. The result holds even with a Cobb-Douglas production function if the labour market friction is retained.

In the euro area it is shown that wage shares have not remained constant over the last two decades, thus the investment impact on unemployment is expected to be strong.

A cross-country estimate of unemployment equations finds the investment effect to be correctly signed and statistically significant, in contrast to the weak effect that labour market reforms seem to play in promoting employment. The estimates can be used to calculate the investment gap in the euro area and determine how much of a new initiative on private and public investment is needed to restore employment.

Our econometric approach produced consistent and precise estimates of the reduced form equation predicted by the model as well as of symmetric endogenous relationships between investment and unemployment not explicitly accounted for in the theoretical model. This is accomplished using standard regression techniques and –in the case of investment endogeneity– using different combinations of lagged variables as instruments.

Future research will differentiate between private and public investment and examine the optimal capital accumulation paths in the presence of fiscal constraints in each particular country. On the econometric side, the use of other economic variables (e.g., interest rates, money supply, etc) as alternative instruments is going to be examined as long as they qualify as exogenous to the model. Alternative estimation methods that bypass the use of instrumental variables, such as (conditional) Maximum Likelihood may also be employed after an explicit parameterization of the endogenous relationships in the model.

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Appendix A

A. 1. Solving the production function

Efficient allocation implies that wages are set to their marginal product as at $w= f(\kappa)-\kappa f'(\kappa)$. Differentiating, we get $dw=-f''(\kappa)\kappa d\kappa$. -Substituting into (2), expression (3) is readily obtained. Assuming that the initial conditions for output and labour share (y_0, ω_0 respectively) are given at the full employment level, the integration constant in (4) becomes:

$$\Gamma = \Gamma(\sigma) = \ y_0 {\omega_0}^{-\sigma} \tag{22}$$

A. 2. The slope of the supply-curve

Taking logs, (13) becomes:

$$\frac{1}{1-\sigma} ln\Gamma + \frac{\sigma}{1-\sigma} ln\omega + \ln(1-\omega) = -\theta lnk + \frac{\theta+\delta}{1-\delta} ln(1-u) \tag{23}$$

Differentiating:

$$\frac{\sigma}{1-\sigma}\cdot\frac{d\omega}{\omega} - \frac{d\omega}{1-\omega} = -\theta\frac{dk}{k} - \frac{\theta+\delta}{1-\delta}\cdot\frac{du}{1-u} \tag{24a}$$

Rearranging, it gives (14). For *k=const*, expression (15) is obtained.

To see the comparative statics, we set *u=const*, and obtain:

$$\frac{\partial\omega}{\partial k} = \frac{\sigma-1}{\sigma-\omega}\cdot\frac{\theta\omega(1-\omega)}{k} \tag{24b}$$

For $\omega<\sigma<1$, $d\omega/dk<0$, thus with a rise in investment the supply curve moves downwards, as shown in Fig. 4a.

For $\sigma<\omega<1$or $\sigma>1>\omega$, $d\omega/dk>0$, thus with a rise in investment the supply curve moves upwards, as shown in Fig. 5a and 5b.

A. 3. The Cobb-Douglas case

Setting $\sigma=1$ and substituting (5) into (13), the following expression is obtained for the unemployment rate:

$$\frac{\Gamma-1}{\Gamma}\cdot f\left(\frac{k}{1-u}\right)=k^{-\theta}\cdot\gamma(1-u)^{\frac{\theta+\delta}{1-\delta}} \tag{25}$$

Rearranging, an implicit function is obtained as $A(u, k) -\gamma B(u) =0$, where expressions A and B are defined as:

$$A(u,k):=\frac{\Gamma-1}{\Gamma}\cdot\left(\frac{k}{1-u}\right)^{\theta}\cdot f\left(\frac{k}{1-u}\right) \tag{26a}$$

$$B(u):=(1-u)^{\frac{\delta(1+\theta)}{1-\delta}}. \tag{26b}$$

By the implicit function theorem the slope is obtained as:

$$\frac{du}{dk}=-\frac{\partial A/\partial k}{\partial A/\partial u-\gamma\partial B/\partial u}. \tag{27}$$

Differentiating A and B w. r. t. u and k:

$$\frac{\partial A}{\partial k}=\frac{\Gamma-1}{\Gamma}\cdot\left\{\frac{\theta}{1-u}\left(\frac{k}{1-u}\right)^{\theta-1}\cdot f+\left(\frac{k}{1-u}\right)^{\theta}\frac{f'}{1-u}\right\}>0 \tag{28a}$$

$$\frac{\partial A}{\partial u}=\frac{\Gamma-1}{\Gamma}\cdot\left\{\frac{\theta}{(1-u)^{2}}\left(\frac{k}{1-u}\right)^{\theta-1}\cdot f+\left(\frac{k}{1-u}\right)^{\theta}\frac{kf'}{(1-u)^{2}}\right\}>0 \tag{28b}$$

$$\frac{\partial B}{\partial u} = -\frac{\gamma\delta(1+\theta)}{1-\delta}(1-u)^{\frac{\theta+\delta}{1-\delta}-1} < 0 \tag{28c}$$

Thus,

$$\frac{du}{dk} = -\frac{(+)}{(+)-(-)} = (-) < 0. \tag{27′}$$

This holds for all parameter values $\theta \geq 0, 0 < \delta < 1$. The slope becomes flat only when $\delta \to 1$, i.e. all labour market friction disappears.

Appendix B: Data analysis

B. 1. Data series

All macroeconomic series are directly obtained or compiled from AMECO. Using the most recent data vintage, the G. D. P. growth rate g_{jt} for the country *j* and the year *t* is constructed as $100\frac{OVGD_{jt}-OVGD_{jt-1}}{OVGD_{jt-1}}$, where *OVGD* is defined by AMECO as Gross domestic product at constant market prices. Similarly, the inflation rate p_{jt} is measured as $100\frac{ZCPIN_{jt}-ZCPIN_{jt-1}}{ZCPIN_{jt-1}}$, where *ZCPIN* is defined by AMECO as National consumer price index.

The series on the strictness of employment protection are obtained from OECD data on individual and collective dismissals (regular contracts). Two versions are available:

1. EPL: Series EPRC_V1, 1985-2013. Version 1 of this indicator incorporates 8 data items concerning regulations for individual dismissals. It is therefore identical to the version 1 of the indicator of strictness of employment protection against individual dismissal (regular contracts, EPR_v1).

2. EPRC_V2, 1998-2013. Version 2 of this indicator is the weighted sum of sub-indicators concerning the regulations for individual dismissals (weight of 5/7) and additional provisions for collective dismissals (2/7). It incorporates 12 detailed data items.

B. 2. Econometric tests

Wage share stationarity

First the stationarity of wage shares is examined, so as to implicitly discern whether the elasticity of substitution is unity or not. Figure 6 displays the wage bill as a ratio to GDP and is clear that the series are not stationary. As a matter of fact, the constancy of wage share is far from holding in the euro area even before the crisis.

[Fig. 6, around here]

Table 2 shows that over the period 1991-2006 most euro area countries –with the exemption of Portugal and Greece–exhibited a downward trend, which is statistically significant. In the aftermath of the 2008 crisis, wage shares fall in all of the GIPS countries, but get stabilized or even rise in the rest of the euro area economies. These findings imply that the elasticity of substitution cannot be considered as equal to one and the relationship between unemployment and capital investments should be thoroughly investigated.

Further verification that 2007 is the most likely date of shift in the trend of wage shares provides Figure 7, which reports the coefficients of determination (R-square) from repeated regressions of wage shares on a constant, time trend and a 'dummy' variable that captures a single change in the trend coefficient over the whole period in question starting from the year 1993 successively to 2012.[6] Fig. 7 confirms that the coefficient of determination attains the highest value when the regression contains shift in the trend around the year 2007.

[Fig. 7, around here]

[6] The method of estimation is pooled least squares regression with country fixed effects in the intercept.

Unit root tests

As shown in Table 3, the hypothesis of either stationarity or trend-stationarity is rejected at the 1% level for both the unemployment rate and the investment ratio. The hypothesis of a common unit root cannot be rejected at the 5% and 1% level for the investment ratio and the unemployment rate, respectively, against either stationarity or trend-stationarity.[7] On the other hand, estimates of the autocorrelation structure by using Ljung-Box Q-statistics with up to 10 lags show that the first and second differences of the aforementioned series exhibit significantly lower and almost no high-order autocorrelation relative to the series in levels; results available upon request. Furthermore, the unit root tests of Table 3 performed on the first differences of each series reject the null hypothesis and fail to reject stationarity at the conventional levels. Consequently, estimation will proceed in first differences.

Cointegration tests

The two variables are also co-integrated, as it is clearly suggested by the findings reported in Table 4. The hypothesis that there exist at most one cointegrating relation between them in a VAR specification with lag order ranging from one to four, cannot be rejected at the 5% level; see Engle and Granger, (1987). Pedroni's (2004) residual-based cointegration test also rejected the hypothesis of no cointegration at the 10% and 1% level against the alternative of common and country effects, respectively. The results and further details are reported in Panel B of Table 4.

Causality tests

A Granger-causality test is also performed in first-differences for the period 1990-2014 and for the pre-crisis period 1990-2007; see Table 5 (Panel A). Granger-causality is found to run both ways, and this is explained by the fact that a reduction in unemployment brings about a rise in demand to which investment is gradually responding as in a typical Keynesian accelerator process. In the pre-crisis period and for lags 3 to 5, it cannot be rejected only for the direction from investment to unemployment, and this can be taken as some evidence that

[7] Comparing with the investment ratio, unemployment rate's results exhibit greater sensitivity to the choice of the unit root test and the tests' parameters, i.e. the number of lags according to either the Schwartz or the Akaike Information Criteria. It is also more sensitive to the formulation of the alternative hypothesis, i.e. stationarity or trend stationarity.

changes in investment precede those in unemployment. This is also supported by an alternative version of the Granger Causality test originally introduced by Dumitrescu and Hurlin (2002) which allows for cross-country heterogeneity in the standard Granger VAR regression specification, as shown in Panel B of Table 5.

[Fig. 8, around here]

A similar impression is conveyed by checking the incidences of changes in the unemployment rate and the investment ratio. Fig. 8 shows that the majority of changes are taking place in opposite direction, contemporaneously as well as with up to two lags or leads. The negative relationship is stronger between lagged unemployment and current investment ratio than the other way around.

B. 3. Generalization of the econometric model and specification tests

Equation (20a) is rewritten below as a "conditional Error Correction Model" (ECM, Pesaran et al 2001) in general form without any terms related to the labour protection series (for simplicity) :

$$\Delta u_{jt} = c_j + \beta_1 u_{jt-1} + \beta_2 g_{jt-1} + \beta_3 p_{jt-1} + \beta_4 k_{jt-1} + \sum_{i=1}^{p_u} \delta_{1i} \Delta u_{jt-i} + \sum_{i=0}^{p_g} \delta_{2i} \Delta g_{jt-i} + \sum_{i=0}^{p_\pi} \delta_{3i} \Delta p_{jt-i} + \sum_{i=0}^{p_k} \delta_{4i} \Delta k_{jt-i} + \varepsilon_{jt,} \qquad (29)$$

where t and j denote year and country, respectively. Compared to equation (20a) the specification above is augmented with lagged differenced terms, which capture short term autocorrelation in the data leaving the disturbance term, $\{\varepsilon_{jt}\}$, serially uncorrelated. Also note that, for $p_u = p_g = p_\pi = p_k = 1$, model (29) nests the case where the disturbance term in (20a) follows the AR(1) process described in (20b), which is the version finally estimated in (21).

The model (29) falls in the category of Autoregressive Distributed Lag (ARDL) models (Greene, 2005, Chapter 19, p. 579) and can therefore be consistently estimated via Least Squares, in which case we obtain (standard errors in parenthesis and *t, j* subscripts are dropped for simplicity):

$$\Delta u = 1.592 - 0.136u_{-1} - 0.052g_{-1} - 0.018p_{-1} - 0.052k_{-1}$$
$$(0.395)^{***}\ (0.028)^{***}\ (0.041)\quad (0.032)\quad (0.030)^{*}$$
$$- 0.080\Delta g - 0.141\Delta p - 0.286\Delta k$$
$$(0.028)^{***}\ (0.043)^{***}\ (0.049)^{***}$$
$$+0.005\Delta g_{-1} + 0.061\Delta p_{-1} - 0.064\Delta k_{-1} + 0.467\Delta u_{-1}$$
$$(0.023)\quad (0.040)\quad (0.049)\quad (0.061)^{***} \tag{30}$$

$$\tilde{R}^2 = 0.73, SER = 0.66, F - stat = 31.21, DW = 2.13, nobs = 251 .$$

The lag order choice is based on minimization of the value of the Schwartz and Akaike Information Criteria over the range {0, 2} and $p_u = p_g = p_\pi = p_k$. Unreported estimations showed that an AR(1) structure in the disturbance term is statistically significant no more. Finally, note that the estimated coefficients differ from those in (21) partly because they incorporate the effect of the AR(1) coefficient of the disturbance term.

B. 4. Accounting for investment's endogeneity

A useful property of the dynamic structure of the "conditional ECM" in (28) is that the systematic part includes only past information of the endogenous variables in the system, while the disturbance term can be assumed to be independently and identically distributed over time. Consequently, relaxation ofthe assumption that investments are exogenous has a small impact on the interpretation and estimation of the model. It merely affects interpretation of the coefficient of contemporaneous investment changes $(\Delta k_{jt}), \delta_{40},$ which does not measure the 'ceteris paribus' effect of Δk_{jt}on Δu_{jt} anymore. Instead, it measures the 'partial' effect of Δk_{jt} on Δu_{jt} without absorbing any feedback to $\Delta k_{jt}$from the other variables of the system.

The 'partial' effect of Δk_{jt} on Δu_{jt}

In order to estimate such a 'partial' effect, given the inconsistency of the OLS estimator, we follow the typical approach and implement Two Stage Least Squares (TSLS) on (29) under the assumption $E(\Delta k_{jt}\varepsilon_{jt}) \neq 0$. The estimated specification with country fixed effects for the period 1990 – 2013 is shown below (p-values in parenthesis and t, j subscripts are dropped for simplicity):

$$\begin{aligned}\Delta u = \; & 1.295 - 0.092u_{-1} - 0.263g_{-1} - 0.060p_{-1} + 0.038k_{-1} \\ & (0.025) ** \; (0.042) ** \; (0.019) ** \; (0.258) \; (0.542) \\ & - 0.295\Delta g - 0.115\Delta p + \mathbf{0.331}\widehat{\boldsymbol{\Delta k}} \\ & (0.007) *** \; (0.050) ** \; (0.265) \\ & -0.056\Delta g_{-1} + 0.130\Delta p_{-1} - 0.134\Delta k_{-1} + 0.536\Delta u_{-1} \\ & (0.182) \; (0.042) ** \; (0.083) * \; (0.000) *** \end{aligned} \tag{31}$$

$$\tilde{R}^2 = 0.53, Prob(J - stat) = 0.743 .$$

Notice that the variable Δk, which was assumed exogenous in (29) is now replaced by $\widehat{\Delta k}$, i.e. the 'instrumented' variable according to the TSLS method.[8] The 'partial' effect of Δk on Δu (the coefficient of $\widehat{\Delta k}$) is estimated positive (0.331) and statistically insignificant, using all exogenous variables in the system together with the set $\{\Delta k_{-2}, \Delta u_{-2}, \Delta k_{-3}, \Delta u_{-3}\}$ as instruments to form $\widehat{\Delta k}$. The validity of this set of instruments is not rejected according to the *J*-statistic. Results using alternative instrument sets remain roughly the same though less precise and are available upon request.

The 'partial' effect of Δu_{jt} on Δk_{jt}

The finding that the TSLS coefficients of Δk is positive and statistically insignificant implies that either the contemporaneous 'partial' effect from investments to unemployment is too weak to be estimated precisely or our estimation method is inefficient. In order to fully explore the first implication we run the inverse exercise, i.e. reversing the position between Δk and Δu in (28) and implement TSLS as before. The reversed specification is denoted with prime superscripts on the coefficients as:

[8] In the first stage, TSLS finds the portions of the endogenous and exogenous variables that can be attributed to the instruments. This stage involves estimating an OLS regression of each variable in the model on the set of instruments. The second stage is a regression of the original equation, with all of the variables replaced by the fitted values from the first-stage regression.

$$\Delta k_{jt} = c'_j + \beta'_1 u_{jt-1} + \beta'_2 g_{jt-1} + \beta'_3 \pi_{jt-1} + \beta'_4 k_{jt-1}$$

$$+\sum_{i=0}^{p_u} \delta'_{1i} \Delta u_{jt-i} + \sum_{i=0}^{p_g} \delta'_{2i} \Delta g_{jt-i} + \sum_{i=0}^{p_\pi} \delta'_{3i} \Delta \pi_{jt-i} + \sum_{i=1}^{p_k} \delta'_{4i} \Delta k_{jt-i} + \varepsilon'_{jt} \quad (32)$$

and the results from TSLS implementation (p-values in parenthesis):

$$\begin{aligned}
\Delta k = {} & 0.090 - 0.032u_{-1} + 0.406g_{-1} + 0.098p_{-1} - 0.0171k_{-1} \\
& (0.933) \quad (0.688) \quad (0.000)*** \; (0.232) \quad (0.001)*** \\
& +0.449\Delta g + 0.029\Delta p + \mathbf{0.570}\widehat{\boldsymbol{\Delta u}} \\
& (0.000)*** \; (0.776)(0.284) \\
& +0.119\Delta g_{-1} - 0.200\Delta p_{-1} + 0.237\Delta k_{-1} - 0.450\Delta u_{-1} \\
& (0.006)*** \quad (0.021)** \quad (0.017)** \quad (0.112)
\end{aligned} \quad (33)$$

$$\tilde{R}^2 = 0.46, Prob(J - stat) = 0.287\,.$$

The ‘partial’ effect of Δu on Δk (the coefficient of $\widehat{\Delta u}$) is estimated positive (0.570) and statistically insignificant, using all exogenous variables in the system together with the set $\{\Delta k_{-2}, \Delta k_{-3}, \Delta u_{-2}, \Delta u_{-3}, \Delta p_{-2}, \Delta p_{-3}, \Delta g_{-2}, \Delta g_{-3}\}$ as instruments to form $\widehat{\Delta u}$. The validity of this set of instruments is not rejected according to the *J*-statistic. Results using alternative instrument sets remain roughly the same though less precise and are available upon request.

Joint estimation of the partial effects

We improve the precision of our estimation method in two ways: first, estimation of (30) and (32) is conducted jointly as a system. In this way we take advantage of possible correlation of the disturbance terms across equations. This is done by employing the standard “Seemingly Unrelated Regression” (SUR) method together with Two-Stage Least Squares as before. This method is typically called Three-Stage Least Squares (3SLS).

Second, we impose cross-equation restrictions on the cointegration coefficients between unemployment and investment. These restrictions secure that both variables respond to the same cointegration error, or equivalently that:

$$\frac{\beta_1 u_{jt-1} + \beta_2 g_{jt-1} + \beta_3 p_{jt-1} + \beta_4 k_{jt-1}}{\beta_1} = \frac{\beta'_1 u_{jt-1} + \beta'_2 g_{jt-1} + \beta'_3 p_{jt-1} + \beta'_4 k_{jt-1}}{\beta'_1} \quad (34)$$

which implies the following three restrictions:

$$\beta'_2 = \frac{\beta'_1 \beta_2}{\beta_1},\ \beta'_3 = \frac{\beta'_1 \beta_3}{\beta_1},\ \beta'_4 = \frac{\beta'_1 \beta_4}{\beta_1}. \quad (35)$$

Joint 3SLS estimation of (29) and (32) under the coefficient restrictions in (35) yields the following output (p-values in parenthesis):

$$\begin{aligned}\Delta u = \ & const - \underset{(0.000)**}{0.151 u_{-1}} - \underset{(0.074)}{0.015 g_{-1}} - \underset{(0.573)}{0.017 p_{-1}} - \underset{(0.020)**}{0.078 k_{-1}} \\ & - \underset{(0.306)}{0.050 \Delta g} - \underset{(0.001)***}{0.141 \Delta p} - \underset{(0.005)***}{0.358 \widehat{\Delta k}} \\ & - \underset{(0.182)}{0.056 \Delta g_{-1}} + \underset{(0.042)**}{0.130 \Delta p_{-1}} - \underset{(0.083)*}{0.134 \Delta k_{-1}} + \underset{(0.000)***}{0.536 \Delta u_{-1}} \end{aligned} \quad (36a)$$

$$\begin{aligned}\Delta k = \ & const - \underset{(0.000)***}{0.357} \left(\frac{-0.151 u_{-1} - 0.015 g_{-1} - 0.017 p_{-1} - 0.078 k_{-1}}{-0.151} \right) \\ & - \underset{(0.504)}{0.088 \Delta g} - \underset{(0.005)***}{0.357 \Delta p} - \underset{(0.000)***}{2.426 \widehat{\Delta u}} \\ & + \underset{(0.489)}{0.037 \Delta g_{-1}} + \underset{(0.253)}{0.119 \Delta p_{-1}} - \underset{(0.383)}{0.109 \Delta k_{-1}} + \underset{(0.004)***}{1.057 \Delta u_{-1}} \end{aligned} \quad (36b)$$

The ‘partial’ effect of Δk on Δu (the coefficient of $\widehat{\Delta k}$ in 36a) is estimated negative (-0.358) and statistically significant, using all exogenous variables in the system together with the set $\{\Delta k_{-2}, \Delta u_{-2}, \Delta u_{-3}\}$ as instruments to form $\widehat{\Delta k}$. Notice that this estimate is larger in magnitude than thevalue (-0.286) of the 'total' effect of Δk on Δu, estimated in (30), i.e. which includes possible contemporaneous feedback from Δu. In this context, it implies that the ‘partial’ effect from investment to unemployment suffices to explain their total negative relationship, which holds *ceteris paribus* in equilibrium.

The same intuition holds looking at the ‘partial’ effect of Δu on Δk (the coefficient of $\widehat{\Delta u}$ in 36b), which is estimated negative (-2.426) and statistically significant using all exogenous variables in the system together with the set $\{\Delta k_{-2}\}$ as instruments to form $\widehat{\Delta k}$. This estimate is much smaller in magnitude than 1/0.286 = 3.496 (i.e. the inverse of the value estimated in (30) as explained above) implying that the partial effect from unemployment to investment does not suffice to explain their negative relationship, which holds ceteris paribus in equilibrium.

Two final remarks should be made; first, the coefficients of unemployment and investments in the (common) cointegrating relationship (β_1 and β_4) are found statistically significant and with the same sign, confirming their negative cointegrating relationship. Second, the coefficients of the adjustment to past cointegration errors are estimated negative (-0.151 and -0.357) and statistically significant in both (36a) and (36b), respectively, verifying that both variables respond in the expected way (i.e. as cointegrated variables) to long run disequilibrium shocks.

Figures

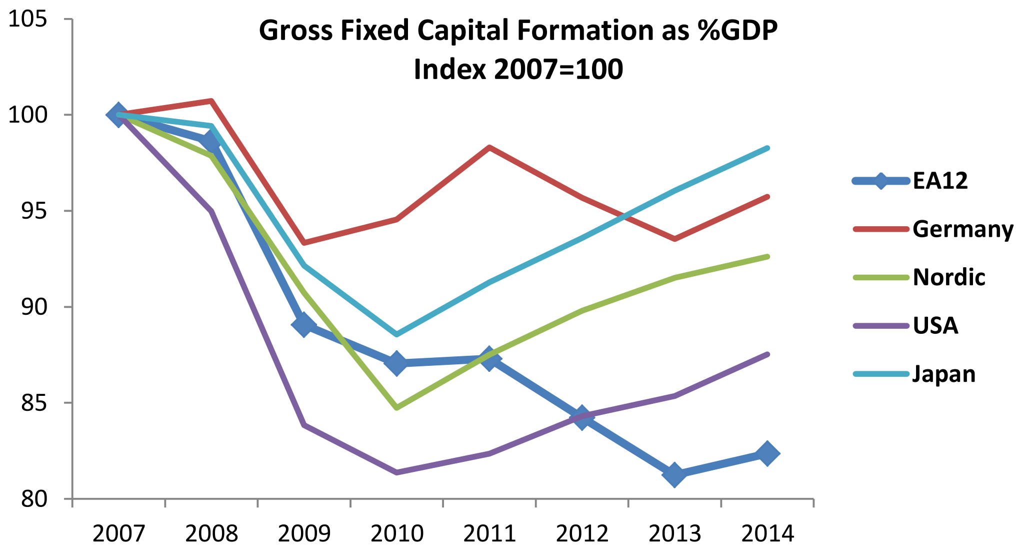

Fig. 1. Gross fixed capital formation, expressed as percentage of GDP. The ratio is taken at current market prices and is indexed to 100 at 2007. The Nordic group is the simple average of Denmark, Sweden and Norway. Source: Ameco.

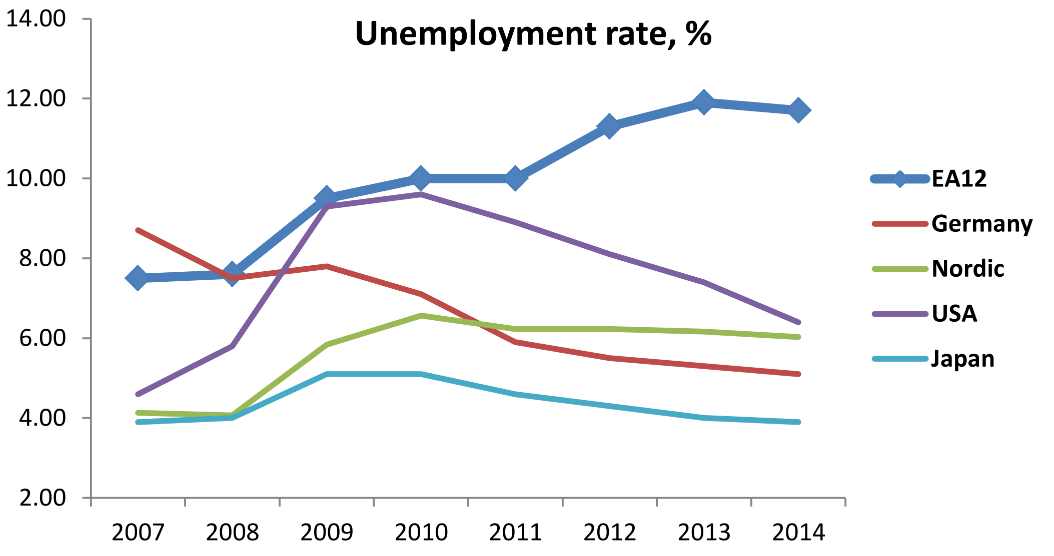

Fig. 2. Unemployment rate expressed as percent of civilian labour force. Source: Ameco.

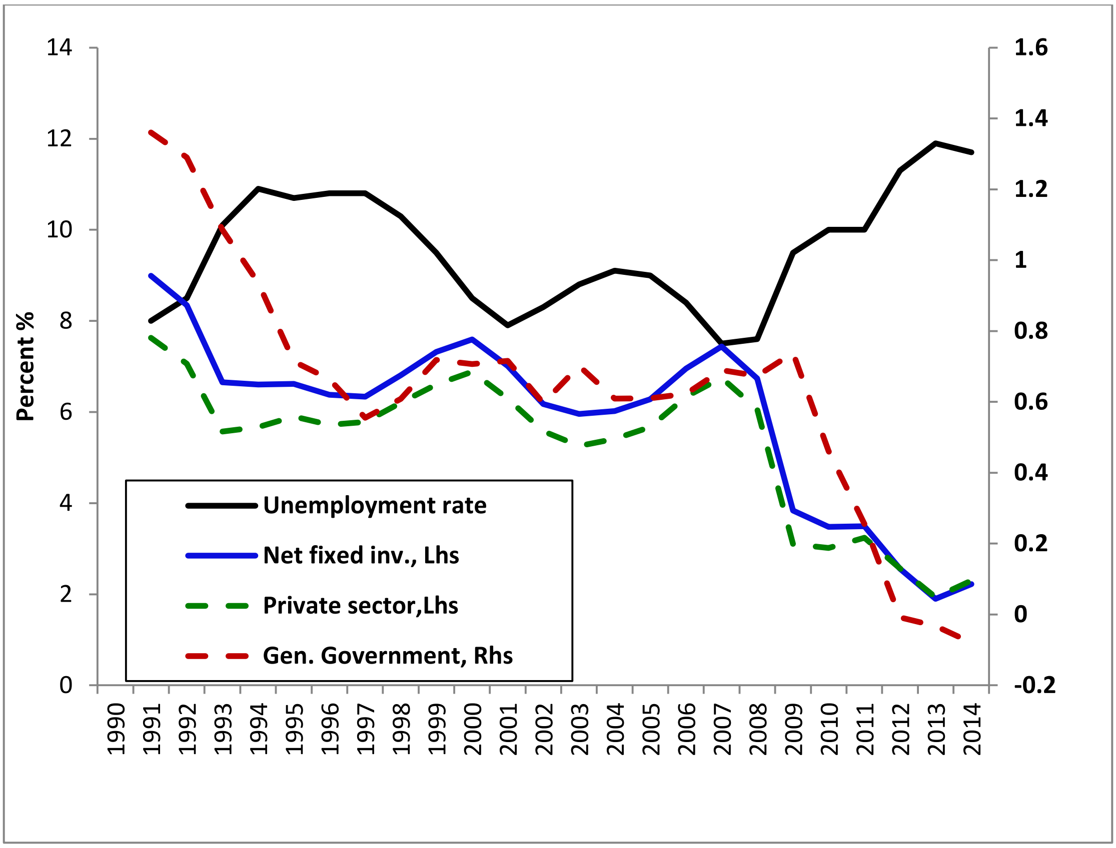

Fig. 3. Unemployment rate in the euro area 12 and net fixed capital formation: total (Lhs), by the private sector (Lhs), and by public sector (Rhs), all expressed as percentages of GDP. Source: Ameco.

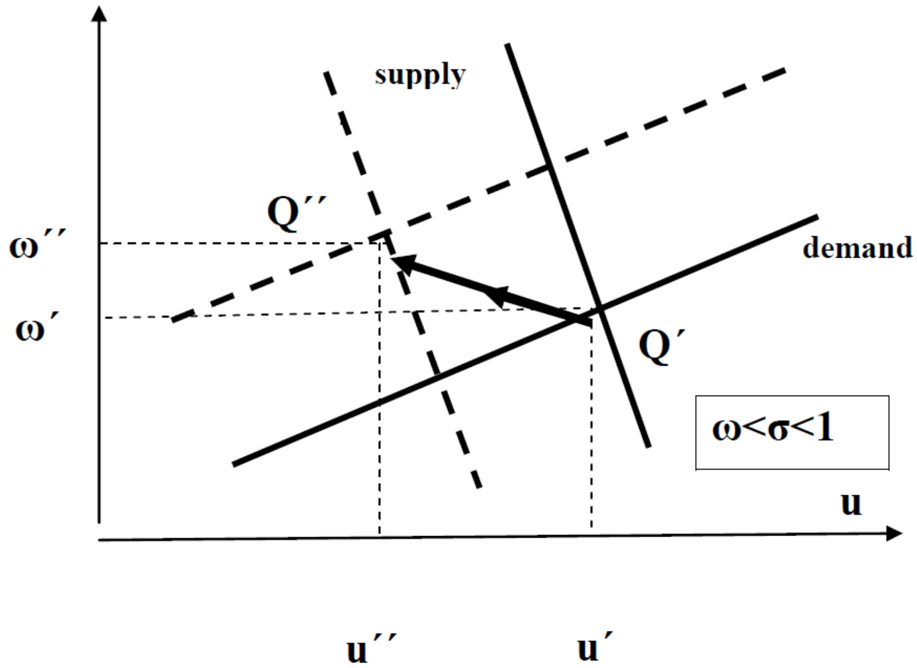

Fig. 4a. Labour demand and supply curves for *ω<σ<1*. With a rise in per capita capital stock *(k),* the supply curve moves to the left, while the demand curve moves upwards. At the new equilibrium (Q´´), unemployment is always lower but the effect on the wage share depends on the slopes.

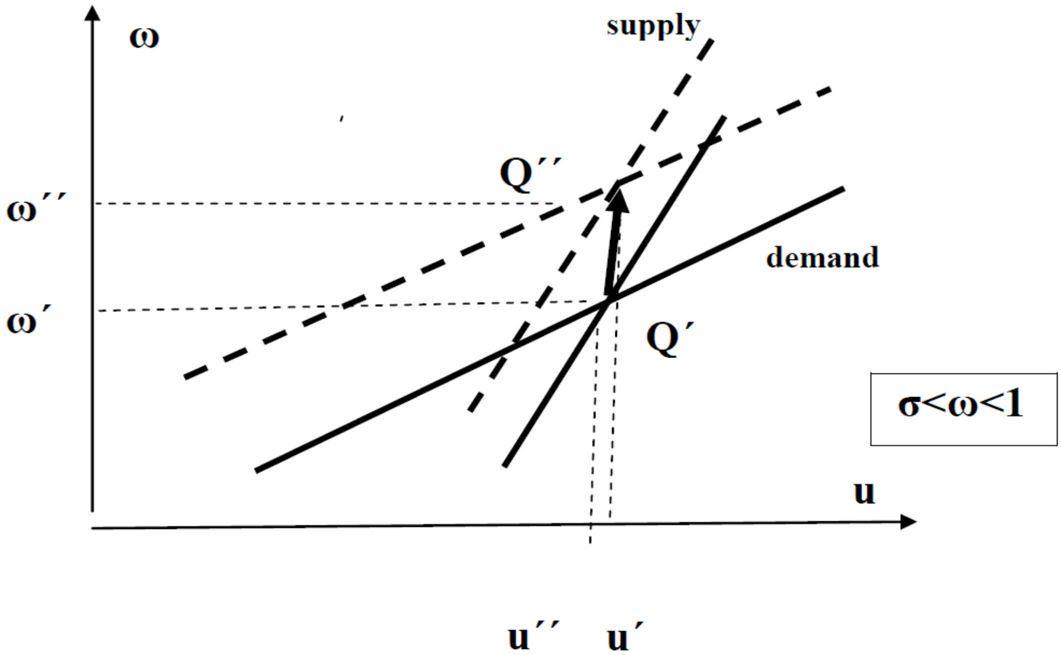

Fig. 4b. Labour demand and supply curves for *σ<ω<1*. With a rise in the capital stock, the wage share is always higher but the effect on unemployment depends on the slope of the supply curve.

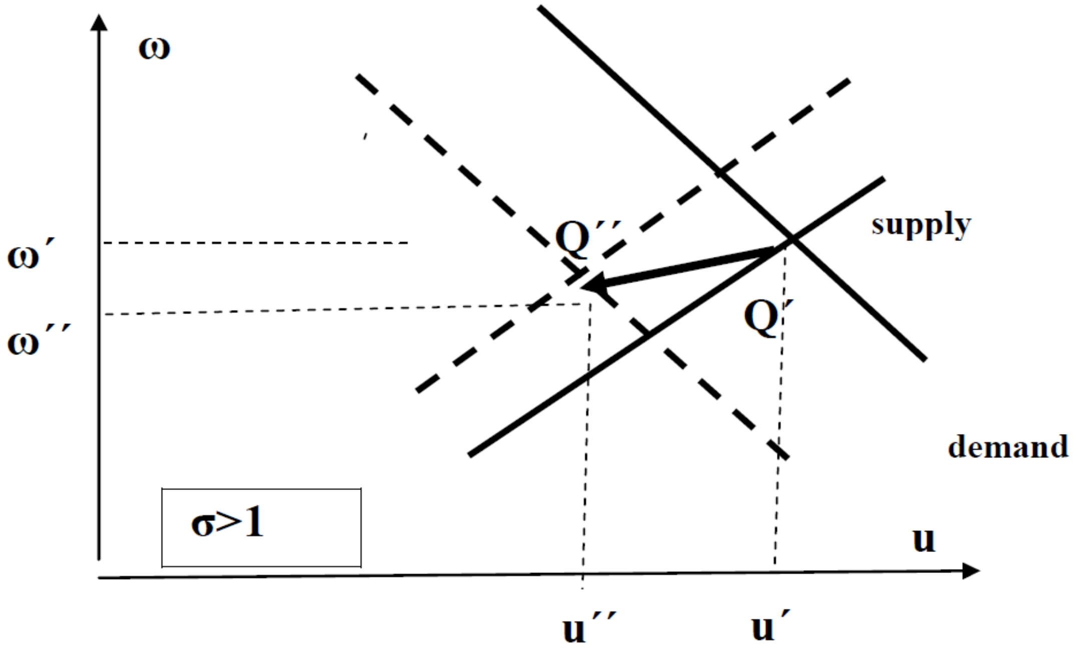

Fig. 5a. Labour demand and supply curves for *σ>1*. With a rise in the capital stock, unemployment is always lower but the effect on the wage share depends on the slope of the supply curve.

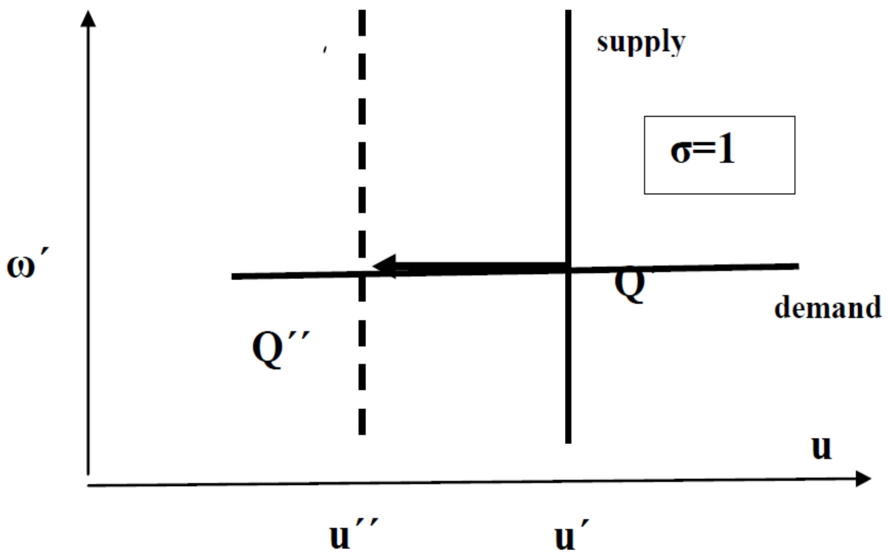

Fig. 5b. Labour demand and supply curves for *σ=1*. With a rise in per capita capital stock *(k)*, the supply curve moves to the left. At the new equilibrium (Q´´), unemployment is lower.

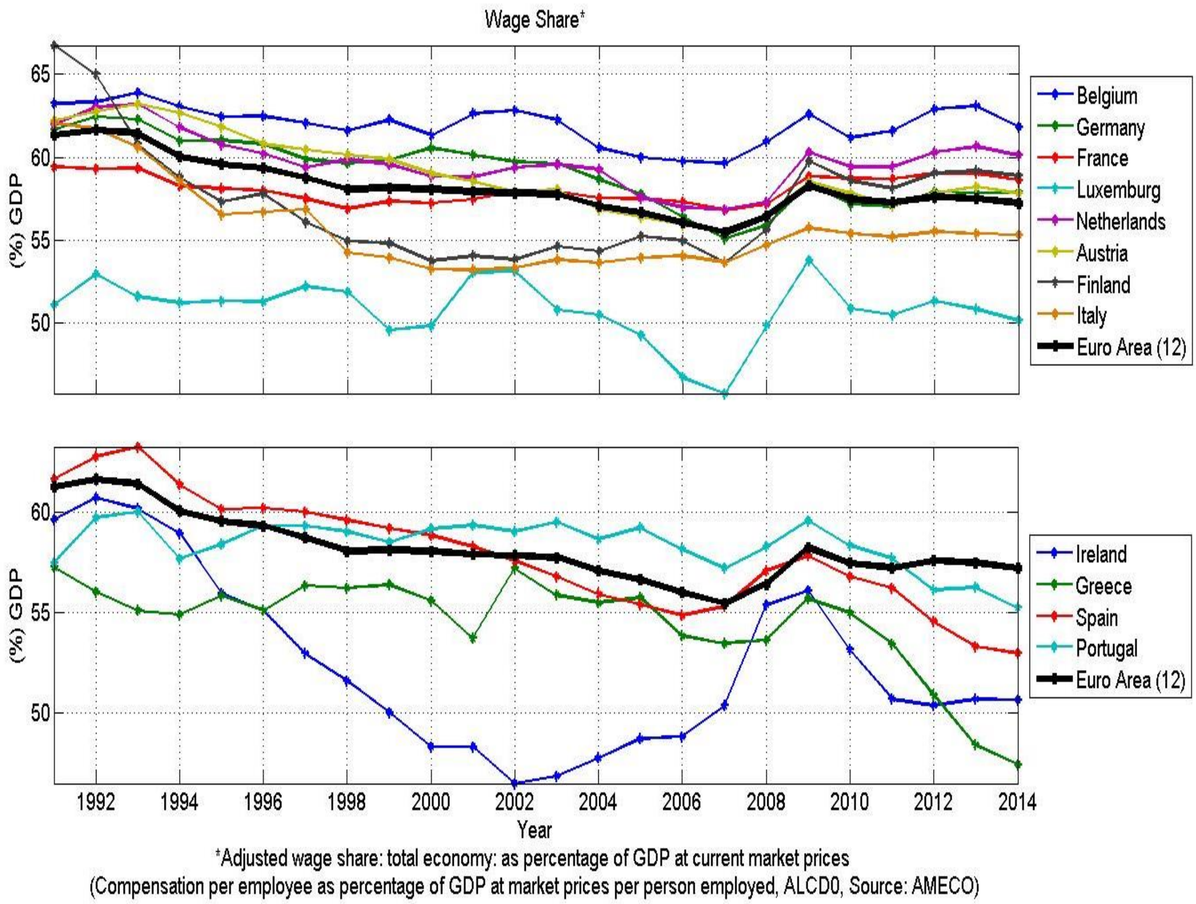

Fig. 6. Wage share in GDP for the euro area 12

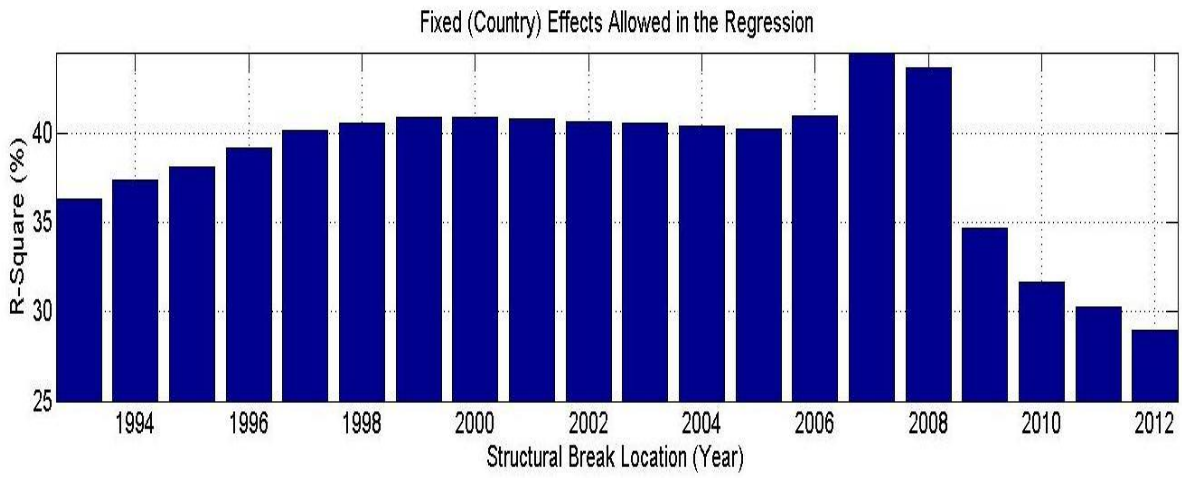

Fig. 7. Coefficients of determination from repeated regressions (pooled least squares with country fixed effects) of wage shares series on constant, time trend and dummy variable that captures one possible shift ('break') in the trend occurring once over the whole period, starting from 1993 successively to 2012.

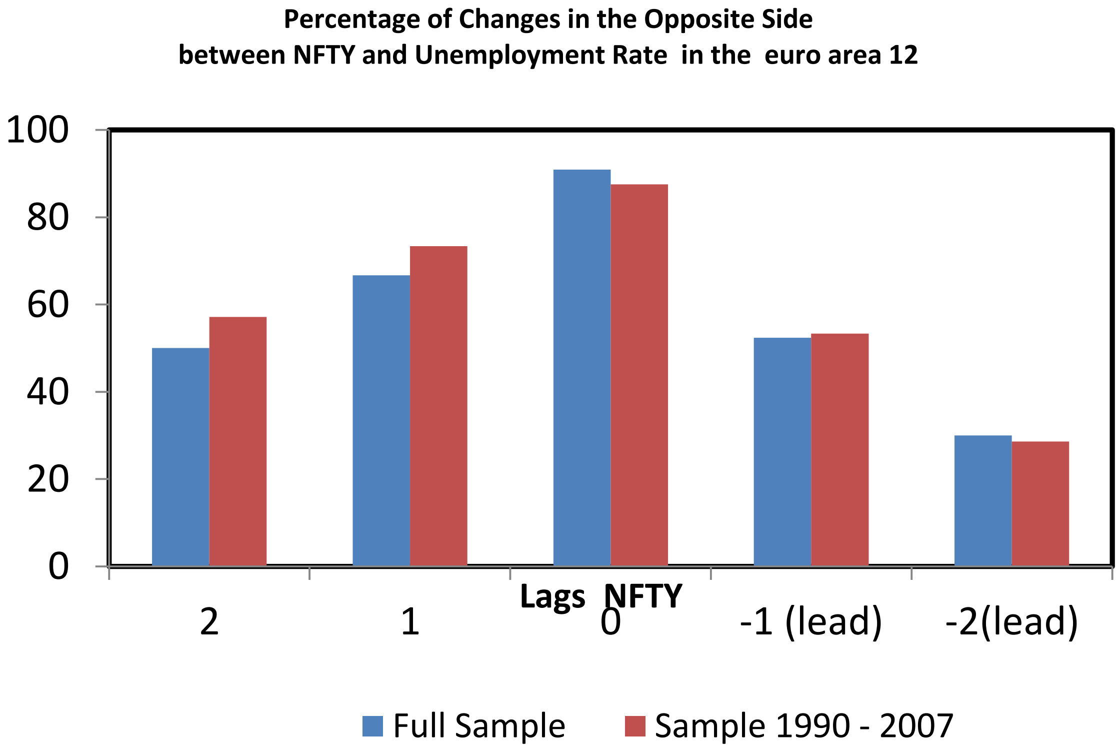

Fig. 8. Changes in unemployment rate and investment in opposite directions as percent of total changes, 1990-2014.

Tables

Table 1. Results in the literature

Author	**Period**	**Countries**	**Method**	**Capital effect**
Karanassou, Sala and Salvador (2008)	1973-2005 1966-2005 1976-2005	Denmark Sweden Finland	3SLS estimates	On employment **0.60** **0.70** **0.80**
Alexiou and Pitelis (2003)	1961-1998	12 EU countries (incl. 3 non-EA)	Panel Fixed effects	On unemployment **-0.49**
Sigurdsson (2013)	1970-2011	15 OECD countries	Panel Fixed effects	**−0.524**
Stockhammer and Klar (2008)	1982-2003	20 OECD countries (incl. 10 non-EA)	panel least squares;	**-0.87** **-1. 69**[a]

Notes: (a) The coefficient is obtained for the change in capital stock.

Table 2. Detrending the wage share in EA 12

Period	**1991-2006**		**2007-2014**	
Country	**coefficient**	**p-values**	**coefficient**	**p-values**
BE	-0.202	0.003	0.324	0.130
FI	-0.679	0.000	0.613	0.005
FR	-0.120	0.077	0.267	0.211
GE	-0.297	0.000	0.332	0.121
IT	-0.575	0.000	0.172	0.420
NL	-0.335	0.000	0.470	0.029
AS	-0.488	0.000	0.264	0.215
LX	-0.174	0.010	0.330	0.123
GR	-0.061	0.367	**-1.007**	0.000
IE	-1. 000	0.000	**-0.490**	0.023
PT	0.012	0.854	**-0.416**	0.053
SP	-0.517	0.000	**-0.543**	0.012

Note: A simple time trend is employed.
Source: AMECO. Adjusted wage share in total economy as percentage of GDP at current market prices. Compensation per employee as percentage of GDP at market prices per person employed. (Variable ALCD0).

Table 3. Panel unit-root tests 1990 - 2014: p-values

Test:	**Levin, Lin&Chu (2002)**		**Breitung (2000)**		**Hadri (2000) Heter/dastic Consistent Z-stat**
Null Hypothesis:	**Unit Root (Individual Country)**				**Stationarity (Individual Country)**
Number of lags based on:	**SIC**	**AIC**	**SIC**	**AIC**	
Variable:	**Unemployment Rate**				
1990 - 2014:	0.039	0.457	0.057	0.020	0.001
1990 – 2007:	0.002	0.001	0.204	0.147	0.000
1990 - 2014 (Deterministic Trends Included) :	0.015	0.026	0.133	0.148	0.000
1990 – 2007(Deterministic Trends Included) :	0.062	0.073	0.036	0.036	0.000
Variable:	**Net Fixed Capital Formation (% GDP)**				
1990 - 2014:	0.140	0.888	0.127	0.183	0.000
1990 – 2007:	0.029	0.035	0.482	0.447	0.000
1990 - 2014 (Deterministic Trends Included) :	0.076	0.266	0.236	0.298	0.000
1990 – 2007(Deterministic Trends Included) :	0.017	0.300	0.720	0.616	0.000

Table 4: Cointegration Tests: 1990-2014

<table>
<tr><td colspan="6">Panel A: Johansen's (1991, 1995) Cointegration Test: 1990-2014</td></tr>
<tr><td>Number of lags:</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td></td><td colspan="5">Number of Cointegrating Equations (Relations)</td></tr>
<tr><td>Trace Statistic Based:</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>Max. Eigenvalue Statistic Based:</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td colspan="6">Panel B: Pedroni (1999, 2004) Cointegration Test: 1990-2014</td></tr>
<tr><td colspan="2">Null Hypothesis: No co-integration</td><td colspan="2">statistic</td><td colspan="2">p-value</td></tr>
<tr><td>Alternative Hypothesis 1:
Common AR coefficient (*)</td><td>Panel ADF</td><td colspan="2">-1.469</td><td colspan="2">0.071</td></tr>
<tr><td>Alternative Hypothesis 2:
Country AR coefficient (*)</td><td>Group ADF</td><td colspan="2">-3.060</td><td colspan="2">0.001</td></tr>
</table>

Note: Panel A: Test based on a panel bivariate Unemployment - Investment Vector Autoregression (VAR) Model with net fixed capital formation(% GDP) as the investment variable. For the statistical tests (a) the level of significance is set to 5%, (b) trend and intercept are allowed in the VAR and (c) no trend is allowed in the cointegrating equation. Panel B: Cointegration test between the unemployment rate series and net fixed capital formation (% GDP).

(*) Two alternative test hypotheses account for either a common or different autoregressive coefficient (AR) in the cointegration error across countries.

Table 5: Causality Tests

Panel A: Granger Causality Test				
Δ (Unemployment Rate) does not G-Cause Δ (Investment share) p-value Δ (Investment share) does not G-Cause Δ (Unemployment Rate) p-value				
Number of lags				
1	**2**	**3**	**4**	**5**
Period 1990-2014				
0.00 0.00	0.00 0.01	0.00 0.00	0.00 0.01	0.01 0.00
Period prior to the crisis, 1990 – 2007				
0.01 0.00	0.00 0.00	**0.13** **0.05**	**0.30** **0.08**	**0.46** **0.01**

Panel B: Dumitrescu-Hurlin (2002) Causality Test		
Δ (Unemployment Rate) does not DH-Cause Δ (Investment share) p-value Δ (Investment share) does not DH-Cause Δ (Unemployment Rate) p-value		
Number of lags		
1	**2**	**3**
Period 1990-2014		
0.83 **0.00**	**0.09** **0.40**	**0.03** **0.00**
Period prior to the crisis, 1990 – 2007		
0.76 **0.00**	0.00 0.00	**0.89** **0.04**

Note: Panel A: Reported p-values are those of the standard Granger F-type test conducted on the panel bivariate Vector Autoregressive (VAR) model for changes in the unemployment rate and net fixed capital formation (% GDP). Panel B: Test statistics are formed by taking weighted averages (across countries) of individual country Granger-Causality regression statistics.

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