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Long run relationships between sector shares and economic growth – A panel data analysis of the Schengen region

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LONG RUN RELATIONSHIPS BETWEEN SECTOR SHARES AND ECONOMIC GROWTH

A Panel Data Analysis of the Schengen Region

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Abstract

The structural change of economy entails that in long run the dynamics of sector shares (industry, service, and agricultural) are related to each other and to economic growth. For this purpose co-integration, error correction (EC), and Granger non-causality test (GC) models were estimated in panel setting. The panel data consists of 15 Schengen countries in period 1970-2004. The co-integration analysis confirmed long run relationships between the sector shares. EC-model estimates based on different presentations of sector share co-integration relations indicated that long run structural adjustments between all sector share pairs existed. Shocks in industry sector share cause turbulence in sector share relationships which slowly correct to equilibrium. The results of GC-tests suggested that unidirectional causality runs from the growth rate of GDP per capita (*GDPc)* to agriculture share growth, but a two-way causality runs between industry share growth and growth rate of *GDPc*. The relationship between services share growth and growth rate of *GDPc* is also bi-directional. Therefore, feedback impacts are found between sector shares and the growth rate of GDP per capita. The links between *GDPc* growth, service, and agriculture shares are complex but industry sector is still the “engine” of economic growth.

Keywords: Sector shares, economic growth, panel data, co-integration, error correction

I. INTRODUCTION

System that grows non-constantly also changes its structure. Just as a growing human body constantly changes the shape and size of its all parts, a growing economy changes the proportions of its basic sectors such as agriculture, industrial and services. These sectors are known as engines of the development. Developed economies heavily build on efficient industrial and services sectors. Therefore, a debate exists why structural changes occur in the developed countries. The neoclassical growth approach is based on the view that structural change is an unimportant side effect of the economic development (Cristina 1997). On other side economist associated with the World Bank, including Kuznets (1971), Rostow (1971), Chenery and Syrquin (1975), and Baumol et at. (1989) posit that growth is brought by the changes in economy's sectoral composition. The objective of this study is to analyze how sector shares are related to economic growth. The main question is whether sector adjustments and their growth impacts are equilibrium phenomena or not. We use the data from Schengen countries in period 1970-2004 to analyze the long run sector adjustment and to test Granger non-causality between sector share growth and growth rate of GDP per capita. For this purpose we estimated co-integration and error correction (EC) models, and conducted Granger non-causality (GC) tests in panel setting.

Unit root tests show that the growth rate of GDP per capita series ($\Delta \ln GDPc_{it}$) are stationary but sector shares are non-stationary. The outcome restricts our analysis concerning the growth effects between these series as the series have different orders of integration. Therefore, we established co-integration relations between non-stationary share series. Error correction (EC) model estimates based on different presentations of sector share co-integration indicated that long run structural adjustments between all sector share pairs exist. Granger non-causality (GC) tests were conducted on the differenced series**.** The results of GC-tests suggested that unidirectional causality runs from the growth rate of GDP per capita (*GDPc)* to agriculture share growth, but a two-way causality runs between industry share growth and growth rate of *GDPc*, and also between services share growth and growth rate of *GDPc*. Also the *GDPc* growth rate effects of equilibrium errors of sector share co-integration relationships are analyzed.

The study is organized as follows. Section 2. reviews some of the theoretical background of structural changes and economic growth. Section 3. presents data and variables. Model of the growth effects of sectoral adjustment and dynamics, methodology frame work, and the results are presented in Sections 4-6. Conclusions with some discussion are given in Section 7.

2. STRUCTURAL CHANGES AND ECONOMIC GROWTH

2.1 Stages of development

In order to study the relationship between sector changes and economic growth in Schengen countries, it is helpful to have an overview of the following stages of economic development. A minimum condition for a positive effect of sector changes on growth is that there has been a net shift of resources out of sectors with relatively low productivity level to sectors with high productivity levels. This implies that sector with high productivity growth should be positively related with economic growth. Typically we can divide an economy into three main sectors: agricultural, industrial, and services sectors. Theoretically there exist some broad arguments how these sectors are related to economic growth and development, i.e. how the shares of three major sectors develop in time.

An important insight of classical development economics is that economic growth is intrinsically linked to changes in the structure of the production. According to this view, industrialization is the main source of technical change, and therefore, overall productivity increase is mainly a result of the reallocation of labor from low to high productivity sectors. Initially, agriculture is a developing economy’s most important sector. As income per capita rises, agriculture loses its primacy giving a way first to a rise in the industrial sector and then to a rise in the service sector. These two consecutive shifts are called industrialization and post industrialization (or “deindustrialization”). As people’s incomes increase, they start to demand also non-agricultural products. At same time, because of new farm techniques and machinery, labor productivity increases faster in agriculture than in industry. This makes agriculture products relatively less expensive. This further diminishes their share in gross domestic product (GDP). The same trend in relative labor productivity also diminishes the need for agriculture workers, while employment opportunities in industry grow. As a result industrial output takes over a larger share of GDP than agriculture. Employment in industry becomes predominant that demands more services in health, education, information, entertainment, tourism, and many other areas. Meanwhile, labor productivity in services does not grow as fast as in agriculture and in industry because most services jobs are based on human capital, not on physical capital. This makes services more expensive relative to agriculture and industrial goods, further increasing service share of GDP (see Taytyana et al. 2000). Table 1. summarizes the stages of economic development.

Table 1. Stages of economic development (Taytyana et. al 2000)

Characteristics	***Stages***		
	Preindustrial, Agrarian	***Industrial***	***Postindustrial, Knowledge based***
Leading economic sectors	Agriculture	Industry	Services
Nature of dominant technology	Labor- and natural resource intensive	Capital intensive	Knowledge intensive
Major type of consumer products	Food and hand made clothes	Industrial goods	Information and knowledge services
Nature of most production process	Human nature interaction	Human-machine interaction	Human interaction
Major factor of economic wealth/growth	Nature's productivity fertility, climate, biological resources	Labor productivity	Innovation/intellectual productivity

The empirical research on the impact of industrial development on economic growth started with Kaldor (1966). He found strong positive and statistically significant correlation between the rate of growth of manufacturing sector and rate of growth of output. For example Necmi (1999) tested Kaldor's law on "manufacturing as a engine of growth" using the cross country data mainly in developing countries for the period 1960-1994. The study finds that manufacturing output growth rate is exogenous as Kaldor envisaged and his `laws' are applicable to most of the developing world. In order to see the impact of the expansion of services sector on economic growth in cross section of countries Dutt and Lee (1993) regressed the growth rate of GDP on share of services in employment. They found negative and significant coefficient suggesting that relative increase of the services share in employment in associated with decline in the output growth rate.

Tables 2. and 3. report the economic growth and structural change figures in Schengen countries over the period 1970-2004 (see also Figures 1 - 3). Casual observation supports the finding of Kaldor (1966) and Dutt and Lee (1993). The rate of growth for per capita income has fallen for all most of the Schengen counties and share of industrial sector is decreasing while the share of services sector is increasing. We will test these observations in details with the help of dynamic econometric modeling. Note that there has been some convergence between the most advanced Schengen countries on one hand, and between catching-up economies like Spain, Greece and Portugal. They all enjoyed higher growth rates during 1980s and 1990s (see also Linden 2002).

Table 2. Economic Growth in Schengen Countries (Growth Rate of Real GDP per capita) 1970 – 2004

Country Name	***1971-80***	***1981-90***	***1991-2000***	***2001-2004***	***Full Sample Period 1971-2004***
Austria	*3.46*	*2.16*	*1.82*	*1.21*	*2.32*
Belgium	*3.17*	*1.90*	*1.92*	*1.43*	*2.22*
Denmark	*1.56*	*1.55*	*1.93*	*1.04*	*1.60*
Finland	*3.27*	*2.68*	*1.86*	*2.17*	*2.55*
France	*2.71*	*1.95*	*1.49*	*1.41*	*1.97*
Germany	*2.71*	*2.04*	*1.35*	*0.53*	*1.83*
Grece	*3.74*	*0.19*	*1.95*	*4.09*	*2.20*
Iceland	*5.20*	*1.65*	*1.69*	*2.40*	*2.79*
Italy	*3.15*	*2.22*	*1.41*	*0.80*	*2.08*
Luxemburg	*1.93*	*4.04*	*4.48*	*2.56*	*3.37*
Netherlands	*2.09*	*1.71*	*2.26*	*0.38*	*1.82*
Norway	*4.18*	*2.05*	*2.79*	*1.32*	*2.80*
Portugal	*4.08*	*3.16*	*2.65*	*0.43*	*2.96*
Spain	*2.61*	*2.56*	*2.23*	*2.47*	*2.46*
Sweden	*1.64*	*1.88*	*1.44*	*1.99*	*1.69*

Table 3. Average Structural Change (as %GDP) in Schengen countries 1970-2004.

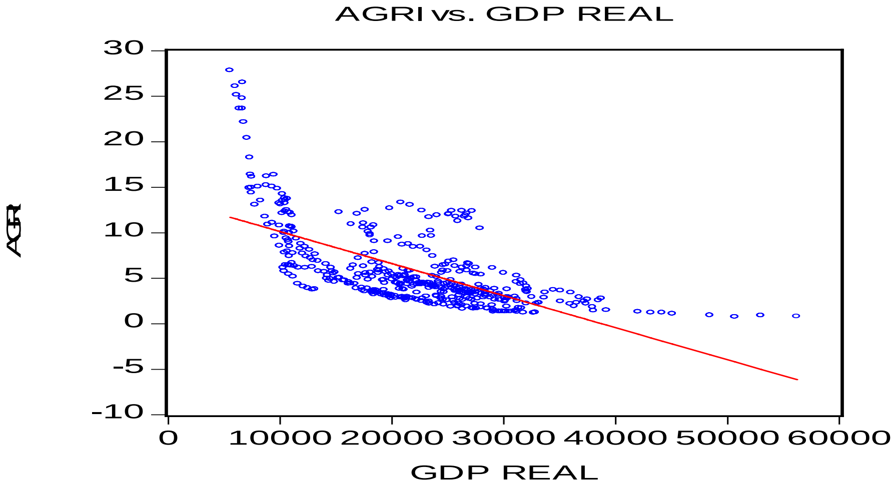
Country	Agriculture share			Industrial Share			Services Share			Over All (1971-2004)		
	1971- 80	1981-90	1991-2000	1971-80	1981-90	1991-2000	1971-80	1981-90	1991-2000	Agri	Industry	Service
Austria	5.81	4.10	2.69	40.13	35.49	32.81	54.06	60.41	64.50	**3.94**	**35.56**	**60.48**
Belgium	3.71	2.59	1.75	40.33	33.40	28.97	55.96	64.01	69.27	**3.24**	**34.42**	**62.33**
Denmark	6.17	5.27	3.40	29.14	27.21	25.99	64.70	67.53	70.61	**4.65**	**27.24**	**68.10**
Finland	10.18	7.60	4.66	38.85	35.85	32.00	50.97	56.55	63.33	**7.00**	**35.11**	**57.88**
France	6.20	4.32	3.23	37.30	32.21	27.00	56.51	63.47	69.77	**4.35**	**31.05**	**64.59**
Germany	2.86	1.97	1.32	42.96	38.44	33.59	54.40	59.60	65.07	**4.45**	**37.23**	**60.83**
Greece	14.57	12.79	9.57	34.28	30.26	23.52	51.15	56.95	66.91	**11.82**	**28.79**	**59.38**
Iceland	12.25	11.37	11.36	33.07	32.49	28.05	54.66	56.12	60.28	**11.66**	**31.18**	**57.15**
Italy	7.35	4.72	3.31	41.02	35.91	30.85	51.63	59.37	65.83	**4.84**	**35.01**	**60.13**
Luxembourg	3.28	2.61	1.12	39.90	34.30	24.92	56.82	63.09	73.96	**2.18**	**31.85**	**65.95**
Netherlands	4.73	4.41	3.48	36.42	32.60	28.22	58.85	62.98	68.30	**4.05**	**31.80**	**64.13**
Norway	5.08	3.76	2.64	34.21	38.45	35.68	60.71	57.79	61.68	**3.62**	**36.32**	**60.04**
Portugal	23.86	13.26	5.31	34.72	32.53	30.80	41.42	54.21	63.90	**12.91**	**32.14**	**54.93**
Spain	9.67	6.24	4.63	40.87	36.40	31.19	49.46	57.36	64.17	**6.47**	**35.36**	**58.16**
Sweden	5.29	4.16	2.35	35.90	32.81	29.44	58.82	63.03	68.21	**3.68**	**32.17**	**64.14**

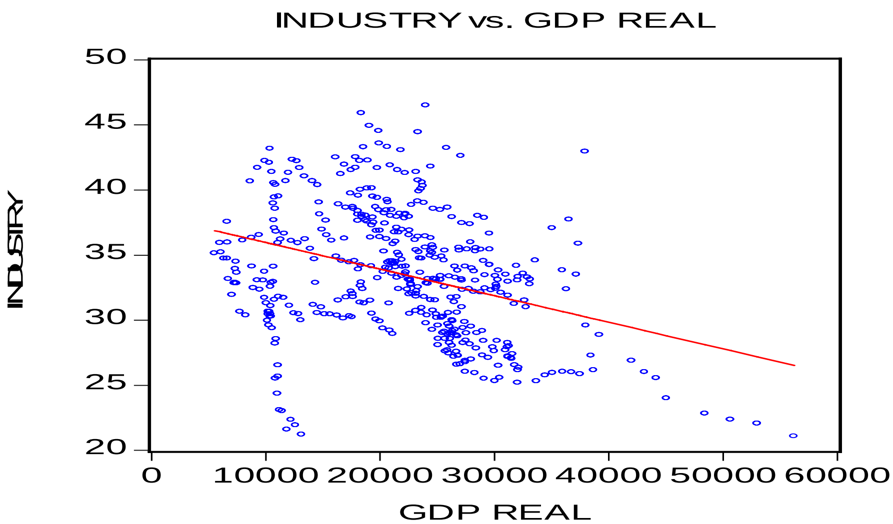
2.1 Relationship of industrial, services and agriculture sectors

The relationship between the *level* of GDP per capita (*GDPc*) and sector shares is represented in Figure 1. Figure shows a quite clear pattern. Services sector is clearly positively related with *GDPc*. This is due to the fact that *GDPc* for all the Schengen countries is increasing over the last three decades and share of services sector is also increasing. Industrial and agricultural shares are showing negative patterns on the level of *GDPc.*

The relationship between sector shares and *growth rate* of GDP per capita ($\Delta \ln GDPc$) is given in Figure 2. The observation is that structure of all the sample countries is quite different compared to preceding figure. We detect a negative pattern between the share of services sector and *GDPc* growth rate but industrial shares show non-negative pattern. Agriculture sector shows a small positive pattern. The opposite patterns in Figures 1 and 2 suggest the importance of dynamics of sector shares to growth rate of output.

Figure 1. Relationship between real GDPc and Sectoral Shares in Schengen countries 1970 - 2004





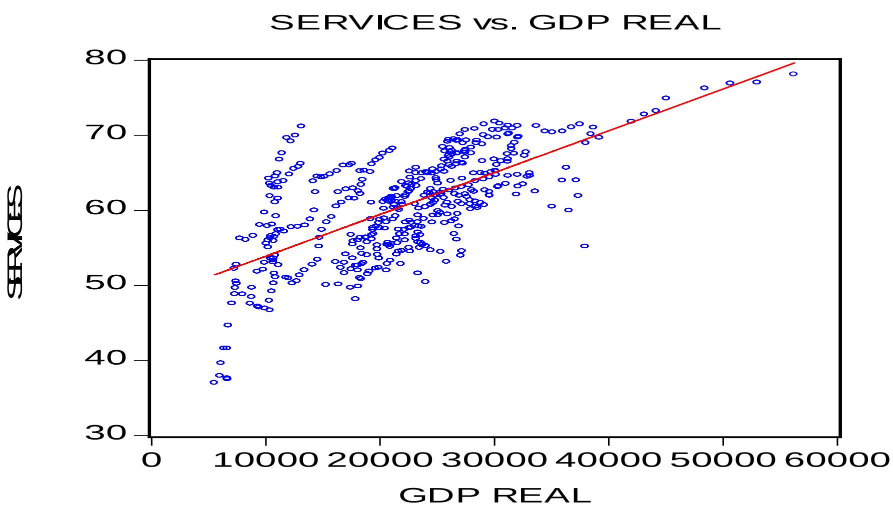
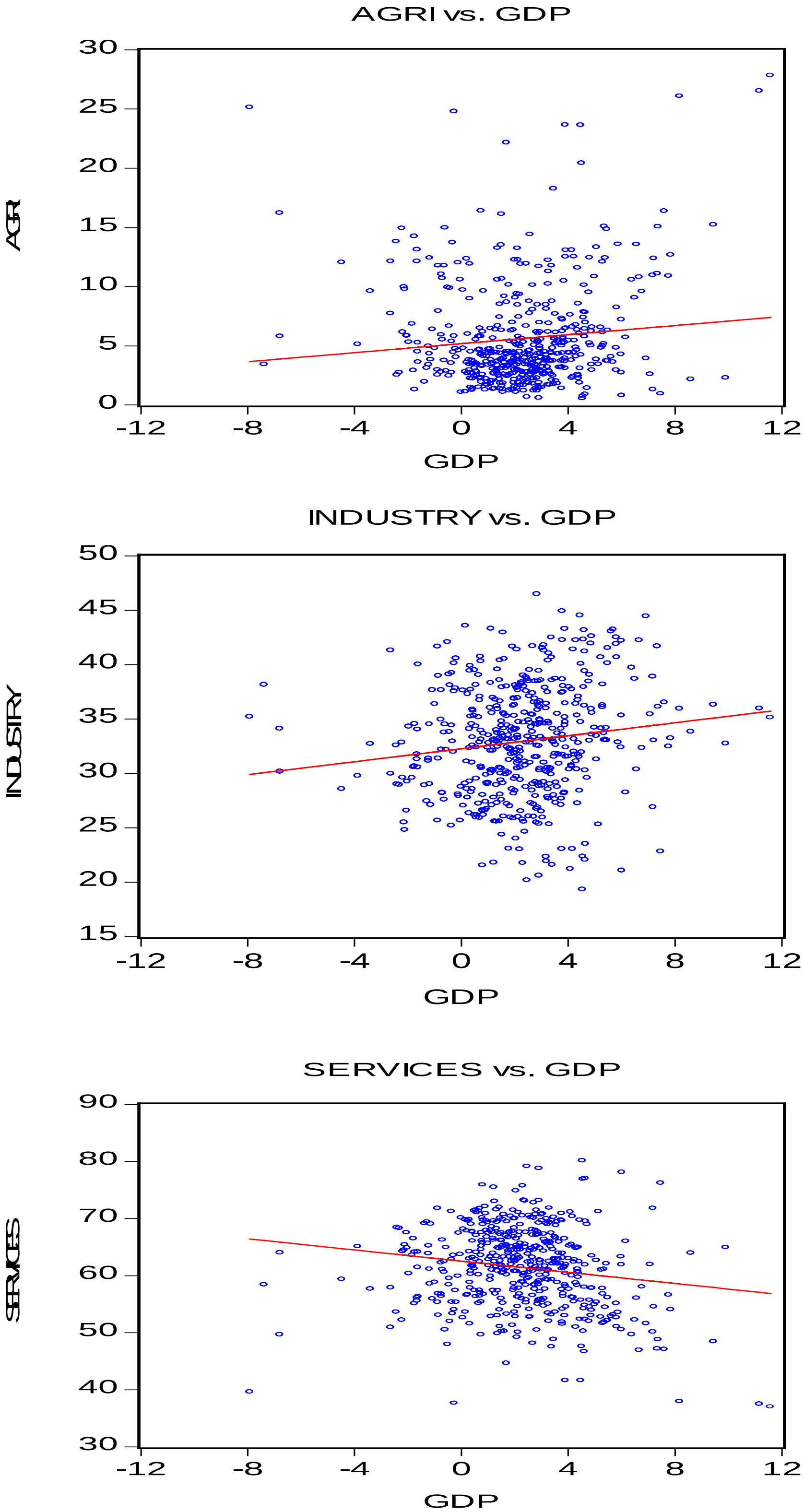


Figure 2. Relationship between ($\Delta \ln GDPc$) and Sectoral Shares in Schengen Countries 1970-2004



The relation of industrial sector with economic growth has it roots in Kaldor's views concerning the manufacturing sector (Kaldor, 1966). He argued that an industrial sector is the "engine of growth". Kaldor explained his ideas by three laws. According to Kaldor's first law the faster the rate of growth in manufacturing sector the faster the growth of overall gross domestic product. He argued that when manufacturing sectors develops then other sectors of the economy also develops through spill over effects. The second law which is also known as Verdoorn's law[1] states that there is a strong relationship between the growth of labor productivity in the manufacturing sector and the growth of output in manufacturing sector. In third law Kaldor states that productivity growth is positively related with the employment in the manufacturing sector where as it is negatively related with non-manufacturing sectors.

The expansion of the service sector relative to the rest of the economy leads to a reduction in the long run rate of growth of output per capita because production of services mostly happens without physical capital (see e.g. Baumol et at. 1985, Bjork 1999, Wolff 1985b, Wilber 2002)[2]. Baumol (1967) argued that scope of productivity growth in the services sector is slower than in the sectors that produce goods. Cristina (1997) suggested a Baumol type of model to describe the expansion of service sector of developed countries during the 20th century. Another explanation is actually based on Kaldor's approach. The growth of engine hypothesis indirectly means that increase in the share of the services sector relative to the other sectors reduces the rate of technological progress and the rate of innovation in an economy. Note that IT-revolution that started in early 1990s' may alter dramatically the role of service sector in the post-industrial economics. The dramatic rise in the share of the services in total economic activity during the post war periods is often cited as a major factor in the apparent productivity slowdown in the U.S. and in other advanced economies during the late 1960s and early 1970s.

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[1] See Verdoorn (1949).

[2] Note that services sector includes the services provided by the government, i.e. education, health care, and defense..

Wilber (2002) investigated the relationship between service sector expansion and growth rate of output using panel data of 25 OECD countries over the period from 1960 to 1994. He found that causality runs from services to growth. Also the relative expansion of the service sector as a whole was associated with a reduction in the rate of growth of total output. He did also disaggregated analysis for the service sector and found that not all services retards the economic growth. Producer services have positive impact on growth while consumer and government services have a negative impact.

There is no direct theory that explains how share of agricultural sector is related with economic growth. Indirectly we can explain this phenomenon by the fact that when a country develops then the labour moves from the traditional sector to the modern sector where labour productivity and wages are higher. During this transitory period the share of agricultural sector declines fast. However in post-industrialized Schengen countries the share of highly subsided agriculture sector declines very slowly. In this case we expect no relationship between share of agriculture sector and growth rate.

3. DATA AND VARIABLES

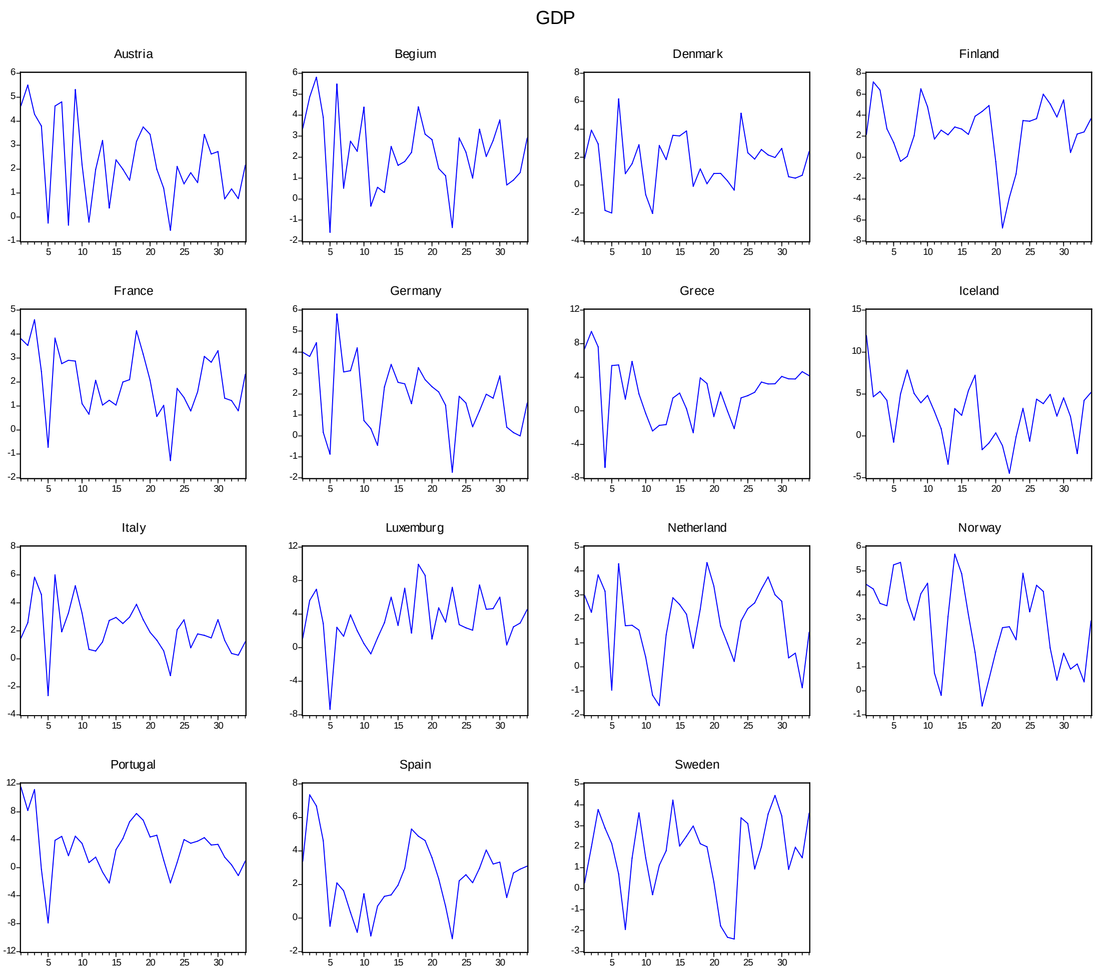
3.1. Definition of variables

In order to test how sector shares relate with long run growth rate of output we must first determine the appropriate variables to measure expansion of each sector. There can be at least three possibilities. First, we could use the growth of output of each sector in the *GDP* share decomposition. In this case shares dynamics and the growth rate of output can be used as variables. Second, it is also possible to use expansion in terms of increases of employment in each sector. Lastly, we can focus on labor productivity in different sectors. This study analyses the development of sector share as an expansion variable.

3.1.1. GDP per capita

We use real GDP per capita growth rate as variable to capture economic growth. We report the results without time averaging of the data in order to capture all dynamics between economic growth and sector shares. Annual percentage growth rate of GDP per capita ($\Delta \ln GDPc$) is based on constant 1995 US$ prices. GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. We use the panel data of Schengen countries in period from 1970 to 2004 (Data source: World Bank national accounts data and OECD National Accounts data files).

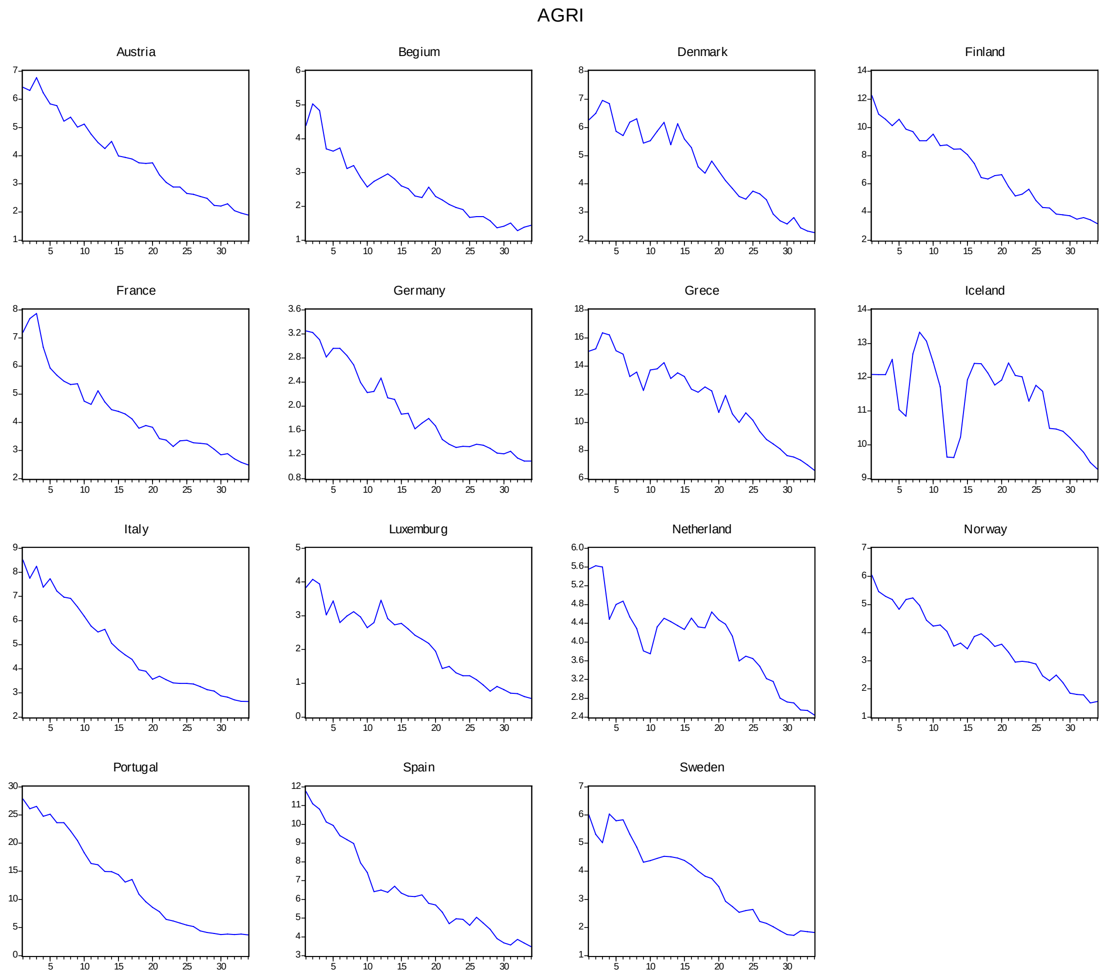
Figure 3. Growth rate of GDP per capita for 15 Schengen Countries in 1970-2004



3.1.2. Agriculture shares (%GDP)

Agriculture corresponds to ISIC divisions 1-5 (cultivation of crops and livestock production) and also includes forestry, hunting, and fishing. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC, revision 3). Graphs show a long smooth decreasing trend for whole panel except for Netherlands and Iceland.

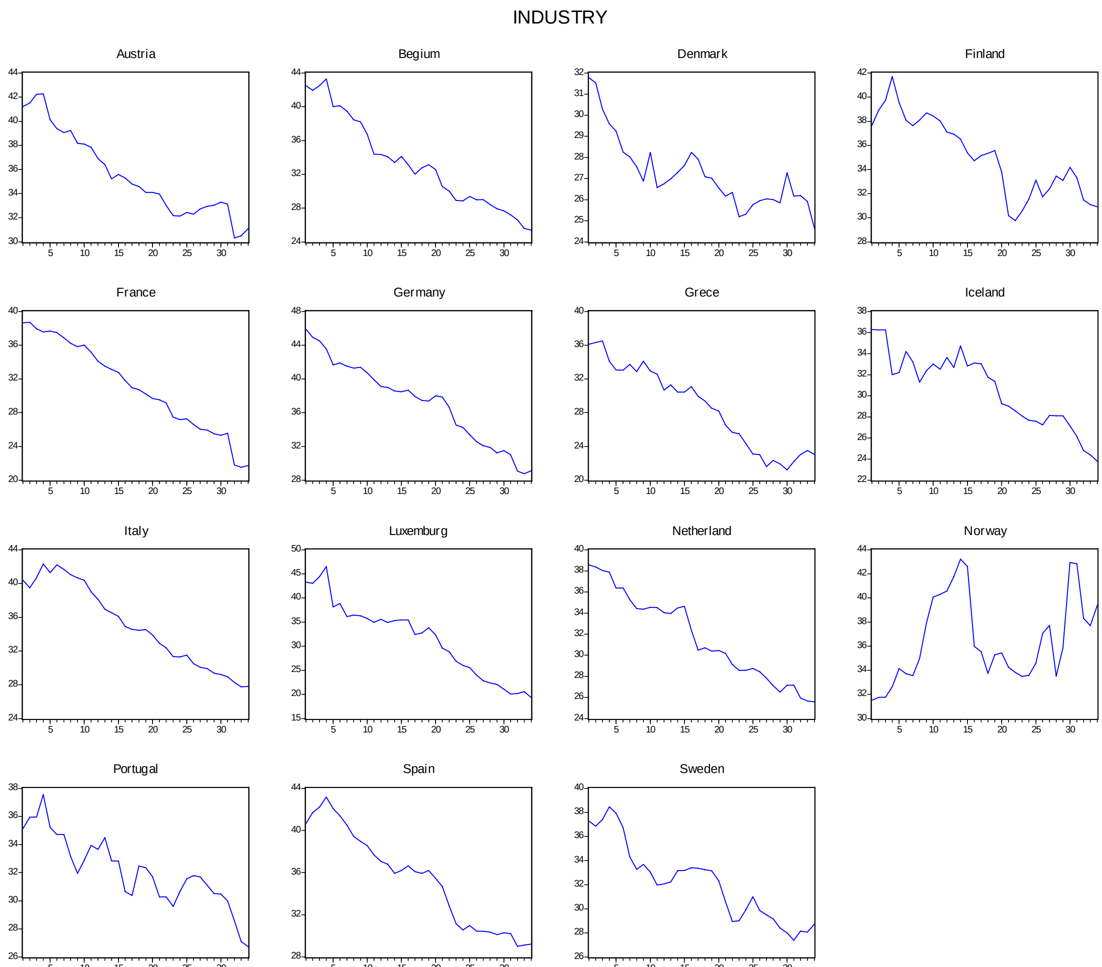
Figure 4. Agriculture Shares of GDP (%GDP) for 15 Schengen countries in 1970-2004



3.1.3. Industry shares (%GDP)

Industry corresponds to ISIC divisions 10-45. It comprises value added in mining, manufacturing, construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC revision 3). Graphs show clear declining trends for all countries except for Norway.

Figure 5. Industry shares of GDP (%GDP) for 15 Schengen countries in 1970-2004

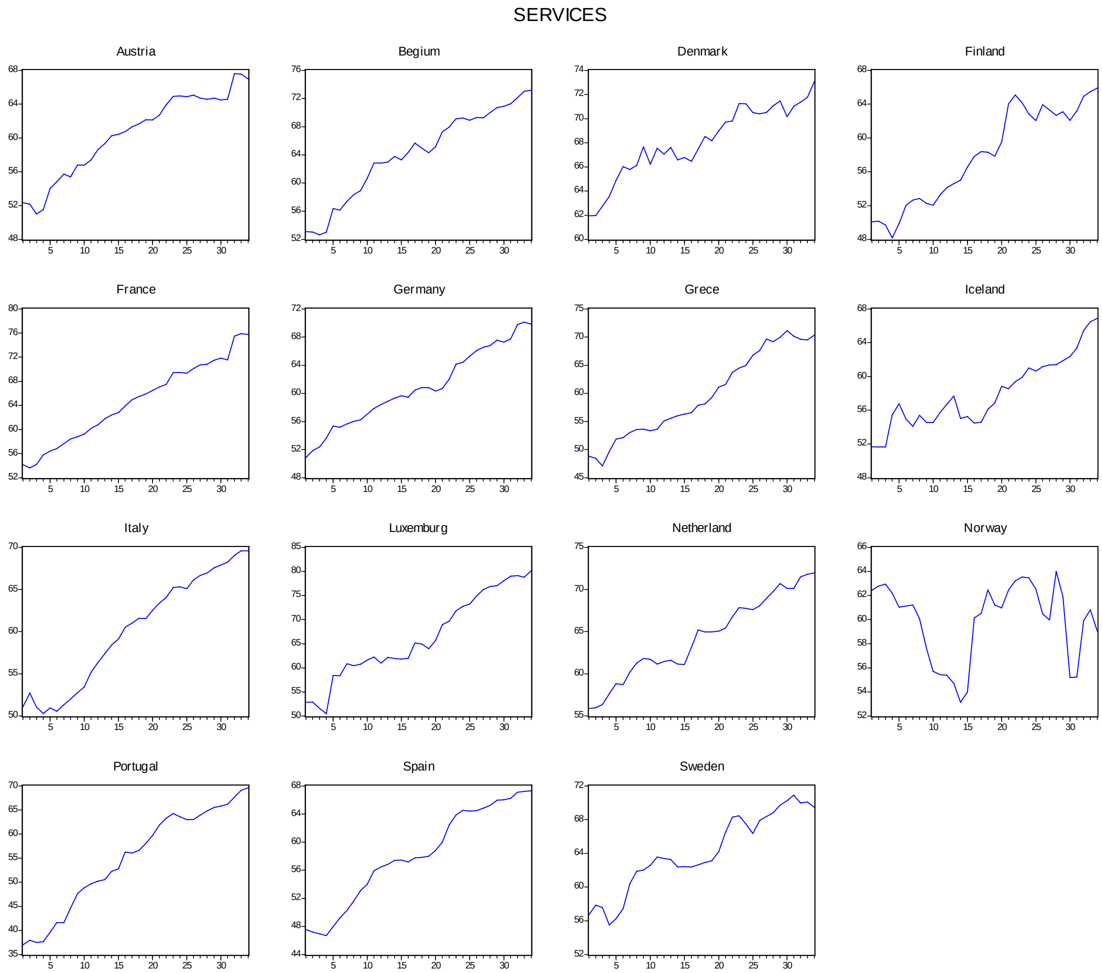


3.1.4. Service shares (%GDP)

Services correspond to ISIC divisions 50-99. They include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional and personal services such as education, health care, and real estate services.

Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. The industrial origin of value added is determined by the International Standard Industrial Classification (ISIC revision 3.) Graphs show upward trends for all countries except for Norway.

Figure 6. Service shares of GDP (%GDP) for 15 Schengen countries in 1970- 2004



3.2. Panel unit root tests

The shares data depicted above show a clear trending behavior. A question raises that are the series trend or difference stationary. In recent years we have seen a growing interest in non-stationary (or difference stationary) panels. The analysis of non-stationary panels is similar to analysis of non-stationary time series that grew during 1980s. However non stationary panels include some unique issue such as cross-sectional heterogeneity and correlation. As with non stationary time series the interest in the panel unit root test has extended to the panel co-integration test. Next we briefly describe the five panel unit root tests which are used in this study. We test unit roots in panel of series, i.e. growth rate of GDP per capita ($\Delta \ln GDPc_{it}$), industrial share, (W_{Iit}) services share (W_{Sit}) , and agriculture share (W_{Ait}) , for 15 cross sections with 35 time periods (1970-2004).

Recent econometric literature has proposed several methods for testing the presence of a unit root under panel data setting. We begin by classifying our unit root test on the basis of whether there is restriction on the autoregressive process of cross-section series. Consider a following AR (1) process for panel data:

$$y_{it} = \rho_i y_{it-1} + X_{it}\delta_i + \varepsilon_{it},$$

where y_{it} represents the panel of original series of interest. X_{it} represents the deterministic variables in the model including any fixed cross effects or individual trends. ρ_i is the autoregressive coefficients, and the errors ε_{it} are assumed to be mutually independent idiosyncratic errors. If $|\rho_i| < 1$ then $y_{i,t}$ is said to be weakly stationary. On other hand if $|\rho_i| = 1$ then $y_{i,t}$ contains a unit root.

There are two natural assumption concerning ρ_i . We assume that the persistence parameters are common across cross-sections, i.e. $\rho_i = \rho$ for all i . Levin, Lin, and Chu (LLC, 2002), and Breitung (2000) tests are based on this assumption:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X_{it}\delta + \varepsilon_{it}$$

Here we assume a common $\alpha = \rho - 1$ for all i but allow the lag order for the difference terms p_i to vary across the cross-sections. The null and alternative hypotheses for the tests are

$$H_0 : \alpha = 0 \qquad H_1 : \alpha < 0 .$$

Note that Breitung's test is based on standardized variables and de-trending transformations.

Alternatively we assume that ρ_i vary freely across cross-sections. Im, Pesaran, and Shin (IPS, 2003), Fisher-ADF, and Fisher-PP (Phillips-Perron) -tests are of this form. The tests are all characterized by the combining of individual unit root tests to derive a panel specification results. IPS-test begins by specifying separate ADF regression for each cross-section:

$$\Delta y_{it} = \alpha_i y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X_{it}\delta + \varepsilon_{it}$$

Here the null hypothesis may be written as

$$H_0 : \alpha_i = 0 \quad \text{for all } i$$

$$H_1 : \quad \alpha_i = 0 \quad \text{for } i = 1, 2, \ldots\ldots, N_1$$

$$\alpha_i < 0 \quad \text{for } i = N + 1, N + 2, \ldots\ldots, N$$

where i may be interpreted as non zero fraction of individual stationary processes. After estimating the separate ADF regressions, the average of the t-statistics for α_i from the individual ADF regressions, $t_{iT_i}(p_i)$, is obtained

$$\overline{t_{NT}} = (\sum_{i=1}^{N} t_{iTi}(p_i))/N$$

The IPS test statictic requires specification of the number of lags and the specification of the deterministic component for each cross-section ADF equation.

Fisher-ADF and Fisher–PP tests are alternative approaches to panel unit root test using Fisher's (1932) result to derive tests that combine the *p-values* from individual unit root tests. This idea has been proposed by Maddala & Wu and Choi (1999). If we define π_i as *p*-value from individual unit root tests for cross-section *i*, then under null of unit root for all *N* cross-section, we have the asymptotic results that

$$-2\sum_{i=1}^{N}\log(\pi_i) \rightarrow \chi^2(2N) .$$

In addition, Choi (2001) demonstrate that:

$$Z = 1/\sqrt{N}\sum_{i=1}^{N}\Phi^{-1}(\pi_i) \rightarrow N(0,1) ,$$

where Φ^{-1} is the inverse of standard normal cumulative distribution function. Next we report only the asymptotic χ^2 static using ADF and Phillip-Perron individual unit root tests. The null and alternative hypotheses are same as in IPS. When the Fisher test is based on ADF test statistic the number of lag used in each cross-section ADF regression must be specified. For PP-form of the test a method for estimating frequency f_0 must be specified. Typically this is done with a kernel based sum of covariance. Table 4. gives a summary of different tests.

Table 4. Summary of five unit root tests

Test	*Null*	*Alternative*	*Possible Deterministic Components**	*Autocorrelation Correction Method*
Levin. Lin and Chu	*Unit Root*	*No Unit Root*	*None. F. T*	*Lags*
Breitung	*Unit Root*	*No Unit Root*	*None. F. T*	*Lags*
IPS	*Unit Root*	*Some cross-sections with out Unit Root*	*F. T*	*Lags*
Fisher-ADF	*Unit Root*	*Some cross- sections with out Unit Root*	*None. F. T*	*Lags*
Fisher-PP	*Unit Root*	*Some cross- sections with out Unit Root*	*None. F. T*	*Kernel*

**) None: no deterministic components. F: fixed cross section effects. T: individual trend effects*

Table 5. and Table 6. present the panel unit root test results for the series and for their first-difference transformations respectively. Table 5. indicates that $\Delta \ln GDPc_{it}$ is a stationary with all tests. Agriculture shows stationary only in LLC-test and PP-test but failed to show stationary in all other three tests.

Table 5. Panel unit root test results

	$\Delta \ln GDPc_{it}$		***Agriculture shares*** W_{Ait}		***Industrial shares*** W_{Iit}		***Services shares*** W_{Sit}	
TEST	*Test value*	*p-value*	*Test value*	*p-value*	*Test value*	*p-value*	*Test value*	*p-value*
LLC	*-9.03*	*0.00****	*-5.01*	*0.00****	*-0.82*	*0.21*	*-1.77*	*0.04***
Breitung	*-4.72*	*0.00 ****	*1.83*	*0.96*	*0.38*	*0.65*	*0.91*	*0.82*
IPS	*-10.15*	*0.00 ****	*-0.26*	*0.39*	*2.64*	*0.99*	*2.67*	*0.99*
Fisher- ADF	*157.71*	*0.00 ****	*37.65*	*0.15*	*15.12*	*0.98*	*11.89*	*0.99*
Fisher-PP	*189.58*	*0.00 ****	*48.37*	*0.02***	*13.24*	*0.99*	*11.16*	*0.99*

Note: (1) Automatic selection of lags 0-3 based on minimum AIC.
*(2) ***, **, and * denote rejection of null hypothesis at 1%. 5% and 10% level of significance.*
(3) Deterministic components. LLC, PP, Breitung, and Fisher-ADF tests: fix cross section effects and individual trends. IPS: fixed cross section effects.

Results in Table 6. indicate that the all four panel first-difference series $\Delta\Delta \ln GDPc_{it}$, ΔW_{Ait}, ΔW_{Iit}, and ΔW_{Sit} are all stationary at 1% level of significance.

Table 6. Panel unit root test results on first differences

	$\Delta\Delta \ln GDPc_{it}$		*Agricultures shares* ΔW_{Ait}		*Industrial shares* ΔW_{Iit}		*Services shares* ΔW_{Sit}	
TESTS	*Test-value*	*p-value*	*Test-value*	*p-value*	*Test-value*	*p-value*	*Test-value*	*p-value*
LLC	*-14.78*	*0.00****	*-12.22*	*0.00****	*-8.85*	*0.000****	*-10.14*	*0.000****
Breiuing	*-11.33*	*0.00 ****	*-6.65*	*0.00 ****	*-6.20*	*0.00 ****	*-5.75*	*0.00 ****
IPS	*-19.50*	*0.00 ****	*-13.72*	*0.00 ****	*-12.46*	*0.00 ****	*-12.91*	*0.00 ****
Fisher-ADF	*327.19*	*0.00 ****	*223.92*	*0.00 ****	*197.37*	*0.00 ****	*206.91*	*0.00 ****
Fisher-PP	*442.67*	*0.00 ****	*402.44*	*0.00 ****	*303.76*	*0.00 ****	*269.40*	*0.00 ****

Note: (1) Automatic selection of lags 0-3 based on minimum AIC..
*(2) ***, **, and * denote rejection of null hypothesis. 1%. 5% and 10% level of significance.*
(3) Deterministic components. LLC, PP, Breitung, and Fisher-ADF tests: fix cross section effects and individual trends. IPS: fixed cross section effects.

The unit root panel testing indicate that the growth rate of GDP per capita series ($\Delta \ln GDPc_{it}$) is stationary but sector shares W_{Ait}, W_{Iit}, and W_{Sit} are non-stationary. The outcome restricts our analysis concerning the growth effects between these series as the series have different orders of integration. Next we propose different models to overcome this problem of unbalanced series order integration.

4. GROWTH EFFECTS OF SECTOR DYNAMICS

4.1 Some theoretical models

Considered following production function type relationship between GDP volume and its main sector sources

$$Q_t = F(I_t, S_t, A_t),$$

where I_t is industrial output, S_t is service output, and A_t is the output primary sector (agriculture etc.) all measured with some physical units. Total differentiation linearizes the equation

$$dQ_t = F_I dI_t + F_S dS_t + F_A dA_t$$

where F_i with $i = I, S,$ and A are the partial derivates of different sectors. Dividing this with Q_t and augmenting it with sector outputs gives

$$\frac{dQ_t}{Q_t} = \frac{F_I}{Q_t} dI_t \frac{I_t}{I_t} + \frac{F_S}{Q_t} dS_t \frac{S_t}{S_t} + \frac{F_A}{Q_t} dA_t \frac{A_t}{A_t}.$$

A closer inspection of this gives

1)
$$\frac{dQ_t}{Q_t} = \frac{\partial F}{\partial I_t}\frac{I_t}{Q_t}\frac{dI_t}{I_t} + \frac{\partial F}{\partial S_t}\frac{S_t}{Q_t}\frac{dS_t}{S_t} + \frac{\partial F}{\partial A_t}\frac{A_t}{Q_t}\frac{dA_t}{A_t}$$
$$= \alpha_1 \frac{dI_t}{I_t} + \alpha_S \frac{dS_t}{S_t} + \alpha_A \frac{dA_t}{A_t}.$$

Under assumption of constant sectoral output GDP elasticities $(\alpha_1, \alpha_S, \alpha_A)$ this specification leads to a *VAR( )* model with variables $\frac{dQ_t}{Q_t}, \frac{dI_t}{I_t}, \frac{dS_t}{S_t}$, and $\frac{dA_t}{A_t}$ since exogeneity assumptions can not be used in this context.

Alternative if we assume that competitive conditions prevail in all sectors then the marginal product pricing rule can be used, e.g. $F_{I_t} = w_{It}$ where w_{It} is the real price of industry "input". Now we have

$$\frac{dQ_t}{Q_t} = \frac{w_{It} I_t}{Q_t}\frac{dI_t}{I_t} + \frac{w_{St} S_t}{Q_t}\frac{dS_t}{S_t} + \frac{w_{At} A_t}{Q_t}\frac{dA_t}{A_t} = W_{It}\frac{dI_t}{I_t} + W_{St}\frac{dS_t}{S_t} + W_{At}\frac{dA_t}{A_t},$$

where $W_{I,t}$ W_{St}, and W_{At} are the sector shares of output. Next if we assume that long run growth rates $dI_t / I_t, dS_t / S_t$ and dA_t / A_t have stationary long run solutions in the following sense

$$dI_t / I_t = g_I + \varepsilon_{It}, \quad \varepsilon_{It} \sim I(0) \text{ with } E[\varepsilon_{It}] = 0$$
$$dS_t / S_t = g_S + \varepsilon_{St}, \quad \varepsilon_{St} \sim I(0) \text{ with } E[\varepsilon_{St}] = 0$$
$$dA_t / A_t = g_A + \varepsilon_{At}, \quad \varepsilon_{At} \sim I(0) \text{ with } E[\varepsilon_{At}] = 0$$

where g_I, g_S, and g_A are constant growth rates. Inserting these into growth decomposition above gives

$$\frac{dQ_t}{Q_t} = (g_I + \varepsilon_{It})W_{It} + (g_S + \varepsilon_{St})W_{St} + (g_A + \varepsilon_{At})W_{At}$$

2) $$= g_I W_{It} + g_S W_{St} + g_A W_{At} + \varepsilon_{Qt}, \ \varepsilon_{Qt} \sim \mathrm{I}(0) \text{ with } E[\varepsilon_{Qt}] = 0.$$

$$= g_I W_{It} + g_S W_{St} + g_A (1 - W_{It} - W_{St}) + \varepsilon_{Qt}.$$

Result in Eq. 2) is interesting since we argue that it exhibits a stationary presentation since dQ_t / Q_t and ε_{Qt} are typically $I(0)$-series but the sector shares $\{W_{It}, W_{St}, W_{At}\}$ are $I(1)$-series.

However this means that the equation $(g_I + \varepsilon_{It})W_{It} + (g_S + \varepsilon_{St})W_{St} + (g_A + \varepsilon_{At})W_{At}$ can be decomposed into two parts: non-stationary elements forming a co-integrated part and a stationary part ε_{Qt} (see Appendix I). As $W_{It} + W_{St} + W_{At} = 1$ by definition, any other linear dependency preserving combination of it sums also to some constant $g = E[dQ_t / Q_t]$, that is $E[g_I W_{It} + g_S W_{St} + g_A (1 - W_{It} - W_{St})] = g$. Thus estimating the co-integration relation based on Eq. 2)

3A) $$W_{It} = \left(\frac{g - g_A}{g_I - g_A}\right) - \left(\frac{g_A - g_S}{g_I - g_A}\right) W_{St} + \mu_t$$

$$\Rightarrow \qquad W_{It} = \alpha_0 + \alpha_1 W_{St} + \mu_t, \qquad \mu_t \sim I(0),$$

gives us the long-run solution (LR) between W_{It} and W_{St} the shares and provide us information concerning the structural adjustment between the sector shares. μ_t displays the short run stationary adjustments around the equilibrium share presentation between W_{It} and W_{St}.

Note we can also solve the co-integration relation for $\{W_{It}, W_{At}\}$ and $\{W_{St}, W_{At}\}$ in similar way, i.e.

$$E[g_I W_{It} + g_S(1 - W_{It} - W_{At}) + g_A W_{At}] = g \quad \text{and}$$

$$E[g_S W_{St} + g_A(1 - W_{St} - W_{At}) + g_A W_{At}] = g$$

leading to two other co-integration models

3B) $$W_{It} = (\frac{g - g_S}{g_I - g_S}) - (\frac{g_A - g_S)}{g_I - g_S} W_{At} + \varepsilon_t$$

$$\Rightarrow \quad W_{It} = \beta_0 + \beta_1 W_{At} + \varepsilon_t, \quad \varepsilon_t \sim I(0), \quad \text{and}$$

3C) $$W_{St} = (\frac{g - g_A}{g_S - g_A}) - (\frac{g_I - g_A)}{g_S - g_A} W_{At} + \lambda_t$$

$$\Rightarrow \quad W_{St} = c_0 + c_1 W_{At} + \lambda_t, \quad \lambda_t \sim I(0).$$

Plugging separately these co-integration, i.e. long run, solutions

$$W_{It} - \alpha_0 - \alpha_1 W_{St} = \mu_t, \; W_{It} - \beta_0 - \beta_1 W_{At} = \varepsilon_t, \text{ and } W_{St} - c_0 - c_1 W_{At} = \lambda_t$$

into Eq. 2) enables us to analyze the long run factor share adjustment effects on the growth of $GDPc_t$.

The results obtained above indicate also that we can use error correction model (ECM) presentations of co-integration models in order to analyze the equilibrium adjustments between sector shares. However before this co-integrating between sector shares must be established.

4.2. Co-integration between sectoral shares

Based on the evidence of previous section that sector share series W_{Iit} , W_{Sit} , and W_{Ait} are best characterized as $I(1)$ series we test for co-integration between { W_{Iit} , W_{Sit} }, { W_{Iit} , W_{Ait} }, and { W_{Sit} , W_{Ait} } panel set of series. Following co-integration relations (recall Eqs. 3A) – 3C) are estimated and tested

$$CI_{IS}: \quad W_{It} = \alpha_0 + \alpha_1 W_{St} + \mu_t ,$$

$$CI_{IA}: \quad W_{It} = \beta_0 + \beta_1 W_{At} + \varepsilon_t ,$$

$$CI_{SA}: \quad W_{St} = c_0 + c_1 W_{At} + \lambda_t .$$

Here, we pool the data of different countries and compute a panel co-integration test as developed by Pedroni (1997). Test involves two steps. In the first step co-integration model regressions are estimated with OLS separately for each countries, i.e. the regression of W_{Iit} on W_{Sit} , W_{Iit} on W_{At} , and W_{Sit} on W_{Ait} , for all *i=1,2,..,15* separately. Thus, we allow the co-integration vectors to vary across the country. The residuals from these regressions are then saved. In the second step a panel unit root test for these residuals are calculated, separately for each model. Thus, we run a panel auto-regression of order one for the residuals and conduct the Phillips-Perron (Fisher - PP) unit root tests (see Table 4 above). Under null hypothesis there is no co-integration between series while under the alternative co-integration exists.

Table 7. Panel Co-Integration Results

Model	Test Statistic	p-value	Results
CI_{IS}:	88.74	0.000***	Reject null hypothesis
CI_{IA}:	98.88	0.000***	Reject null hypothesis
CI_{SA}:	107.46	0.000***	Reject null hypothesis

Next we report the log run parametrization of co-integration relations. Note that we report the averages of 15 countries for each parameter.

Table 8. Long run parameter estimates

Model	
CI_{IS}:	$W_{It} = 77.76 - 0.72W_{St}$
CI_{IA}:	$W_{It} = 23.51 + 2.64W_{At}$
CI_{SA}:	$W_{St} = 76.51 - 3.45W_{At}$

The results are interesting. A negative "trade-off" exists between industry and service sectors, and between agricultural and service sectors. However, in the long run a smaller agricultural sector is related to smaller industry sector. Generally results indicate that on the average among the Schengen countries the service sector has increased at the cost of other two sectors and a positive relationship exists between industry and agricultural sectors. The Appendix II reports the country specific long run results. The variation of coefficient estimates of CI_{IS} -model $W_{It} = \alpha_0 + \alpha_1 W_{St} + \mu_t$ are quite small but in the models $W_{It} = \beta_0 + \beta_1 W_{At} + \varepsilon_t$ and $W_{St} = c_0 + c_1 W_{At} + \lambda_t$ the coefficient estimate variation are large. Typically a large β_1 value (e.g. Belgium, Germany, Luxemburg, and Netherlands) goes hand in hand with small c_1 coefficients and vice versa. Note that results $\beta_0 + c_0 = 100$ and $\beta_1 + c_1 = -1$ stem from the fact that $W_{It} + W_{St} = 1 - W_{At}$.

4.3. Error correction models (ECM)

In order to analyze in details the long run adjustments between sector shares we propose following error correction models based on above the co-integration relations. Note that we have six EC-models since we have not assumed any exogeneity.

ECM$_{IS}$ and **ECM$_{SI}$**

$$\Delta W_{Iit} = \sum_{j=1}^{r} \beta_{Ij} \Delta W_{I\,i,t-j} + \sum_{j=0}^{p} \beta_{Sj} \Delta W_{S\,i,t-j} + \alpha_{IS} \hat{\mu}_{i,t-1} + \varphi_{it} \quad \text{with} \quad \varphi_{it} \sim NID(0, \sigma_{IS}^2),$$

$$\Delta W_{Sit} = \sum_{j=1}^{r} \beta_{Sj} \Delta W_{S\,i,t-j} + \sum_{j=0}^{p} \beta_{Ij} \Delta W_{I\,i,t-j} + \alpha_{SI} \hat{v}_{i,t-1} + \omega_{it} \quad \text{with} \quad \omega_{it} \sim NID(0, \sigma_{SI}^2)$$

ECM$_{IA}$ and **ECM$_{AI}$**

$$\Delta W_{Iit} = \sum_{j=1}^{r} \beta_{Ij} \Delta W_{I\,i,t-j} + \sum_{j=0}^{p} \beta_{Aj} \Delta W_{Ai,t-j} + \alpha_{IA} \hat{\varepsilon}_{i,t-1} + \eta_{it} \quad \text{with} \quad \eta_{it} \sim NID(0, \sigma_{IA}^2),$$

$$\Delta W_{Ait} = \sum_{j=1}^{r} \beta_{Aj} \Delta W_{Ai,t-j} + \sum_{j=0}^{p} \beta_{Ij} \Delta W_{Ii,t-j} + \alpha_{AI} \hat{m}_{i,t-1} + \chi_{it} \quad \text{with} \quad \chi_{it} \sim NID(0, \sigma_{AI}^2)$$

ECM$_{SA}$ and ECM$_{AS}$

$$\Delta W_{Sit} = \sum_{j=1}^{r} \beta_{Sj} \Delta W_{S\,i,t-j} + \sum_{j=1}^{p} \beta_{Aj} \Delta W_{Ai,t-j} + \alpha_{SA} \hat{\lambda}_{i,t-1} + \pi_{it} \quad \text{with} \quad \pi_{it} \sim NID(0, \sigma_{SA}^2),$$

$$\Delta W_{Ait} = \sum_{j=1}^{r} \beta_{Aj} \Delta W_{Ai,t-j} + \sum_{j=0}^{p} \beta_{Si,t-j} \Delta W_{Si,t-j} + \alpha_{AS} \hat{n}_{i,t-1} + k_{it} \quad \text{with} \quad k_{it} \sim NID(0, \sigma_{AS}^2)$$

These specifications mean that we use Granger-Engle two-step estimation procedure to estimate *EC*–models. The method uses stationary residuals $\hat{\mu}_{i,t-1}$, $\hat{v}_{i,t-1}$, $\hat{\varepsilon}_{i,t-1}$, $\hat{m}_{i,t-1}$, $\hat{\lambda}_{i,t-1}$, and $\hat{n}_{i,t-1}$ from the following co-integration regression solutions

$$W_{Iit} = \hat{\alpha}_0 + \hat{\alpha}_1 W_{Sit} + \hat{\mu}_{it} \quad \text{and} \quad W_{St} = \hat{g}_0 + \hat{g}_1 W_{It} + \hat{v}_t,$$

$$W_{Iit} = \hat{\beta}_0 + \hat{\beta}_1 W_{Ait} + \hat{\varepsilon}_{it} \quad \text{and} \quad W_{At} = \hat{h}_0 + \hat{h}_1 W_{It} + \hat{m}_t,$$

$$W_{Sit} = \hat{c}_0 + \hat{c}_1 W_{Ait} + \hat{\lambda}_{it} \quad \text{and} \quad W_{At} = \hat{j}_0 + \hat{j}_1 W_{st} + \hat{n}_t$$

in the EC-models. Table 9. reports the EC-model results for the part of EC-terms.

Table 9. Panel ECM Results for Sectoral Shares
(N = 15, T =35, 1970-2004)

	***ECM**$_{IS}$*	***ECM**$_{SI}$*	***ECM**$_{IA}$*	***ECM**$_{AI}$*	***ECM**$_{SA}$*	***ECM**$_{AS}$*
$\hat{\mu}_{i,t-1}$	*-0.45 (0.000)****					
$\hat{v}_{i,t-1}$		*-0.055 (0.06)**				
$\hat{\varepsilon}_{i,t-1}$			*-0.42 (0.009)****			
$\hat{m}_{i,t-1}$				*-0.15 (0.005)***		
$\hat{\lambda}_{i,t-1}$					*-0.38 (0.05)***	
$\hat{n}_{i,t-1}$						*-0.44 (0.001)****
Country Dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R²	*0.23*	*0.19*	*0.26*	*0.22*	*0.30*	*0.27*
Number of observations	*453*	*453*	*453*	*453*	*453*	*453*
AR(1) p-value AR(2) p-value	0.20 0.90	0.19 0.12	0.19 0.29	0.10 0.09	0.18 0.30	0.37 0.25

*(1) *** significant at 1 % level of significance*
*(2) ** significant at 5 % level of significance*
*(3) * significant at 10% level of significance*
AR(1) and AR(2): residual AR(1) and AR(2) LM-tests, H_0: no residual autocorrelation.

The results show that error correction terms in all models are significant also in statistical terms with level of 10% or less. Industry-service adjustment is interesting. The estimates for EC-terms α_{IS} and α_{AI} are negative (-0.45 and -0.055). Adjustments toward the long run sector equilibrium solutions exist. However, speed of adjustment from service to industry is 2.2 years but the opposite direction takes over 18 years. The adjustment between industry and agriculture has similar patterns (-0.42 and -0.15) with 2.4 and 6.7 years of equilibrium correction. The service-agriculture adjustment is the most balanced one since the EC-estimates are close to each other (-0.38 and -0.44) with c. 2.5 years of adjustment time in both directions. On the general level these results mean that shocks and disturbances in industry sector shares cause turbulence in its sector share relationships which slowly correct back to equilibrium.

5. INDUSTRY SHARE GROWTH EFFECTS: GRANGER NON-CAUSALITY TESTS

5.1. Fixed Effects Approach

Although co-integration implies (Granger) causality and EC- presentations we proceed to Granger no-causality testing. Due to different order of integration, a co-integration between sector shares and growth rate of *GDPc* is not possible. Sensible results are not expected from bivariate Granger non-causality test (GC) between $\Delta \ln GDPc_{it}$ and Z_{it} where $Z_{it} = W_{Iit}, W_{Sit}$, or W_{Ait}. Thus GC-analysis is conducted on the *differenced* sector share series. That is on $\Delta \ln Z_{it}$ where $\Delta \ln Z_{it} = \Delta \ln W_{Iit}$, $\Delta \ln W_{Sit}$, or $\Delta \ln W_{Ait}$. The GC-testing is conducted in panel setting. Fixed effects [3] GC-test models can be written as follows

4A) $$\Delta \ln GDPc_{i,t} = c_i + \sum_{j=1}^{n} \rho_j \Delta \ln Z_{it-j} + \sum_{j=1}^{n} \delta_j \Delta \ln GDPc_{i,t-j} + \varepsilon_{i,t}$$

4B) $$\Delta Z_{i,t} = h_i + \sum_{j=1}^{n} \sigma_j \Delta \ln Z_{it-j} + \sum_{j=1}^{n} \tau_j \Delta \ln GDPc_{i,t-j} + \mu_{i,t}$$

where $\Delta \ln Z_{it} = \Delta \ln W_{Iit}, \Delta \ln W_{Sit}$, or $\Delta \ln W_{Ait}$. *j* represents the lag length used for the analysis. We included up till five lags ($n = 5$) to secure *WN* error terms. The null hypotheses that growth rates in sector shares do not Granger cause economy wide growth rate is found in regression 5A). The null hypothesis is rejected if the joint hypothesis of ρ_j = 0 for all *j* is rejected. Similarly the hypothesis that growth rate does not Granger cause is based on the regression 5B). Null hypothesis corresponds to test joint hypothesis τ_j = 0 for all *j*. We use Wald coefficients restrictions test. The long run impact parameters can be solved with following formulas

$$A_{LR} = \sum_{j=1}^{n} \rho_j / (1 - \sum_{j=1}^{n} \delta_j) \quad \text{and} \quad B_{LR} = \sum_{j=1}^{n} \tau_j / (1 - \sum_{j=1}^{n} \sigma_j)$$

[3] Note that fixed effects OLS estimation method is used despite the fact in dynamic panel models parameter estimate are biased (Nickell 1981) because the explanatory variables and residuals are correlated. However the bias is of order *(1/T*). This is not considered important in this context where *T>30*.

5.2. Results from Granger non-causality test

Unidirectional causality runs from growth rate of *GDPc* to growth of agriculture share (see Table 10.). Agriculture share growth has no impact on economic growth but changes in agriculture shares are forecasted by the past growth of *GDPc*. In post-industrialized Schengen countries the impact of growth of *GDPc* on growth of agricultural share is negative with value of -0.50 .

The GC-test values imply that two-way causality is valid between growth rates of *GDPc* and industry sector, and between growth rates of *GDPc* and service sector. The classical growth theories of Verdoorn (1949) and Kaldor (1957. 1978) suggested that industrial sector productivity and output growth reinforce each other. For the Schengen countries the higher growth rate of *GDPc* means decreasing growth rate of industrial sector share (estimate for B_{LR} is -0.12). However the long run *net effect* between growth rate of *GDPc* and industry share is 0.10 since industry share growth affects *GDPc* growth with value of 0.22.

Table 10. Panel Granger non-causality tests between growth rates of sector shares and *GDP*c

Null Hypotheses : Growth rate of sector share does not Granger cause growth rate of *GDPc*					
Agriculture Shares		**Industrial Shares**		**Services Shares**	
F-stat p-value 0.60		***F-stat p-value 0.02*****		***F-stat p-value 0.003******	
$\chi^2(1)$ *normality test: p-value 0.59*		$\chi^2(1)$ *normality test: p-value 0.10*		$\chi^2(1)$ *normality test: p-value 0.10*	
No of observation: 400		*No of observation: 400*		*No of observation: 400*	
AR (1) 0.88 *AR (2) 0.36*		*AR (1) 0.71* *AR (2) 0.72*		*AR (1) 0.94* *AR (2) 0.85*	
*Fixed effects (0.00) ****		*Fixed effects (0.00) ****		*Fixed effects (0.00) ****	
Long Run Parameter A_{LR}	***0.02***	***Long Run Parameter*** A_{LR}	***0.22*****	***Long Run Parameter*** A_{LR}	***-0.25*****
Growth of agricultural share ***does not*** *cause output growth rate*		*Growth of industrial share* ***does*** *cause output growth rate.*		*Growth rate of service share* ***does*** *cause output growth rate*	

Null Hypothesis: Growth rate of $GDPc$ does not Granger cause growth rate of sector shares					
Agriculture Shares		**Industrial Shares**		**Services Shares**	
F-stat p-value 0.001**		***F-stat p-value 0.04*****		***F-stat p-value 0.08****	
$\chi^2(1)$ *normality test: p-value 0.12*		$\chi^2(1)$ *normality test: p-value 0.09*		$\chi^2(1)$ *normality test: p-value 0.10*	
No of observation: 395		*No of observation: 395*		*No of observation: 395*	
AR (1) 0.94 *AR (2) 0.85*		*AR (1) 0.30* *AR (2) 0.20*		*AR (1) 0.12* *AR (2) : 0.10*	
*Fixed effects (0.00) ****		*Fixed effects (0.00) ****		*Fixed effects (0.00) ****	
Long Run Parameter B_{LR}	***-0.50*****	***Long Run Parameter*** B_{LR}	***-0.12*****	***Long Run Parameter*** B_{LR}	***0.15*****
Output growth rate ***does cause*** *growth of agri-cultural share*		*Output growth rate* ***does cause*** *growth of industry share*		*Output growth* ***rate does cause*** *growth of services share*	

*(1) *** significant at 1 % level of significance*
*(2) ** significant at 5 % level of significance*
*(3) * significant at 10% level of significance*
AR(1) and AR(2): residual AR(1) and AR(2) LM-tests, H_0: no residual autocorrelation.
Normality test on residual of each regression, where H_0: residuals are normaly distributed

The GC-test values and long run solutions of impact parameters imply quite complex relation between $\Delta \ln GDPc$ and sector share growth rates. Higher service growth rates predict negative $GDPc$ growth rates. Causality runs also in opposite direction with positive economy wide growth effects on service share growth. However the net effect is negative.

In general GC-analysis implies that industry (share) growth rate is still the engine of growth rate of economy. Agricultural share does not have growth effects and service share effects are negative. However $GDPc$ growth rate predicts only positive growth effects on service sector. The growth effects on other sector shares are negative.

6. GROWTH EFFECTS FROM EQUILIBRIUM SECTOR SHARE DYNAMICS

Finally we analyze how *GDPc* growth rate is affected by co-integration presentations of sector shares. This means that we try to test empirically our basic theoretical results obtained in Eq. 2) above

$$\frac{dQ_t}{Q_t} = (g_I + \varepsilon_{It})W_{It} + (g_S + \varepsilon_{St})W_{St} + (g_A + \varepsilon_{At})W_{At}$$

$$= g_I W_{It} + g_S W_{St} + g_A(1 - W_{It} - W_{St}) + \varepsilon_{Qt}, \quad \varepsilon_{Qt} \sim I(0) \text{ with } E[\varepsilon_{Qt}] = 0$$

where the right hand side of the equation was presented by three different co-integration relationships based on the assumption that long run *GDPc* growth rate is some constant, i.e. $g = E[dQ_t / Q_t]$. Note that in estimating $\Delta \ln GDPc_{it}$ on $g_I W_{It} + g_S W_{St}$ + $g_A(1 - W_{It} - W_{St})$ we can use one co-integration presentation only, not all in same equation, since sector share identity $W_{It} + W_{St} + W_{At} = 1$ is always valid and only one co-integration relationship is valid for each pair of sector shares.

Thus we estimate three regression for $\Delta \ln GDPc_{it}$ on $\hat{\mu}_{i,t-1}, \hat{\varepsilon}_{i,t-1}$, and $\hat{\lambda}_{i,t-1}$ augmented with short run dynamics of $\Delta \ln GDPc_{it}$ and corresponding sector share dynamics. We use lagged values of "equilibrium errors" to avoid the endogeneity bias problems stemming from effect of contemporaneous *GDPc* growth rate effects on sector shares. The estimated models have the same presentations as error correction models but we stress the fact that they are *not* EC-models since *no* co-integration is valid for *GDPc* growth rates and sector share levels. Instead we argue that these models include features of sector dynamics that are important for economic growth but are not presented by the GC-tests on growth rates.

The results presented in Table 11. (on the next page) are interesting. Basically first model tells the following story. If the level of service sector share shots above its long run

Table 11. Panel model results for output growth effects on sector share equilibrium errors. Endogenous variable $\Delta \ln GDPc_{i,t}$ (N = 15, T =35, 1970-2004)

$\Delta \ln GDPc_{i,t-1}$	*0.258 (2.75)****	*0.263 (5.21)****	*0.261 (9.97)****
$\hat{\mu}_{i,t-1}$	*-0.420 (-2.57)****		
$\hat{\varepsilon}_{i,t-1}$		*-0.122 (-2.20)***	
$\hat{\lambda}_{i,t-1}$			*0.134 (2.34)***
$\Delta \ln W_{Ii,t-1}$	*0.278 (1.30)**	*0.200 (0.366)*	
$\Delta \ln W_{Ii,t-2}$	*0.422 (3.82)****	*0.074 (1.68)***	
$\Delta \ln W_{Si,t-1}$	*0.247 (1.20)*		*-0.100 (-1.02)*
$\Delta \ln W_{Si,t-2}$	*0.346 (3.28)***		
$\Delta \ln W_{Ai,t-1}$		*-0.260 (-1.60)**	*-0.173 (-0.82)*
$\Delta \ln W_{Ai,t-2}$		*-0.371 (-2.29)***	
Time Dummies	*yes*	*yes*	*yes*
Country Dummies	*yes*	*yes*	*yes*
R^2	*0.40*	*0.40*	*0.43*
Number of observations	*443*	*443*	*459*
AR(1) p-value AR(2) p-value	0.20 0.11	0.82 0.64	0.60 0.15

*(1) *** significant at 1 % level of significance*
*(2) ** significant at 5 % level of significance*
*(3) * significant at 10% level of significance*
AR(1) and AR(2): residual AR(1) and AR(2) LM-tests, H_0: no residual autocorrelation.

equilibrium relation level with respect to industry sector share level then this has a negative impact on the *GDPc* growth. Similarly if the level of agricultural level decreases in short run below the equilibrium level with respect to industry sector level then *GDPc* growth halters also. Finally if the level agricultural sector share increases for a some time above the equilibrium relation level with respect service sector level then the *GDPc* growth speeds up [4].

Note that these results do not conflict with results from Granger causality test in Table 10. The high growth rate and level of industry sector is good for general output growth. Both the growth and level effects of service sector share are growth retarding. The level of agricultural share with respect to service sector predicts higher *GDPc* growth but growth of agricultural share does not have output growth effects.

7. DISCUSSION AND CONCLUSIONS

The objective of this study has been in analyzing how the sector shares adjustments are related to economic growth in Schengen countries in period 1970-2004. For this purpose we estimated co-integration, error correction (EC) models, and conducted Granger non-causality (GC) tests in panel setting. In post-industrial economies the sector share dynamics and their growth effects may difference largely from the features earlier phase of economic development. On abstract theory level one could argue that competitive economy seeks out a general equilibrium state where sector shares are at optimum level. However in the dynamic Schumpeterian economy with market imperfections, fierce competition, creative destruction, and uneven technological progress in sectors such a state would be a miracle. Typically some sectors are losers and some winners making their growth effects unpredictable as many feedback and spill-over effects are evident among the sectors. Our modest attempt was to analyze how three main sector shares of economy in Schengen countries developed from the growth perspective during period 1970-2004.

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[4] Note that co-integration relationships had the following OLS regression presentations

$$CI_{IS}: \quad W_{It} - 77.76 + 0.72W_{St} = \mu_t$$
$$CI_{IA}: \quad W_{It} - 23.51 - 2.64W_{At} = \varepsilon_t$$
$$CI_{SA}: \quad W_{St} - 76.51 + 3.45W_{At} = \lambda_t$$

First we proposed a co-integration relation between non stationary sector share series. The share identity $W_{It} + W_{St} + W_{At} = 1$ caused some special requirements to our co-integration analysis. The pair-case sector shares { W_{Iit} , W_{Sit} }, { W_{Sit} , W_{Ait} }, and $\{W_{Iit}, W_{Ait}\}$ are co-integrated, and the result allows for three different presentations of long run relationship between them. Service sector has increased at the cost of other two sectors but a positive relationship existed between industry and agricultural sectors. Pair-wise error correction presentations of co-integration relationships supported the view that adjustments toward equilibrium relationships between the sectors have been quite fast albeit the shocks in industry sector share levels had slowly correcting mechanism with other sector shares.

The stationary of *GDPc* growth rate series and co-integration between non-stationary sector share series divided the analysis of sector share growth effects in two parts. We first analysed the Granger causality between *GDPc* growth rate and *growth rates* of sector shares. Second the growth effects from the share equilibrium errors from share co-integration results were analysed with error correction type models. The GC-test values implied that a two-way causality was valid between growth rates of *GDPc* and industry sector, and between growth rates of *GDPc* and service sector. However, for the Schengen countries the higher growth rate of *GDPc* means decreasing growth rate of industrial sector share but the industry share growth effects are positive on *GDPc* growth rate. The dynamic impacts between growth rates of *GDPc* and service share are opposite. Larger service sector share growth rate predicts smaller *GDPc* growth rate but the opposite causality from *GDPc* growth rate to service share growth implies positive impacts. The causality between *GDPc* growth rate and growth of agricultural share is unidirectional running from *GDPc* to agricultural share with negative impact. By stressing the results of sector share growth effects we observe that industry sector is still the “engine” of economy and the larger service sector retards the *GDPc* growth rate.

The growth effect results from the share equilibrium dynamics with “pseudo” error correction models on *GDPc* growth rate were in accordance with results from Granger causality tests. A positive “shock” to the level of service sector share compared to industry sector share halters output growth. However a positive shock to level of agricultural share with respect to industry or service sector level predicts higher *GDPc* growth.

We conclude that the long run relationships existed between economy's main sector shares among Schengen countries in period 1970-2004. However the *GDPc* growth effects from share dynamics are not uniform. Reinforcement impact is still strong between industrial shares and economic growth although the industrial shares are decreasing. The links between *GDPc* growth and service and agriculture shares are complex but e.g. EU policy bolstering the agriculture sector is not growth retarding. More likely it is the increasing service sector with low productivity that retards the economic growth in Europe.

REFERENCES

Baumol, W. J.. (1967). "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis", *American Economic Review* 57: 415-426.

Baumol, W. J., Batey, B. S. and E. N. Wolff (1985). "Unbalanced Growth Revisited: Asymptotic Stagnancy and New Evidence", *American Economic Review* 75: 806-17.

Baumol, W. J., Blakman, B.J., and E. N. Wolff (1989). *Productivity and American Leadership*. Cambridge UP.

Bjork, G. C. (1999). "The Way it Worked and Why it Won't: Structural Change and the Slowdown of U.S. Economic Growth" *Westport. Praeger Publishers*.

Breitung, J. (2000) "The Local Power of Some Unit Root Tests for Panel Data" in B. Baltagi (ed), Advances in Econometrics, Vol. 15: *Nonstationary, Panel Cointegration, and Dynamic Panels,* JAI Press, 161-178. Amsterdam.

Chenery, H. and M. Syrquin (1975). *Patterns of Development 1950-70*. Oxford UP.

Choi, I. (2001). "Unit Root Test for a Panel Data", *Journal of International Money and Finance* 20:249-272.

Cristina, E (1997). "Changes in Sectoral Composition Associated with Economic Growth", *International Economic Review*. 38: 431-52.

Dutt, A. K. and K.Y. Lee (1993). “The Service Sector and Economic Growth: Some Cross-Sectional Evidence”, *International Review of Applied Economics* 7: 311-329.

Fisher, R.A. (1932). *Statistical Methods for Research Workers,* 4th Edition, Edinburgh: Oliver and Boyd.

Granger, C. W. J.. (1969). “Investigating Causal Relations by Econometric Models and Cross Spectral Methods”, *Econometrica* 37: 424-438.

Im, K. S., Pesaran, M. H., and Y. Shin (2003). “ Testing for Unit Roots in Heterogeeous Panels,” Journal of Econometrics, 115, 53-74.

Kaldor, N. (1957). “A Model of Economic Growth”, *Economic Journal* 67:591-624.
_______(1966). *Causes of the Slow Rate of Growth in UK.* Cambridge UP.
_______(1967). *Strategic Factors in Economic Development*. Cambridge UP.
_______(1978). “Causes of the slow rate of growth of the UK” in *Further Essays on Economic Theory*. London. Duck Worth.

Kuznets, S. (1971). *Economic Growth of Nations. Total Output and Productive Structure.* Harvard UP.

Levin, A., Lin, C.F. and C. Chu (2002). “Unit Roots in Panel Data: Asymptotic and Finite Sample Properties”, *Journal of Econometrics* 108:1-14.

Linden, M. (2002). “Trend Model Testing of Growth Convergence in 15 OECD Countries 1946-1997", *Applied Economics* 34: 133-142

Necmi, S. (1999). “Kaldor’s Growth Analysis Revisited” *Applied Economics* 31:653-660.

Nickell, S. (1981). Biases in Dynamics Models with Fixed Effects”, *Econometrica* 47: 1399-416.

Pedroni, P. (1997). “Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Test with an Application to the PP Hypothesis. New Results”. *Indiana University* wp.

Rostow. W. W. (1971). *The Stages of Economic Growth.* Cambridge UP.

Taytyana, P., S. Soubbotina, and S. Katherine (2000). “ Beyond Economic Growth Student Book: An introduction to Sustainable Development”, The international Bank for Reconstruction / World Bank

Verdoorn, P. J. (1949). “Factors Governing the Growth of Labor Productivity”. *L’ Industria*. Vol. 1. 3-10. (English translation by Thirlwall. A. P. and Thirwall. G. (1979) in *Researh in Population and Economics*).

Wolff, E. N. (1985). "The Magnitude and Causes of the Recent Productivity Slowdown in the United States: A Survey of Recent Studies", In Baumol. W. and McLennon. K. (eds). *Productivity Growth and U.S. Competitiveness*, 27-57. Oxford UP.

Wilber, S. (2002). "Are Services Bad for Growth? Evidence from a Panel of OECD Economies". Unpublished Ph.D. Thesis. Georgetown University Washington DC.

World Bank (1989). *World Ddevelopment Report*, Oxford UP.

Appendix I.

As the factor shares have the same structure it is only necessary to show that

$$\frac{w_{It} I_t}{Q_t} \frac{dI_t}{I_t} = W_{It} \frac{dI_t}{I_t}$$

includes both non-stationary and stationary components. Assume that

$$\begin{aligned} W_{It} &= W_{I0} + \sum\nolimits_{j=0}^{t} \mu_{It}, \quad W_{I0} \sim IID(\omega_{I0}, \phi^2) \text{ and } \mu_{It} \sim IID(0, \sigma_{I\mu}^2), \\ dI_t / I_t &= g_I + \varepsilon_{It}, \qquad\qquad \varepsilon_{It} \sim IID(0, \sigma_{I\varepsilon}^2). \end{aligned}$$

Now their product $W_{It} \frac{dI_t}{I_t} = (W_{I0} + \sum\nolimits_{j=0}^{t} \mu_{Ij})\ (g_I + \varepsilon_{It})$ decomposes into non-stationary and stationary parts, i.e. in

$$(W_0 + \sum\nolimits_{j=0}^{t} \mu_t)\ (g_I + \varepsilon_{It}) = W_{I0} g_I + W_{I0} \varepsilon_{It} + g_I \sum\nolimits_{j=0}^{t} \mu_{Ij} + \varepsilon_{It} (\mu_{I0} + \mu_{I1} + ... + \mu_{It})$$

only the third component on the right hand side is non-stationary as long as $E[\varepsilon_{It} \mu_{Ij}] = 0$ for all j. Similarly if

$$\begin{aligned} W_{St} &= W_{S0} + \sum\nolimits_{j=0}^{t} \mu_{St}, \quad W_{S0} \sim IID(\omega_{S0}, \tau^2) \text{ and } \mu_{St} \sim IID(0, \sigma_{S\mu}^2), \\ dS_t / S_t &= g_S + \varepsilon_{St}, \qquad\qquad \varepsilon_{St} \sim IID(0, \sigma_{S\varepsilon}^2), \end{aligned}$$

then (see Eq. 2)

$$\frac{dQ_t}{Q_t} = (g_I + \varepsilon_{It})W_{It} + (g_S + \varepsilon_{St})W_{St} + (g_A + \varepsilon_{At})W_{At}$$

$$= g_I W_{It} + g_S W_{St} + g_A(1 - W_{It} - W_{St}) + \varepsilon_{Qt}$$

preserves a stationary presentation if W_{It} and W_{St} include the same stochastic trend and parameters g_I, g_S and g_A form parameters α_0 and α_1 which provide the co-integration relation $W_{It} = \alpha_0 + \alpha_1 W_{St} + \mu_t$, i.e. $\mu_t \sim I(0)$.

Appendix II

PARAMETERS FROM CO-INTEGRATON REGRESSION

	CI_{IS}		CI_{IA}		CI_{SA}	
Country	α_0	α_1	β_0	β_1	c_0	c_1
Austria	78.05	-0.70	26.38	2.32	73.64	-3.32
Belgium	87.74	-0.84	20.35	5.10	79.64	-6.10
Denmark	63.93	-0.53	23.22	0.86	76.77	-1.86
Finland	66.96	-0.55	27.74	1.05	72.25	-2.05
France	82.10	-0.79	16.61	3.31	83.38	-4.31
Germany	90.10	-0.87	24.82	6.40	75.17	-7.40
Greece	68.32	-0.66	6.59	1.85	93.40	-2.84
Iceland	82.03	-0.89	33.71	0.20	66.78	-0.80
Italy	78.69	-0.72	23.08	2.46	76.92	-3.46
Luxemburg	89.79	-0.87	17.81	6.50	82.18	-7.50
Netherlands	86.52	-0.85	14.58	4.23	85.43	-5.23
Norway	97.71	-0.99	40.81	1.22	59.18	-0.22
Portugal	43.99	-0.21	28.84	0.25	71.15	-1.25
Spain	73.66	-0.65	23.85	1.77	76.14	-2.27
Sweden	76.86	-0.69	24.28	2.14	75.71	-3.14