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Did the European Unification Increase Economic Growth ? In Search of Scale-Effects and Persistent Changes.

Patrick Vanhoudt*

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* Fellow of the Belgian Fund for Scientific Research at the University of Antwerp (UFSIA, Belgium) and Fulbright Scholar. I would like to thank, without implications Bruno de Borger, Walter Nonneman, Mathew Tharakan, and Jürgen Vandenbroucke as well as the members of the electronic discussion list on economic growth (majordomo@ufsia.ac.be) for stimulating discussions and interesting suggestions.

Universitaire Faculteiten St.-Ignatius
Prinsstraat 13 - B 2000 Antwerpen
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Abstract

In this paper we investigate whether the European unification has had an impact on economic growth. We find that it has not, and that the EU growth experience is well described by a textbook Solow model.

JEL-classification
E13, F02, O52

Key Words
Integration, economic growth, time series tests

DID THE EUROPEAN UNIFICATION INCREASE ECONOMIC GROWTH? IN SEARCH OF SCALE-EFFECTS AND PERSISTENT CHANGES.

I. INTRODUCTION

The European Union has steadily known an increase in the size of the market. According to 'new growth theory' this integration should have lead towards higher long-run growth rates of per capita income. Neo-classical growth theory, however, disagrees with this conclusion: integration—like any other change in economic policy—has at most a temporary effect on the growth rate. The issue is not without any policy relevance.

During the late fifties and until the mid eighties, the dominating paradigm in the field of economic growth was the simple yet elegant Solow-Swan exogenous growth model. In short, this model states that every period a fraction of income—generated by physical capital and labor—is forgone, and re-invested in physical capital. The latter is assumed to be subject to diminishing returns, so that investing a constant fraction of output will yield less additional output as time evolves. In the long run, the economy will therefore converge to a stable *steady state* in which the (per capita) income level is determined by the rate of capital accumulation, as well as by the exogenous growth rate of the number of efficiency workers plus some technological parameters. The long-run growth rate is solely determined by the growth rate of technology which is assumed to be exogenous, i.e. independent of economic behavior[1]. Changes in economic policy will henceforth only have a temporary effect on the economy. So will integration. Due to possible differences in marginal productivity, opening borders in this theory may imply a re-allocation of capital and labor across the regions resulting in a temporary change of the growth rate. In the long run, however, the integrated economy will experience a constant per capita growth rate equal to the rate of technological change. Since technology is—and was—available at no cost as a perfect public good for all countries, there is therefore no reason to believe that the integrated economy as a whole—nor the economies taken separately—will experience a change of their long-run per capita growth rate compared to the long-run situation without integration.

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[1] It is well known that this theory is unsatisfactory from a theoretical point of view. Neo-classical theory starts off from perfect competitive markets and a linearly homogenous production function with constant returns to scale. Under these conditions total output will be exactly exhausted by the distributive shares for all the input factors—physical capital and labor—which is precisely Euler's theorem. Therefore it is not clear why technological change—notably the only possible engine of long-run growth in this story—would occur in the first place: it is a public good available and produced at no cost. Technology in this story is a "mystery variable" whose exact meaning is not specified and whose behavior is taken as exogenous. This means the theory leads to a dead end when it comes to understanding the details about technological change. Yet researchers have recently become interested again in the neo-classical approach. It appears that a Solow model augmented with elements from 'new' growth theory (see further) enables us to describe cross-country growth performances rather well (see e.g. Mankiw, Romer and Weil [1992] or Nonneman and Vanhoudt [1996]).

Non-convex, neo-schumpeterian new growth theory—which arose in the literature around the mid eighties—takes another stand. Economies throughout history have been renovating and innovating from the inside. They did so presumably in response to forces *endogenously* determined by the market and institutions. Opening borders may change incentives in favor of faster technological change and hence economic growth. The key in this theory is the observation that resulting new technology and knowledge is a special economic good (see Romer [1990]). New or qualitative superior goods appear in the economy because firms devote resources to research and development. They engage *intentionally* in R&D because it may yield them a temporary monopoly power in the form of patent rights or royalties. Because the patent protection is limited in time new technology is only partially excludable—unlike a prefect private good. Contrary to a perfect public good, new technology is non-rival. Knowledge is written down in the patent so that it can be used as an input for further inventions at no additional cost, as often as desired, without limiting at all the use of the knowledge by others. Henceforth the innovator cannot capture all monopoly rents from his invention—precisely the productivity gains of his piece of new knowledge in future innovations are not included. This incomplete appropriability of knowledge gives rise to what is commonly referred to as knowledge spill-overs[2]. Spill-overs imply that the neo-classical constant returns to scale assumption no longer holds on the aggregate level: doubling all production factors clearly leads to a more than proportional increase in output through the spill-overs associated with knowledge. Hence non-convex theory[3].

In fact, the nucleus of this non-convex endogenous growth theory—the feature which makes sure that a model generates sustained endogenous long-run growth—is the so called *scale effect*: the larger the scale of an economy, the higher its long-run growth rate. The intuition behind this is twofold. First, an increase in the scale of an economy—in terms of e.g. population (market size), researchers or human capital units (which improve the efficiency of the research sector)—increases the total impact of the spill-overs as well as the quantity of rents that can be captured by successful innovators. Second, the cost associated with a new invention is sunk and independent of the number of people who will use it. A larger population implies that this cost can be spread out over a larger base. Moreover 'wasteful duplication' can be avoided. In equilibrium these factors should lead to a rise in innovative activity and hence spur economic growth[4]. In contrast to the neo-classical theory this has implications on the

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[2] Not only R&D generates knowledge spill-overs. Human capital accumulation is another factor which has been put forward to explain sustained growth (Uzawa[1964], Lucas [1988], Stokey [1988]). Like R&D, human capital must have some effect that is internalized; otherwise no one would spend valuable resources to accumulate it. Yet people learn from one another so that the total gains of investments in human capital cannot be completely captured by the agent investing in it.

[3] Convex new growth theory relaxes the assumption of decreasing returns to capital accumulation while markets are still perfectly competitive. The argument is that if capital and labor are easily substitutable—implying that the elasticity of substitution exceeds unity—production may eventually be possible without labor. Indeed, under these assumptions the accumulation of capital may drive out the non-reproducible factor (labor) so that long-run growth is no longer determined by exogenous factors. This type of new growth models is therefore known as 'Ak'-models (see e.g. Jones and Manuelli [1990] or Rebello [1991]). Such a scenario seems, however, highly implausible, and time series data reject these kinds of models based on their implications with regard to permanent effects (see e.g. Jones [1995]). Moreover, empirical results in estimating neo-classical production functions point in the direction that the elasticity of substitution is smaller than one (e.g. Barro and Sala-i-martin [1992] or Mankiw, Romer and Weil [1992] among many others).

[4] Only in the case of "equivalent innovation" there might be sustained growth without scale effects (see Young [1995]). Equivalent innovation refers to the fact that innovation improves the quality of an existing good only in the sense that it provides more utility (Young gives the example of the number and

empirical side: new and increased growth rates should be permanent—there's no convergence to the old equilibrium—and growth rates should not be stationary around a steady state because of increases of the market size (see also Grossman and Helpman [1989], [1991], Rivera-Batiz and Romer [1991] and Aghion and Howitt [1992] for the relation between innovation, trade, scale and growth).

The *example par excellence* of successive increases in 'size of the economy'—both in terms of population and surface as well as in terms of GDP—clearly is the development of the European Union since the Benelux start in 1948. Our objective is to check whether the hypotheses that there exists a long-run *time series* relation between growth rates of per capita income and the scale of this EU-economy, and that its growth rate shows persistent changes can be confirmed. This would strongly support the new growth ideas. The alternative testable hypothesis is given by the neo-classical theory which predicts that time series of growth rates after successive enlargements of the market will be rather flat, fluctuating randomly around a steady state growth rate, determined by economic fundamentals.

II. TIME SERIES PROPERTIES OF THE GROWTH RATE IN THE EUROPEAN UNION

We have constructed weighted yearly data for the EU at its several stages as presented in table I. Basic data come from the Penn World Tables (Mark 5.6). Table II shows the definition and source of the variables used in this paper; all data can be found in appendix I.

Following Jones [1995] we can now consider the following simple exercise. An economist living in 1970 in the European Economic Community of the six computes weighted data for the Benelux and the EEC6 based on the historical data from 1950-1970. Thereafter he fits a constant and a time trend to the log of the per capita GDP for this time series on the European Community since 1950. Next he uses the regression results to forecast dynamically per capita GDP in 1990. For he could not possibly have forseen whether or by how many countries the EEC would have expanded by 1990, advocates of new growth theory would argue that his prediction would significantly underestimate per capita GDP in the later and larger scale stages of the unification. How far off would the prediction in fact be?

We can use the prediction error from this constant growth path as a rough indicator of the importance of permanent movements in growth rates—if any—as suggested by new growth theory. Charts I and II display the somewhat surprising result for this exercise in the light of the discussion of growth theory in the introduction. The prediction is off by as much as 28 percent of per capita GDP. Unfortunately the prediction *overestimates* per capita GDP rather than underestimating it, indicating that the average growth rate between 1970 and 1990 was actually significantly lower than during the interval 1950-1970. If any scale effect came into play, it rather seems a negative one!

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types of contraceptives). The higher quality has, however, no impact on productivity. When utility improvements require higher efforts of research activity over time, a larger scale may only have demand-effects in that the profitability of an improvement increases. More research then does not necessary translate into higher real consumption possibilities or higher per capita incomes as no new technologies appear on the market to improve the efficiency of production. It is, however, hard to believe that the post-war research activities were solely concerned with these kinds of innovations.

This casual observation deserves further investigation. Table III reports the results of some statistical tests on the growth rate series. The methodology of the tests is described below the table. Although the time trend estimated over the whole sample is at first sight not significantly negative at the traditional confidence levels, an Augmented Dickey Fuller tests firmly rejects the hypothesis of a unit root indicating that the growth rates randomly fluctuate around a trend rate, which in this case is estimated significantly negative. We find a significant structural shift in the mean growth rate in 1973 which possibly drives the result concerning the trend. The average annual growth rate before the structural break was approximately 3.4 percent p.a. whereas this reduced to 1.6 percent p.a. afterwards. This difference in means is found to be statistically significant at the traditional confidence levels. Both before and after the break we tested for possible trends in the growth rates, which were not statistically different from zero. Apparently, the time series of EU per capita growth is stationary around two different trend lines which is confirmed by ADF tests for the different sub-periods—a unit root is in both cases rejected at the 5 percent level. The hypothesis of equal variances in the growth rates before and after the break is not rejected by an F-test at the same confidence level.

In short, time series statistics show that the level of EU output is fit well by a stationary growth process with a constant mean, which has shifted *downward* rather than upward as from 1973. Finally, regressions of the EU growth rate on total population, total workers or total GDP as measures of the scale of the economy and a constant, yield a coefficient on the scale variable which is not statistically different from zero, a as can be seen from table IV. Growth rates of per capita EU income are thus apparently independent of the absolute scale. These findings are difficult to reconcile with predictions of non-convex endogenous growth theory.

Note that the 'supply shock' argument due to oil price shocks does not suffice to explain the drop in the *growth* rate as from 1973 (which coincidentally goes together with the second enlargement of the EEC, but has been bserved in other countries as well). The oil shocks in 1956-57 (Suez crisis), 1973 (Arab-Israeli war), 1979 (Iranian revolution) and 1990 (Iraq's invasion in Kuwait) are best viewed as one-time shocks—this has been documented in several studies, e.g. Raymond and Rich [1997]—which might nevertheless have had a *level* effect (see e.g. Perron [1989]). The next section provides an alternative explanation to the 'exogenous supply shock' argument for the EU growth experience.

III. A NEO-CLASSICAL EXPLANATION

In fact, both the stationarity and the independence of scale property of the EU growth rate as documented in the previous section are very much compatible with neo-classical growth theory. Perhaps applying such a framework to explain the pooled EU growth experience might not be so naive after all.

Chart III suggests yet another hypothesis in this sense. It plots EU actual and average values for annual growth rates and investment shares in physical capital. As from 1973, the EU investment share has gone down significantly[5]. Table V reports the magnitude

[5] Although investment shares went down in nearly all countries after 1973, this was more importantly the case in Luxembourg, Germany and Italy. Moreover the UK had an investment share significantly below the EU average upon entry in 1973. The same was true for Greece in 1981. Portugal and Spain drove the weighted average a little higher again when they entered in 1986.

and the statistical significance of the changes in the EU weighted investment share and growth rate in more detail. The positive correlation between medium-run growth rates and average investment shares is one more feature supporting the neo-classical model (see e.g. Mankiw, Romer and Weil [1992]). According to the Solow-model lower investment shares translate into slower enlargements of the capital stock, and hence a slow-down in growth of per capita GDP, which indeed is observed in the EU.

We also constructed EU weighted average investment shares in schooling based on the Barro-Lee dataset. As far as we have observations (1960-84) the data, however, do not support the human capital augmented Solow idea (as in Mankiw-Romer-Weil [1992]) that investment in schooling is important to explain economic growth in the EU. The investment shares in schooling show a significant upward trend over the considered time span, whereas the growth rate is stagnant (see chart IV).

Finally the neoclassical model provides us with direct testable hypotheses to check whether there is additional theory-consistent statistical support for the casual observation that a textbook Solow framework seems to enable us to understand the EU growth experience. In such models, the growth rate namely has a 'convergence' property as described in the introduction. Starting from a Cobb-Douglas constant return production function of the form $Y=K^{\alpha}(AL)^{1-\alpha}$—with capital (K), labor (L) and technology (A) being the inputs—it can be shown that the rate of convergence towards the long-run equilibrium is given by $\lambda=(1-\alpha)(n+x+\delta)$ (see e.g. Barro and Sala-i-Martin [1995]). In this expression α stands for the capital share in GDP, n is the growth rate of the work force, and x and δ are technology parameters which indicate the exogenous rate of technological change and depreciation respectively. Using some plausible values for these parameters yields a theoretical expected value for this speed of convergence. If we for instance take 2.5 percent for x (this is the average of the steady state growth rates before and after the break), 5 percent for δ and 2 percent for n (i.e. the average growth rate of the working force in the EU with exception of the one time change from the BeNeLux to EEC6), a capital share of typically one third will result in a speed of convergence of a little over 6 percent p.a.

Usually cross-country or cross-region data are employed to test the convergence equation which has been derived by Barro and Sala-i-Martin [1992] as a log linear approximation of the adjustment process to the steady state.:

$$\text{[1]} \qquad \log\left[\frac{y_t}{y_0}\right]_i = (1-e^{-\lambda t})(\beta X_i - \varphi \log(n_i + x + \delta) - \log[y_{0i}]) + u_i$$

with y per worker income, X a vector of average accumulation rates (in logarithms) (investment share in physical capital, schooling, and R&D over the period [0,t]). The main hypothesis to test in (1) then is the significance and magnitude of λ—the speed of convergence. According to the neoclassical assumptions, the sum of the coefficients on the accumulation rates (in logs) should moreover be equal to the negative coefficient on $\log(n+x+\delta)$, and the capital share—which can be computed from the estimated coefficients—should be around one third to 0.4. These are additional testable hypotheses.

Yet we can also view the convergence hypothesis in a time-series set-up as an adjustment process around a cointegration relationship, and the convergence equation in

(1) as a non-fully specified error correction model. Equation (1) can be generalized to allow for adjustment costs as:

$$[2]\ \log\left[\frac{y_t}{y_{t-1}}\right]=(1-e^{-\lambda})(\beta X_t-\varphi\log(n_t+x+\delta)-\log[y_{t-1}])+\sum_i a_i\log\left[\frac{y_{t-i}}{y_{t-i-1}}\right]+u_t$$

How well would this equation fit the EU growth process, and would the regression results confirm the model's theoretical hypotheses if we only take into account the accumulation of physical capital? Table VI reports interesting regression results in this respect. Remarkably, non of the built-in hypotheses are rejected, and variations in the EU growth rate are for over 90 percent well described by the two fundamentals, investment in physical capital and the growth rate of the working population.

IV. CONCLUSION:

The European Union has steadily known an increase in the size of the market. According to 'new growth theory' this integration should have lead towards higher long-run growth rates of per capita income of the integrated economy. Neo-classical growth theory, however, disagrees with this conclusion: integration—like any other change in economic policy—has at most a temporary effect on the growth rate. The issue is not without any policy relevance.

Based on time series data for the EU at several stages, we investigated whether or not the increase in scale lead to permanent changes in the growth rate. We did find a permanent shift, but it was a downward one, rather than an upward movement as suggested by new growth theory. The structural break is situated in 1973 when the EEC enlarged for the second time. The time series for the growth rate are stationary around the two trend lines before and after the break. These results are hard to reconcile with non-convex 'new' growth theory and rather support a neo-classical framework. We found three important indications which support the latter theory in explaining the EU growth experience. The stationarity property of the growth rates in fact can be interpreted as a first indication in favor of the neo-classical Solow theory. A second indication comes from the significant co-movement of investment shares and medium-run growth rates—both went down significantly after 1973. It is noteworthy that the 'human capital hypothesis' which follows from the augmented Solow model—namely that an increase in the investment share in human capital leads to growth—seems not reflected in the data. The investment share in education shows an important upward trend while growth rates are stagnant. The Solow model also provides us a direct testable equation—the convergence equation— which was estimated for the period 1950-90. Non of the built-in neoclassical hypotheses (speed of convergence, capital share, and restrictions on the coefficients) were rejected. Variations in the EU growth rate between 1950 and 1992 are for over 90 percent due to and well described by changes in only two fundamentals: investment in physical capital and the growth rate of the working population. This is a third confirmation of the theory.

The European unification may have lead to an increase of trade flows. Products from every member country are indeed readily available all over the EU. In this sense the unification might have induced higher utility of its inhabitants. However, we are unable to report that the unification caused higher growth. In other words, although integration possibly had trade effects there were no growth effects associated with it.

EU policy makers have already agreed on monetary criteria for member countries to join the monetary union. The findings in this paper show that a criterion on the real side of the economy needs to be applied as well. A potential new member country should minimum have an investment share such that it leaves the weighted average EU investment share at least unchanged. A decreased EU investment share will cause a lower medium run growth rate of per capita income, and a lower steady state income level in the enlarged EU compared to the situation without the new member.

TABLES AND CHARTS

Table I: Chronology of the EU

Name	Date Effective	New Member Countries
Benelux	January 1948	Belgium, the Netherlands, Luxembourg
"European Coal and Steal Community" (ECSC), later extended (all sectors) as Europe of the six, or "European Economic Community" (EEC6)	July 1952 January 1958	France, West-Germany, Italy.
Customs Union Liberalization of movement of labor, capital and services.	March 1968 July 1968	
Europe of the nine (EEC9)	January 1973	Great Britain, Ireland, Denmark
Europe of the ten (EEC10)	January 1981	Greece
Europe of the twelve (EEC12)	January 1986	Spain, Portugal
	October 1990	East-Germany - (Unification of Germany)
"European Union" (EU)	January 1993	
Europe of the fifteen (EU15)	January 1995	Austria, Finland, Sweden

Source: Web-site of the EU.

Table II: data description

Variable	Definition	Source
EU-GDP per capita$_t$	$\frac{\sum_{EUmember=1}^{\#\,of\,members\,at\,time\,t}\left(RGDPC_{EUmember_t}\cdot POP_{EUmember_t}\right)}{\sum_{EUmember=1}^{\#\,of\,members\,at\,time\,t} POP_{EUmember_t}}$	Penn-World Table, mark 5.6 (NBER, Harvard)
EU-GDP per worker$_t$	$\frac{\sum_{EUmember=1}^{\#\,of\,members\,at\,time\,t}\left(RGDPW_{EUmember_t}\cdot POP_{EUmember_t}\right)}{\sum_{EUmember=1}^{\#\,of\,members\,at\,time\,t}\left(\frac{RGDPC_{EUmember_t}}{RGDPW_{EUmember_t}}\cdot POP_{EUmember_t}\right)}$	Penn-World Table, mark 5.6 (NBER, Harvard)
EU-investment share in physical capital$_t$	$\frac{\sum_{EUmember=1}^{\#\,of\,members\,at\,time\,t}\left(INV_{EUmember_t}\cdot RGDPC_{EUmember_t}\cdot POP_{EUmember_t}\right)}{EU-GDP\ per\ capita_t\cdot EU-POP_t}$	Penn-World Table, mark 5.6 (NBER, Harvard)
EU-(public) investment share in human capital$_t$	$\frac{\sum_{EUmember=1}^{\#\,of\,members\,at\,time\,t}\left(GEETOT_{EUmember_t}\cdot RGDPC_{EUmember_t}\cdot POP_{EUmember_t}\right)}{EU-GDP\ per\ capita_t\cdot EU-POP_t}$	Penn-World Table, mark 5.6 (NBER, Harvard) and Barro-Lee dataset (NBER, Harvard) Note: GEETOT is only available as 5-year average.
growth rate of a variable	$\frac{\Delta(\text{variable}_t)}{\text{variable}_{t-1}}$	

Table III: Time series properties of post-war European growth rates.

	Coefficient	SE	Test-stat	note
1. Time Trend[a]	$b=-0.000381$	0.000394	-0.966504	
2. ADF Test[b]	$\mu=-1.077545$	0.197474	-5.456652^{++}	$k^*=1$, trend $\beta<0^{**}$
3. Endogenous Mean Shift[c]	$\gamma=-0.017793$	0.008851	-2.010199^{++}	$T^*=1973$
4. Difference in Means[d]	$\overline{\Delta g}=1.76$ %		2.17633^{++}	
5. F-Test Two-Sample for Variances[e]	$\sigma_1=9.38E-04$ $\sigma_2=4.71E-04$		1.99372^{+}	conclusion in 4. does not change if it is assumed that $\sigma_1=\sigma_2$
6. ADF Test before Mean Shift[b]	$\mu=-1.19975$	0.273318	-4.389440^{++}	$k^*=1$;
ADF Test after Mean Shift[b]	$\mu=-1.278182$	0343621	-3.719740^{++}	trend≈0

Note: $^{+}$: significant at the 10 percent level, $^{++}$: significant at the 5 percent level or better

a. The time trend reports the estimate of b from the regression $g_t \equiv \Delta y_t/y_{t-1} = a + b.t$

b. The ADF equation reports the estimates of μ from the regression:

$\Delta g_t = \alpha+\beta.t+\mu.g_{t-1} + \Sigma_j^k \delta_j.\Delta g_{t-j}$. The test-statistic tests the null hypothesis of $\mu=0$. If the hypothesis of a unit root is rejected, the growth rate series is trend stationary which means that the growth rate randomly fluctuates around a trend.

Note: we use a fairly ad hoc method to determine the number of lags in the test equation. Following Perron [1989] we start with an a priori upper bound of k=8. If this lag is not significant we reduce the number of lags until we obtain a significant one. If no lag is significant we set k=0. The criterion for significance is a t-statistic of at least 1.6 in absolute value which corresponds to a significance level of almost 10 percent. The MacKinnon critical values for rejecting the hypothesis of a unit root were used.

c. In order to determine the mean shift the following equation is estimated: $g_t=\delta+\gamma.D_{T^*}$. The dummy D_T takes the value of one for $t>T^*$. This equation is estimated for $T^* \in [1951\text{-}1989]$. We opted for T^* which maximizes the absolute t-statistic for γ, thus we have chosen the break year which gives the highest probability of finding a level change in the growth rate.

d. This reports the results of a t-tests to check whether the difference in means ($\overline{\Delta g}$) before and after the mean-shift break found in c. is non-zero.

e. This reports the results of an F-test to check whether the variance before and after the mean shift found in c. is equal.

table IV: results from regressions of the form $g_t=\rho+\chi.scale_t$

Scale variable	ρ	χ	test-stat for χ
total population	0.027^{++}	-5.42 E-09	-0.12
total workers	0.027^{++}	-1.12 E-08	-0.12
total GDP	0.032^{++}	-3.20 E-12	-0.94

Note: $^{+}$: significant at the 10 percent level, $^{++}$: significant at the 5 percent level or better

Table V: Significance and magnitude of changes in averge annual EU weighted growth rates and average investment shares.

	Growth Rates		Investment Share	
	Δ	t-test	Δ	t-test
BeNeLux-EEC6	+ 2.84 percent	$1.76^{+\ b}$	+ 6.58 percent	$9.00^{++\ b}$
EEC6-EEC9	- 2.97 percent	$-3.57^{++\ a}$	- 4.34 percent	$-7.98^{++\ a}$
EEC9-EEC10	- 0.75 percent	$-0.53\ ^{a}$	- 3.43 percent	$-5.87^{++\ b}$
EEC10-EEC12	+ 2.05 percent	$1.94^{++\ b}$	+ 1.51 percent	$3.87^{++\ a}$

Note: [a]: F-test did not reject equal variances, [b]: F-test rejected equal variances
$^{+}$: significant at the 10 percent level, $^{++}$: significant at the 5 percent level or better

Table VI: A time series test of the neoclassical convergence equation
Dependent variable is the annual growth rate of income per worker (g_t) 1950-90*

variable	**coefficient**	**test-stat**
constant	0.535	6.660^{++}
$\log(inv_t)$	0.039	1.997^{++}
$\log(n_t+x+0.05)$**	- 0.051	-17.085^{++}
$\log(GDP_{t-1}$ / $worker_{t-1})$	- 0.058	-6.778^{++}
g_{t-1}	- 0.007	- 0.121
g_{t-2}***	- 0.083	- 1.552
R^2	92.02 %	
Wald test of restriction	H_0: C(2)=-C(3)	0.373, p=0.546
implied capital share****	0.402	
implied speed of convergence (λ)*****	6.00 %	

Note: $^{+}$: significant at the 10 percent level, $^{++}$: significant at the 5 percent level or better

* 1972-74 appeared to be outliers and were omitted from the regression.

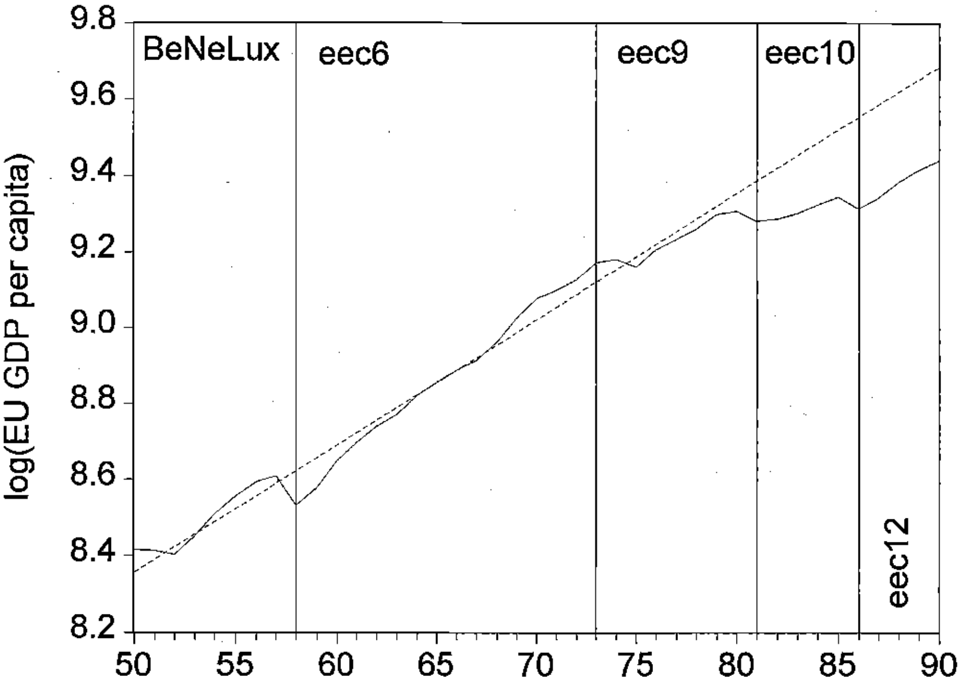
** x is set to 3.4 percent before 1973 and 1.6 percent after the structural break. These figures are the respective long-run growth rates of per capita income.

*** According to the Akaike info criterion the optimal lag length=2 (Akaike: -8.40)

**** The capital share can be computed as follows. Divide the coefficient on log(inv) by minus the coefficient on $\log(GDP/Worker)_{t-1}$. According to the textbook Solow model, this value should be equal to $\alpha/(1-\alpha)$, from which α implied by the regression can be solved.

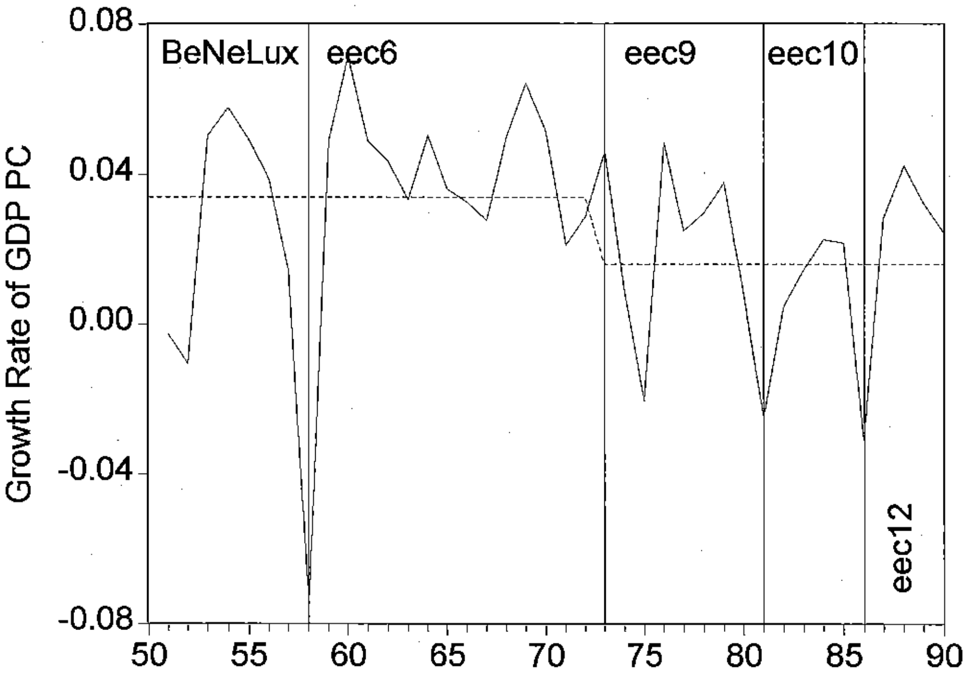
***** λ can be found by adding one to the coefficient on $\log(GDP/Worker)_{t-1}$ and taking the logarithm.

Chart I: Per Capita GDP in the European Union's different stages of development.



Note: the trend line represents the time trend calculated using data from 1950-70.

Chart II: Growth rates of per Capita GDP in the European Union's different stages of development.



Note: the dotted line represents the fitted values for $g_t=\delta+\gamma.D_{T*}$. $\delta=3.4^{++}$ percent, $\gamma=-1.8^{++}$ percent

Chart III: Average and actual annual growth rates and investment shares (as a percentage of total EU GDP) in the European Union's different stages of development.

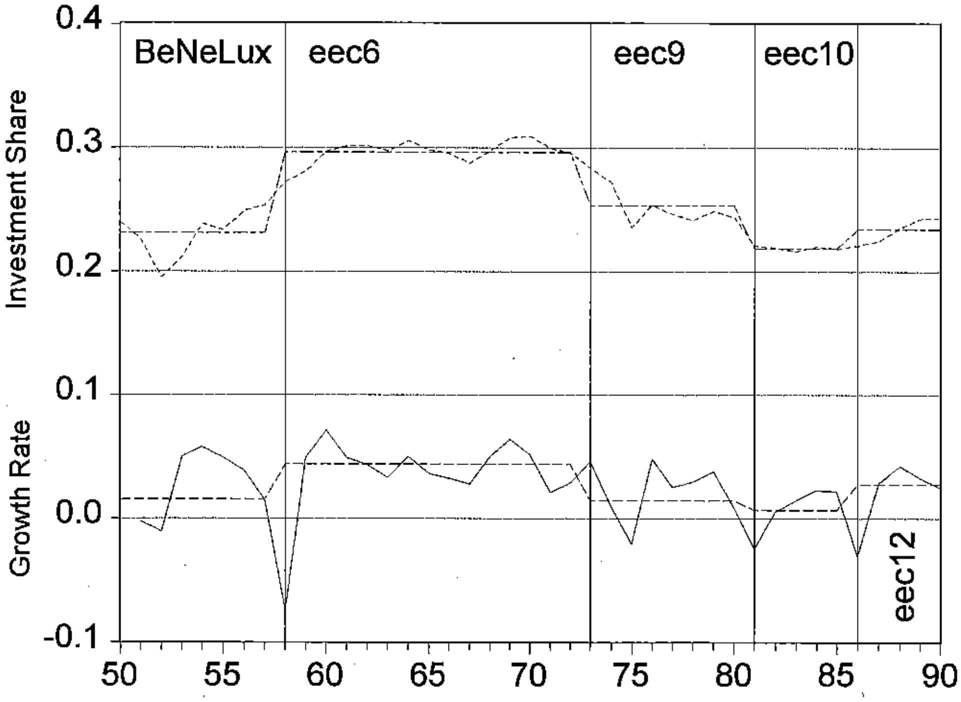
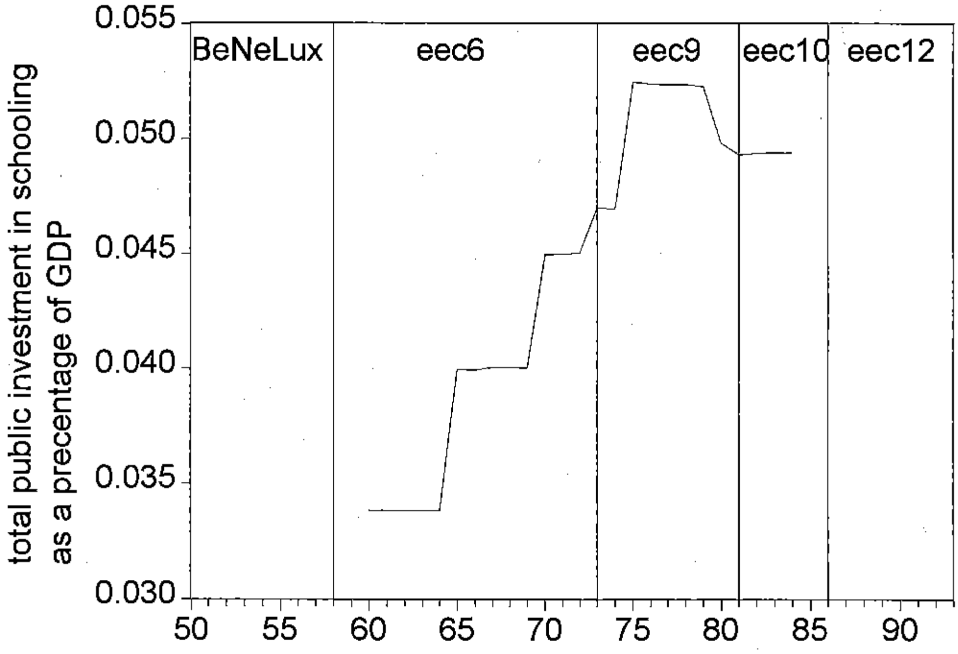


Chart IV: 5-year average public investment in education (as a percentage of total EU GDP) 1960-1984.



Appendix I: Data Used

EU-Stage	year	GDP per capita	GDP per worker	Total population	Total work force	Investment in physical capital	(Public) Investment in education
		(US$)	(US$)	(x1000)	(x1000)		
BeNeLux	1950	4518	11243	19049	7655	0.2395	
BeNeLux	1951	4506	11307	19224	7661	0.2252	
BeNeLux	1952	4459	11282	19400	7668	0.1953	
BeNeLux	1953	4684	11949	19574	7673	0.2119	
BeNeLux	1954	4955	12748	19750	7676	0.2381	
BeNeLux	1955	5198	13489	19924	7678	0.2334	
BeNeLux	1956	5399	14131	20129	7690	0.2490	
BeNeLux	1957	5477	14463	20334	7701	0.2533	
EEC6	1958	5071	11660	168946	73468	0.2723	
EEC6	1959	5319	12278	170617	73913	0.2808	
EEC6	1960	5700	13209	172241	74327	0.2970	0.0338
EEC6	1961	5979	13909	173983	74790	0.3013	0.0338
EEC6	1962	6241	14574	176027	75374	0.3017	0.0338
EEC6	1963	6448	15119	177978	75902	0.2974	0.0338
EEC6	1964	6773	15946	179705	76330	0.3058	0.0338
EEC6	1965	7018	16587	181437	76768	0.2981	0.0399
EEC6	1966	7248	17202	182938	77077	0.2954	0.0399
EEC6	1967	7450	17751	183992	77215	0.2877	0.0400
EEC6	1968	7825	18726	185055	77329	0.2972	0.0400
EEC6	1969	8329	20012	186538	77639	0.3080	0.0400
EEC6	1970	8762	21141	188262	78031	0.3096	0.0449
EEC6	1971	8949	21818	189841	77863	0.2998	0.0450
EEC6	1972	9206	22403	191143	78544	0.2959	0.0450
EEC9	1973	9631	22670	256693	109045	0.2835	0.0470
EEC9	1974	9715	22818	257705	109715	0.2720	0.0469
EEC9	1975	9518	22305	258254	110205	0.2355	0.0524
EEC9	1976	9979	23334	258618	110598	0.2535	0.0524
EEC9	1977	10229	23861	259086	111063	0.2463	0.0523
EEC9	1978	10532	24515	259584	111518	0.2415	0.0523
EEC9	1979	10931	25380	260254	112085	0.2486	0.0522
EEC9	1980	11020	25528	261093	112710	0.2439	0.0498

EU-Stage	year	GDP per capita	GDP per worker	Total population	Total work force	Investment in physical capital	(Public) Investment in education
		(US$)	(US$)	(x1000)	(x1000)		
EEC10	1981	10748	24838	271479	117471	0.2206	0.0493
EEC10	1982	10801	24798	271984	118468	0.2190	0.0493
EEC10	1983	10959	24998	272387	119410	0.2162	0.0494
EEC10	1984	11208	25401	272768	120353	0.2199	0.0494
EEC10	1985	11452	25787	273292	121370	0.2180	
EEC12	1986	11100	25140	322754	140353	0.2208	
EEC12	1987	11413	25765	323632	141111	0.2245	
EEC12	1988	11898	26775	324678	141965	0.2353	
EEC12	1989	12284	27283	325825	144316	0.2426	
EEC12	1990	12585	27821	327932	145690	0.2426	

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Address for correspondence:
University of Antwerp (UFSIA)
Econ. Dept.: SESO B-128
Prinsstraat 13 B-2000 Antwerp Belgium
Phone: +32 - 3 - 220 40 50
Fax: +32 - 3 - 220 40 26
e-mail: dse.vanhoudt.p@alpha.ufsia.ac.be

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