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TRACING EMPIRICAL TRAILS OF SCHUMPETERIAN DEVELOPMENT*

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Abstract

Schumpeterian development is characterised by the simultaneous interplay of growth and qualitative transformations of the economic system. At the sectoral level, such qualitative transformations become manifest as variations in the sectoral composition of production. Following the implementation of Harberger's method of visualising the impact of differential productivity growth, dynamic panel estimations are applied to a standard growth model modified to include specific structural variables for both the manufacturing and the services sectors. Covering 28 countries over the period between 1990 and 2000, the results give empirical substance to the evolutionary emphasis on Schumpeterian development as opposed to mere aggregate growth.

Key Words: Structural change – economic growth – Schumpeterian development – evolutionary economics

JEL Classification: O11, O30, O41

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"*As a matter of fact, capitalist economy is not and cannot be stationary. Nor is it merely expanding in a steady manner. It is incessantly being revolutionized from within by new enterprise, i.e. by the intrusion of new commodities or new methods of production or new commercial opportunities into the industrial structure as it exists at any moment*" (Schumpeter, 1942/50, p. 31).

1. Introduction

A major source of distinction between neoclassical and evolutionary economics is that the latter replaces conventional emphasis on mere growth with the broader concept of *Schumpeterian development*, which is characterised by the simultaneous processes of growth and qualitative transformations in the economy (Schumpeter, 1911)[1]. Qualitative transformations arise as a result of the continual tension between the disequilibrating force of entrepreneurial 'creative response' and the equilibrating tendencies in terms of 'adaptive response' to such disturbances (Schumpeter, 1947)[2]. Although the central idea of endogenous technological change through creative destruction also resides prominently in the latest generation of endogenous *Schumpeterian growth* models[3], it is fair to say that these remain subdued to the restricted framework of steady state equilibrium analysis and thus bypass the more complex evolutionary dynamics of Schumpeterian development[4].

Conversely, evolutionary analysis in the tradition of Nelsen and Winter (1982) characterises the market economy as a process of continuous change and qualitative transformation. Its

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[1] Building upon the classic contribution of Nelson and Winter (1982), recent examples of evolutionary approaches to growth and development are presented e.g. in Silverberg (1988), Silverberg-Verspagen (1997), Metcalfe (2001), and Montobbio (2002). Fagerberg (1994) and Verspagen (2001) survey the empirical evidence of technological change and growth from an evolutionary perspective.

[2] Our interpretation of Schumpeterian development thus encompasses both radical and incremental changes.

[3] The Schumpeterian kind of endogenous growth models are typically characterised by innovation races, a replacement mechanism and temporary monopoly power. Examples are the models in Grossman and Helpman (1991), Aghion and Howitt (1998) or Dinopoulos and Thompson (1998). Cheng and Dinopoulos (1996) present a rare example of a multisectoral endogenous growth model, where, depending on the choice of assumptions, the steady-state equilibrium can be replaced by deterministic cycles.

[4] For example, Aghion and Howitt (1998) are very precise about the limitations of steady state analysis: "The economy is always a scaled up version of what it was years ago, and no matter how far it has developed already the prospects for future developments are always a scaled-up version of what they were years ago" (Aghion and Howitt, 1998, p. 65).

dynamics are also driven by innovation; but "[i]nnovation is a matter of differential behaviour and differential behaviour is the basis for structural change" (Metcalfe, 1998, p.37). As the fundamental diversity of micro-behaviour involves dynamics which are much richer than in steady state growth, simple aggregation cannot do away with the fact that the potential paths of development are various and depend on the idiosyncratic characteristics of an economy, among others including its sectoral composition of production. From the evolutionary perspective, structural change is therefore an inevitable companion of growth and the notion of Schumpeterian development the more relevant description of aggregate dynamics.

The importance of structural change to economic growth might prove to be the ultimate empirical test of the general relevance of the evolutionary agenda. Due to omnipresent diversity in firm behaviour and performance, most sceptics would accept that an evolutionary view offers the more realistic description and explanation of micro-economic processes. But, based on the claim that such variations only represent unsystematic noise, tied down sufficiently by the forces of gravitation towards general equilibrium, they can still insist on its overall irrelevance to the analysis of aggregate phenomena. If we are not able to demonstrate the importance of evolutionary change to aggregate development, the neo-classical reduction by means of assuming away diversity at the micro- and meso-levels can claim to be sufficiently accurate[5].

This paper will focus on the presence of variation in industrial structure as one such example of qualitative transformations and its impact on aggregate development[6]. Sequentially permeating different layers of observation, Section 2 opens with a simple illustration of the

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[5] See, for instance, Kongsamut, Rebelo, and Xie (2001) or Meckl (2002). Both papers propose a "generalized balanced growth path", where – despite the presence of differential growth at the level of disaggregated sectors – some very specific knife-edge conditions produce steady state constant growth rates in the aggregate. As a general intuition, structural change does not affect an economy's resource constraints in such models. Despite the very particular assumptions presented in the paper, Meckl (2002, p. 244) is very straightforward about his conclusion: "Our analysis indicates that as long as we are only interested in the behavior of aggregate variables, there is simply no need to disaggregate". Opposite conclusions were drawn by Echevarria (1997), who assumed differential productivity growth between sectors and presented according simulations with up to two percentage points of variation in growth rates explained by the sectoral composition of production.

[6] Recent and complementary empirical evidence for a significant link between trade specialisation in the manufacturing sector and economic growth are provided by Plumper and Graff (2001), Lewer and Van den Berg (2003), or Peneder (2003).

correlation in time between structural change and aggregate income, followed by the more demanding visualisation of Harberger's decomposition of aggregate productivity growth. Section 3 turns to econometric estimations of a macro-panel, where a standard growth model is augmented by structural variables. Section 4 provides a brief summary and concludes.

2. Visual inspections

2.1 Readily observable trails

To begin with a rather simple visualisation, the lines in Figure 1 depict developments in real GDP per capita on the vertical axis, in combination with the systematic shifts in the sectoral composition of production on the horizontal axis. Structural change is illustrated by the relative shares of particularly technology-driven manufacturing industries, classified in Peneder (2002), and the group of business related services taken from the OECD services statistics. The three marks on each line in Figure 1a refer to the years 1985, 1992 and 1999, the two marks in Figure 1b to 1992 and 1999. Since GDP p.c. grew in all European countries, the upper marks always indicate the later years.

In short, the figures reveal that the development of aggregate levels of income and structural change cannot be considered as independent processes. At the very least, we are able to observe co-movement over time, whereby GDP per capita and the shares of both industry types tend to increase. What makes the two figures particularly appealing in our context is that they encompass the typical elements of heterogeneity and selection of the evolutionary process mentioned above. First of all, even among EU countries, there is wide variety in the paths of development, with much variation in both industrial structure and GDP per capita. Secondly, since income levels, as well as industrial structure, are highly persistent, movements along the vertical and horizontal axes can easily be recognised as path dependent. Thirdly, despite the various directions taken by individual paths of development, their long run course exhibits a common (non-random) orientation. Countries are heading towards the north-eastern segments of the map, which are characterised by higher shares of technology-driven manufacturing and business-related service industries.

Figure 1a: GDP and the value added share of technology-driven industries: 1985/92/99

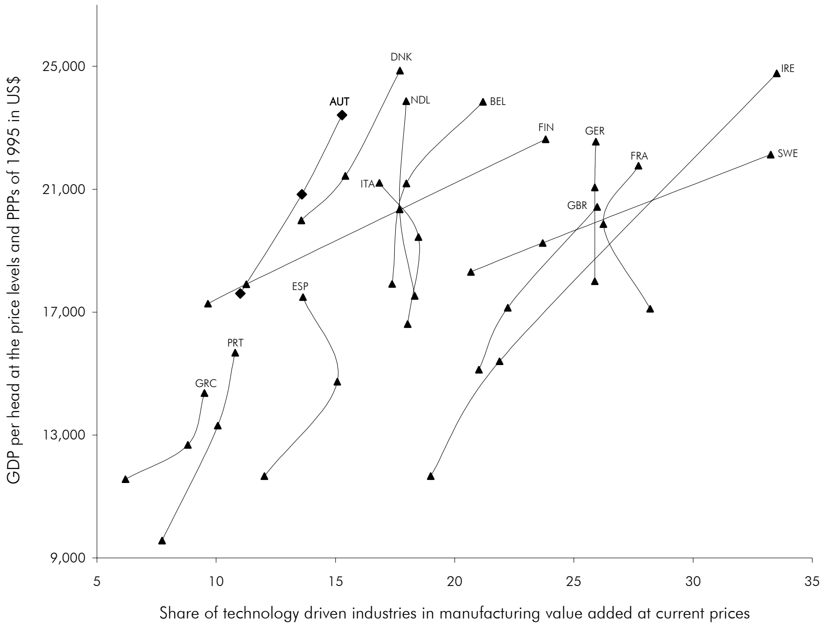
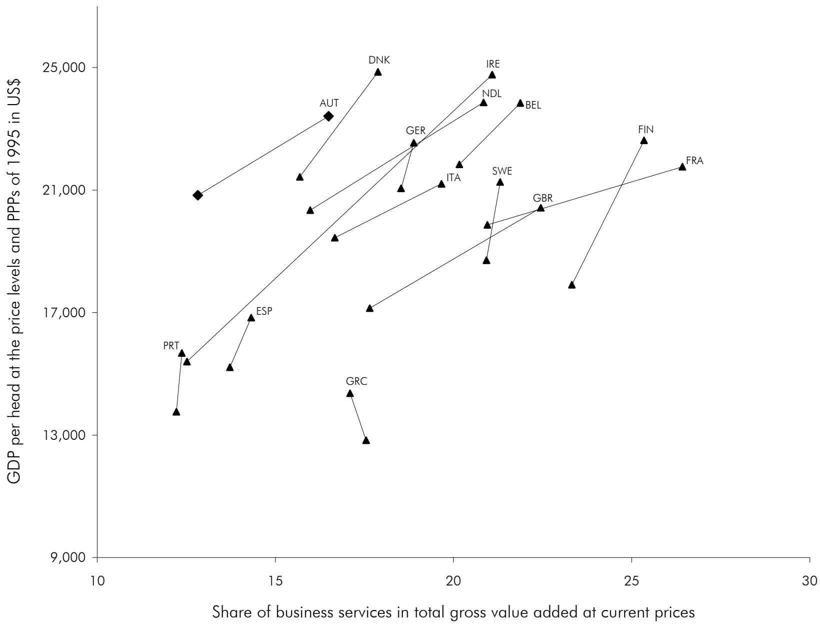


Figure 1b: GDP and the value added share of business services: 1992/99



Note: First year 1993 (Sweden); 1995 (Belgium, Greece, Portugal, Spain); final year 1998 (Spain, Sweden).

2.2 Harberger's decomposition: "mushrooms" vs. "yeasts"

At a more refined level, Arnold C. Harberger (1998) offers an attractive visualisation of what he calls the "yeast versus mushroom" issue: "The analogy with yeast and mushrooms comes from the fact that yeast causes bread to expand very evenly, like a balloon being filled with air, while mushrooms have the habit of popping up, almost overnight, in a fashion that is not easy to predict" (Harberger, 1998, p. 4). Each analogy illustrates a different mechanism in the meso-macro link of productivity growth. The yeast analogy corresponds to a vision of the growth process driven by economies of scale and broad externalities applicable to the entire economy. Conversely, the mushroom analogy refers to advances in productivity "stemming from 1001 different causes" (p. 5) and appearing in irregular, often clustered patterns, which are more prevalent in some industries than in others. This implies that within specific periods of time, productivity growth would be highly concentrated in relatively few industries, but over time the clustered appearance of productivity growth might also shift between different branches of production. Based on his empirical results, Harberger argues in favour of the \`mushroom´ analogy and ultimately relates his vision of the growth process directly to Schumpeter and his idea of \`creative destruction´.

Similar illustrations can be based upon data for manufacturing industries in the EU member countries, plus the USA. Due to the disaggregated breakdown of NACE 3-digit industries and the according data limitations, we refer only to labour productivity. This is in contrast to Harberger, who based his work on total factor productivity (TFP). Value added is measured at constant 1995 prices, using the industry-specific deflators presented in Egger and Pfaffermayr (2001).

The cumulated shares of each of *i* industries in the total value added of manufacturing in the base year (*by*) are indicated on the horizontal axis:

(1) $$CS(VA_{i,by}) = \frac{\sum_{c=1}^{i} VA_{c,by}}{VA_{tm,by}}$$

CS = cumulated shares (i.e. calculating the sum over individual industries i); VA = value added; tm = total manufacturing

The cumulated contributions of each industry *i* to the changes in aggregate labour productivity between the final year (*fy*) and the base year (*by*) of the observation period are indicated on the vertical axis:

(2) $$C\Delta(LP_i) = \frac{\sum_{c=1}^{i}(LP_{c,fy} * \frac{L_{i,fy}}{L_{tm,fy}} - LP_{c,by}\frac{L_{i,by}}{L_{tm,by}})}{LP_{tm,fy} - LP_{tm,by}}$$

CΔ = cumulated changes; LP = labour productivity; L = employment

Through straightforward substitution, this expression can be reduced to

(3) $$C\Delta(LP_i) = \frac{\sum_{c=1}^{i} VA_{i,fy} - VA_{i,by}}{VA_{tm,fy} - VA_{tm,by}}$$

CΔ = cumulated changes; LP = labour productivity; VA = value added

Before the cumulated shares can be calculated, industries must be sorted according to the ratio of their share in productivity growth and their share in the total value added of the base year. The resulting Lorenz-type curve is a visual representation of the degree of concentration with regard to the contribution of individual industries to the changes in aggregate labour productivity. Finally, we re-scale the vertical axis, so that it corresponds to the average annual growth of value added per employee for total manufacturing.

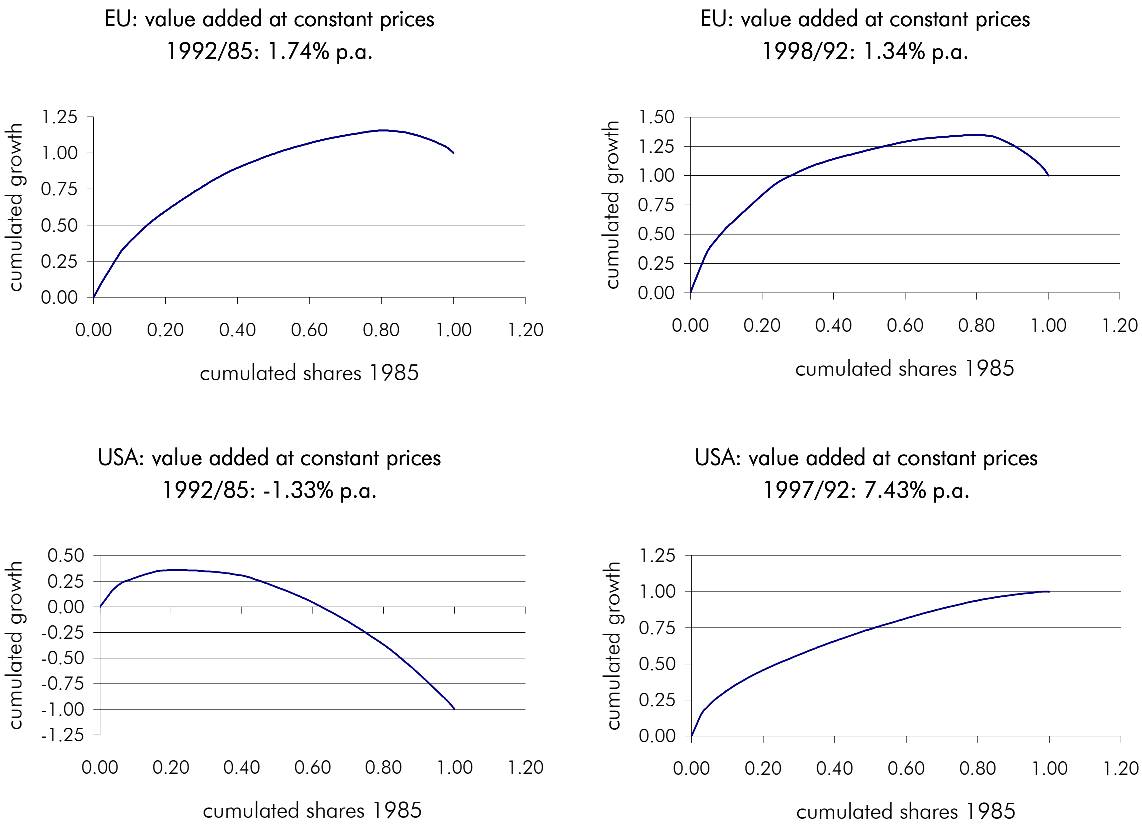
The graphs in Figure 2 and Figure A.1 in the Appendix are easy to interpret. A straight line from the origin to the end, where the cumulated shares of value added in the base year amount to unity, implies that the contribution of all industries to the aggregate growth of labour productivity was in exact proportion to their initial size. Conversely, a strong curvature of the line indicates that the contributions to aggregate productivity growth are unevenly distributed across industries, even after accounting for variations in initial size.

As the importance of structural change is easily recognisable due to the strong curvature of the lines in most of the graphs, we generally reject the yeast analogy (as did Harberger). Industries do not contribute proportionally to overall growth in labour productivity. The great variation in productivity growth among industries implies that diversity and heterogeneity at the levels of markets and industries are undeniable facts of economic development.

Beyond this initial observation, two additional features suggest a more complex Schumpeterian interpretation of industrial development:

- First, structural change itself is not a uniform process, but rather appears in clusters. The productivity growth of industries exhibits a more uniform pattern in some periods and a more varied performance in others.
- Secondly, the graphs suggest a certain tendency of structural change to be more pronounced during periods of low aggregate growth, whereas smoother developments are often evident in conjunction with larger productivity increases.

Figure 2: Contributions to the aggregate growth of labour productivity in manufacturing



The case of the USA best illustrates the latter pattern of development. The graph demonstrates that the impressive US surge in productivity throughout the New Economy boom was preceded by a phase of severe restructuring within the manufacturing sector during the period prior to 1992. Contrary to conventional wisdom, the period following 1992 was characterised by relatively smooth overall development, lacking any pronounced structural changes within the manufacturing sector[7]. Although this pattern has been much less pronounced in Europe, the last point implies the problem of a complex non-linear relationship between structural change and economic development. We should keep this in mind as a warning that even the straightforward econometric setting applied in the next section cannot fully uncover the meso-macro link in Schumpeterian development.

3. The econometric evidence

So far we have established that differential growth between industries is an undeniable empirical fact which is apparently related (be it through correlation over time or simple mechanical decomposition) to aggregate patterns of development. However, the visual inspections only suggest plausible interpretations, without making any allowances for causal inferences. In this final section, we will ask more specifically, whether the patterns of industrial specialisation and structural change have any significant impact on income levels and growth. In other words, we want to know whether qualitative transformations of the productive system, which in our case are exemplified by variations in industrial structure, have an impact on aggregate development.

The panel structure has special merits, because in traditional cross-country regressions we can only account for those determinants, which are tangible enough to enable the proper measurement of internationally comparable indicators. However, intangible factors such as knowledge, organisation, and institutions, which comprise many dimensions of social interaction that cannot be readily observed or measured, also have a decisive impact on an economy´s path of development and growth (Nelson, 1998). Taking individual country effects into consideration, the panel econometric framework enables us to control for heterogeneity in

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[7] The overall pattern invokes a Schumpeterian interpretation of creative destruction, clustered in certain periods of major technological breakthroughs and enabling productivity growth to be more evenly distributed during the phase of widespread adaptive response thereafter. It is consistent with neo-Schumpeterian views on the processes of innovation and diffusion, where, for instance, Freeman, Clark and Soete (1982), Perez (1983) or Freeman and Louca (2001) argue that technological and organizational innovations are more likely in periods of slow growth, especially in a few leading sectors. Periods of rapid growth are often characterised by a more uniform process of diffusion across other sectors as well. I am grateful to one of the anonymous referees for making that point.

those unobserved country-specific factors, which we can reasonably assume to remain constant over the period under investigation[8].

We will test for both income levels and growth. The variables used in the two models are explained in Table 2. The first will be a fixed effects panel regression (LSDV) with GDP per capita at purchasing power parities for 1995 as the dependent variable. Among the regressors, we include data on demography, the business cycle, labour markets and capital accumulation, augmented by a vector X of various structural indicators of relative specialisation patterns. Since these indicators refer to relative shares of typically fast growing industrial branches (technology driven manufacturing, total services, and business services), our specific hypothesis is that these structural indicators have a significant and positive impact, which can be due either to differential opportunities for entrepreneurial discovery and productivity growth, or positive spillovers[9]. We use time lags to keep out the opposite effect of growth on structural change via differential income elasticities of demand.

The basic model for the estimation of income levels is the following:

$$\begin{aligned} lY_{i,t} &= \alpha + \beta_1 lPOP_{i,t} + \beta_2 lPOPWA_{i,t} + \beta_3 EMR_{i,t} + \beta_4 EMR_{i,t-1} + \beta_5 lINVT_{i,t-1} + \beta_6 \Delta lINVT_{i,t} \\ &\quad + \beta_j \mathbf{X}_{i,t-1} + \eta_t + \mu_i + \varepsilon_{i,t} \end{aligned} \tag{4}$$

In the second model, we take the growth of GDP p.c. as the dependent variable. The dynamic specification requires the presence of a lagged dependent variable among the set of regressors. Correlations between the lagged dependent variable and the error term are then resolved by first differencing, which also removes the country specific fixed effects (μ_i). The following expression provides the corresponding model for our estimation of growth rates:

$$\begin{aligned} \Delta lY_{i,t} &= \alpha + \beta_1 \Delta lY_{i,t-1} + \beta_2 \Delta lPOP_{i,t} + \beta_3 \Delta lPOPWA_{i,t} + \beta_4 \Delta EMR_{i,t} + \beta_5 \Delta EMR_{i,t-1} + \beta_6 \Delta lINVT_{i,t-1} \\ &\quad + \beta_7 \Delta 2lINVT_{i,t} + \beta_{j>7} \Delta X_{i,t} + \Delta \eta_t + \Delta \varepsilon_{i,t} \end{aligned} \tag{5}$$

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[8] For a detailed discussion of the benefits and limitations of the panel framework see e.g. Baltagi (1995). The application of panel econometrics to issues of economic growth was pioneered by Islam (1995).

[9] The latter is also consistent with endogenous growth theory. For a detailed discussion of causal linkages between industrial structure and aggregate growth, see Peneder (2001, 2003).

Table 2: Denomination of the variables

Label	Description
	Dependent variable
Aggregate level of income	
$lY_{i,t}$	GDP per capita at PPPs of 1995 (logarithm)
Aggregate growth	
$\Delta\ lY_{i,t}$	Growth of $Y_{i.t}$
	General explanatory variables (Macro-level)
Catching up	
$\Delta\ lY_{i,t-1}$	Lagged dependent variable in the growth estimation
Demography	
lPOP	Total population (logarithm)
Δ lPOPWA	Growth of POP
lPOPWA	Population at working age (logarithm)
Δ lPOPWA	Growth of POPWA
Business cycle / labour markets	
EMR	Employment rate ('national business cycle' effects)
Δ EMR	First differences of EMR
$EMR_{(t-1)}$	Lagged employment rate ('tightness of labour market')
$\Delta\ EMR_{(t-1)}$	First differences of $EMR_{(t-1)}$
η_t	Time trend ('global business cycle' effects)
Capital accumulation	
$lINVT_{(t-1)}$	Lagged gross fixed capital investment (logarithm)
Δ lINVT	Growth of INVT
$\Delta\ lINVT_{(t-1)}$	Lagged growth of INVT
Δ2 lINVT	Second differences of lINVT
	Structural explanatory variables (Meso-level)
Manufacturing	
$XSR\_tdi_{(t-1)}$	Lagged share of technology driven industries in total exports relative to OECD
Δ XSR_tdi	First differences of XSR_tdi
$\Delta\ XSR\_tdi_{(t-1)}$	Lagged first differences of XSR_tdi
Δ2 XSR_tdi	Second differences of XSR_tdi
$MSR\_tdi_{(t-1)}$	Lagged share of technology driven industries in total imports relative to OECD
Services	
$SOTS_{(t-1)}$	Lagged share of total services in gross value added (at current prices)
$\Delta\ SOTS_{(t-1)}$	Lagged first differences of SOTS
Δ2 SOTS	Second differences of SOTS
$SOBS_{(t-1)}$	Lagged share of business services in gross value added (at current prices)
$\Delta\ SOBS_{(t-1)}$	Lagged first differences of SOBS
Δ2 SOBS	Second differences of SOBS

Data sources: OECD (ECO) for the dependent and the general explanatory variables; UNO (COMTRADE) for structural variables on manufacturing; OECD (Services statistics) for structural variables on services.

For the dynamic specification, we apply the *generalized method of moments* (GMM) estimator developed by Arellano and Bond (1991), who resolved the correlation between the differenced dependent variable and the transformed error term by means of an extensive instrument matrix[10]. We calculate both the one-step and two-step GMM estimators, which should be asymptotically equivalent, if the error terms are independent and homoscedastic across countries and over time (Arellano and Bond, 1991, p. 279). In our calculations, the coefficients are indeed very similar, but the one-step estimations are considerably less favourable in terms of the statistical significance of the individual variables. The major source of this problem seems to be the heteroscedasticity of the error term. Since we only present the two-stage results in Table 4, we should keep in mind this caveat regarding the robustness of our findings. A critical assumption for the validity of Arellano-Bond GMM estimator is the lack of second order serial correlation. The test results (A-B(2)) are reported at the bottom of Table 4. The estimates are inconsistent when the null hypothesis of no second order autocorrelation in the first-differenced residuals is rejected at a significant level[11].

The regressors are divided into two groups of general and structural explanatory variables. The first refer only to the macro-level and together comprise the baseline specification, in which no structural factors are included. Among them, we find demography (total population and population at working age), capital accumulation (lagged levels and growth in gross fixed capital investment) and those variables which were primarily intended to control for business cycle effects. Whereas the overall time trend (dummies for individual years) captures the influence of the global business cycle, we use the employment rate as the best available proxy

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[10] Method of Moments techniques estimate the unknown parameters by matching theoretical moments with the appropriate sample moments, generally relying on less restrictive assumptions than the more traditional econometric modelling approaches. The GMM estimator is used when parameters are over-identified by the moment conditions. For more information, e.g. about the asymptotic consistency and efficiency of GMM techniques, see Mátyas (1999).

[11] The Wald test of the null hypothesis that all the coefficients except the constant are zero is rejected in every specification and is not reported separately. However, the Sargan test of the validity of the restrictions concerning over-identifying restrictions reveals extreme discrepancies in the one-step and two-step estimators under the assumption of homoscedastic error terms, always rejecting when the former, but never when the latter is applied. This also indicates the aforementioned problems of heteroscedasticity (see also Arellano-Bond, 1991, p. 287).

to control for the influence of national business cycles. Additionally, the lagged rate of employment is applied as an indication of the relative tightness of the labour market[12].

The second set of structural variables is again divided into two groups of measures, namely one for relative specialisation in a specific type of manufacturing and one for service industries. The first refers to particularly technology driven industries, a group which was classified in Peneder (2002). Calculating export and import shares relative to the OECD, an overall time trend was eliminated right from the beginning. The second consists of the share of total services in gross value added as a broad measure of tertiarisation, as well as the respective share of business services. Due to limited data availability, business services are comprised of ISIC codes 70 to 74 (including real estate). Because of the many missing values, no reliable global benchmark could be constructed, and the overall time trend has to be captured by the year dummies.

The analysis is based upon a data panel comprising i = 28 OECD countries[13], covering the years 1990 to 2000. The OECD ECO database was the source of data on GDP, populations, employment, and capital investment. Value added shares in the services sector were extracted from OECD (2001). All other structural variables stem from the UN COMTRADE database.

The estimations for aggregate income levels are reported in Table 3, while those on aggregate growth are presented in Table 4. The basic specification excludes all structural variables and is consistent with prior expectations based on general considerations found in the growth literature. *Ceteris paribus* GDP per capita must fall with the size of the population, whereas the size of the population at working age has a positive impact. The employment rate is pro-cyclical and the respective coefficient therefore positive. Finally, both the lagged levels and growth of capital investment foster per capita income. The only variable which fails to be significant is the lagged employment rate in the fixed effects panel regression, although it is nevertheless retained in the model, thanks to its significant (negative) impact in the other

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[12] Research and development expenditures are not included for lack of equally comparable time series in many of the OECD countries included in the regressions.

[13] The selection of countries reflects the availability of data for the variables listed in Table 2 in the OECD national accounts data base. The sample exceeds the one used for Harberger's visualisation, because the latter relied on a more demanding disaggregation of production statistics at the 3-digit level.

specifications augmented by the structural indicators. The lagged dependent variable in the dynamic estimations is significant and positive, thereby controlling for 'catching up' effects.

Table 3: Fixed effects panel regression of Log GDP p.c.: 1990 to 2000

Dependent variable: $lY_{i,t}$	**I** β(t)	**II** β(t)	**III** β(t)	**IV** β(t)	**V** β(t)	**VI** β(t)
lPOP	-2.2779***	-1.9243***	- 2.1282***	-2.4481***	-2.4447***	-1.7657***
	(- 8.87)	(-6.74)	(-7.22)	(-7.61)	(-7.58)	(-5.34)
lPOPWA	1.6155***	1.4541***	1.5270***	1.8087***	1.8058***	1.3988***
	(8.15)	(6.83)	(6.79)	(7.49)	(7.46)	(5.80)
EMR	0.5963***	0.7161***	0.8496***	1.0225***	1.0157***	0.6487**
	(3.97)	(3.26)	(3.58)	(4.01)	(3.97)	(2.59)
$EMR_{(t-1)}$	-0.1088	-0.4156*	-0.5819**	-0.7290**	-0.7084**	-0.4657*
	(-1.00)	(-1.71)	(-2.16)	(-2.54)	(-2.43)	(-1.68)
$lINVT_{(t-1)}$	0.2126***	0.2146***	0.2361***	0.2248***	0.2230***	0.2216***
	(8.57)	(7.88)	(7.73)	(7.18)	(7.03)	(7.44)
Δ lINVT	0.2112***	0.1588***	0.1658***	0.1457***	0.1452***	0.1707***
	(8.43)	(4.80)	(4.58)	(3.95)	(3.93)	(4.89)
$XSR\_tdi_{(t-1)}$		0.0636***				0.0720***
		(3.47)				(3.72)
Δ XSR_tdi		0.0005				
		(0.02)				
$MSR\_tdi_{(t-1)}$		0.1187***				0.1193***
		(3.95)				(3.64)
$SOTS_{(t-1)}$			0.0009		-0,0006	-0.0024*
			(0.68)		(-0.42)	(-1.84)
$SOBS_{(t-1)}$				0.8646***	0.8938***	0.8788***
				(4.18)	(4.09)	(4.23)
Year dummies (η_t)	Yes	Yes	Yes	Yes	Yes	Yes
No. observations	330	272	255	231	231	231
No. countries	29	29	29	29	29	29
R-sq within:	0.9006	0.9212	0.9158	0.9197	0.9198	0.9306

Note: GDP at PPP of 1995; XSR = shares in total exports relative to OECD; MSR = shares in total imports relative to OECD; tdi = technology driven industries; hs = high skill industries.

Table 4: Dynamic panel regression of growth in GDP per capita: 1990 to 2000

Dependant variable : Δ $lY_{i,t}$	**I** β(t)	**II** β(t)	**III** β(t)	**IV** β(t)	**V** β(t)
Δ lY $_{(t-1)}$	0.7166***	0.6632***	0.5751***	0.4549***	0.7100***
	(9.95)	(7.87)	(4.93)	(6.49)	(6.07)
Δ lPOP	- 0.8071***	- 0.8208***	0.0188	- 0.4762**	0.1257
	(- 5.18)	(-2.92)	(0.05)	(-2.50)	(0.37)
Δ lPOPWA	0.4477***	0.6635***	-0.0909	0.4725***	-0.2889
	(3.57)	(2.91)	(-0.24)	(3.08)	(-0.94)
Δ EMR	0.4071***	0.3632***	0.5992***	0.4054***	0.2038
	(3.16)	(3.43)	(3.04)	(3.63)	(1.41)
Δ EMR $_{(t-1)}$	- 0.3453*	- 0.4212	-0.9123***	- 0.8143***	-0.2768
	(- 1.96)	(- 1.53)	(-2.78)	(-4.75)	(-0.98)
Δ lINVT $_{(t-1)}$	0.0495***	0.0579	0.1386***	0.1666***	0.0849***
	(3.65)	(1.60)	(2.80)	(6.09)	(4.92)
$\Delta2$ lINVT	0.1965***	0.1816***	0.2125***	0.2127***	0.2547***
	(19.79)	(14.14)	(16.40)	(18.01)	(21.47)
Δ XSR_tdi $_{(t-1)}$		0.0258***			
		(3.12)			
$\Delta2$ XSR_tdi		0.0405***			
		(4.88)			
MSR_tdi $_{(t-1)}$		0.0049***			
		(2.60)			
SOTS $_{(t-1)}$			-0.0003*		-0.0004**
			(-1.91)		(-2.46)
$\Delta2$ SOTS			-0.0023***		-0.0037***
			(-4.56)		(-13.36)
Δ SOBS $_{(t-1)}$				0.8827***	0.5674**
				(3.21)	(2.07)
$\Delta2$ SOBS				0.5269*	0.3432**
				(1.76)	(2.25)
Year dummies (η_t)	Yes	Yes	Yes	Yes	Yes
No. observations	275	242	197	173	173
No. Countries	29	29	28	28	28
A-B test (2)	0.1720	0.9365	0.9033	0.7162	0.6621

Note (1): GDP at PPP of 1995; Δ var = variable in first differences; Δvar_{t-1} =.. lagged differences; $\Delta2$var = .. second differences; XSR (MSR) = shares in total exports (imports) relative to OECD; tdi = technology driven industries; hs =high skill industries.
Note (2): Time dummies were only used for 1992, 1994, 1995, 1998, and 1999, which were selected because of being significant in the base model of specification I and in order to avoid second order serial correlation in A-B test (2).
Note (3): MSR_tdi(t-1) and SOTS(t-1) were introduced as strictly exogenous variables without first differencing.

In a world of Schumpeterian development, we expect that, in addition to all these factors, aggregate income and growth cannot remain totally unaffected by the specific production structure of the economy. This proposition is in sharp contrast to the conventional neo-classical growth models, in which (due to their purely macroeconomic focus) industrial structure has no role to play. Augmenting the basic model with selected structural variables, we find ample evidence of its significant impact in Tables 3 and 4. With regard to the manufacturing sector, both the relative export and import shares of technology driven industries matter. While the first can be explained by differential growth, as well as producer related externalities, the second finding clearly indicates the presence of user related spillovers in this type of industry. With respect to services, an interesting differentiation also surfaces. The share of total services in overall value added is insignificant in the regression on income levels, but is significantly negative in the growth equations. Taken on its own, this result is largely consistent with Baumol's cost disease argument[14]. Services, however, comprise an extremely heterogeneous sector, which requires further differentiation (Peneder, Kaniovski and Dachs, 2003). For instance, if we focus on the value added share of business services, a reversed image emerges with significant positive coefficients. This pattern of a negative impact exerted by the share of total services, contrasted by a positive coefficient for business services, also persists when both kinds of structural variables are included.

In conclusion, the econometric evidence convincingly demonstrates that variations in industrial structure have a significant impact on aggregate development and thus substantiates our concern for the meso-macro link in economic development. But in closing this section, we should also emphasise the weaknesses of the analysis. Besides the aforementioned econometric problems with the dynamic model, we must acknowledge that the interpretation of the structural effects is not as straightforward and precise as we might wish. Remember that we have not been able to capture the more complex time patterns of creative destruction suggested in some of the Harberger visualisations. But also with respect to the structural effects, which were actually identified, we face the problem of multiple alternative explanations.

[14] It predicts a decrease in overall growth due to rising shares of relatively stagnant service industries (Baumol, 1967; Baumol et al. 1985).

In a straightforward evolutionary interpretation, it is tempting to treat structural effects as a result of the direct impact of differential growth. Some industries tend to expand faster and achieve higher growth in labour productivity than others. Assuming an under-utilisation of productive resources, the greater specialisation of a country in industries of this type enhances its prospects for aggregate growth. Secondly, industries might differ in their propensities to generate positive externalities to the rest of the economy. For instance, producer related spillovers may stem from the enhanced knowledge diffusion of technologically sophisticated production within a relatively small area. Similarly, user related spillovers may stem from new technology which is embodied in capital goods. Although not at odds with an evolutionary interpretation, this explanation is at the same time consistent with the steady state endogenous growth models. Thirdly, variations in sectoral specialisation might capture correlations with certain intangible and location bound factors of competitive capabilities (e.g. the aggregate R&D ratio, the national innovation system, or other institutional factors for which sufficiently comparable data was not available), which are not constant over time and therefore have not been eliminated by the country dummies or first differences.

4. Summary and conclusions

This paper opened under the presumption that Schumpeterian *development* is characterised by the simultaneous interplay of growth and the qualitative transformation of the economic system. At the sectoral level, such qualitative transformations become manifest as variations in the sectoral composition of production, i.e. structural change. In contrast to Schumpeter's broader notion of development, theories of economic growth tend to focus exclusively on macroeconomic phenomena. For the sake of analytic tractability and clear identification of the steady state equilibrium solutions, the meso-level of industrial structure is bypassed by the assumption of balanced steady-state growth, uniformly spread across all industries.

We presented an empirical validation of this evolutionary emphasis on Schumpeterian development, focusing on variations in industrial structure and its impact on aggregate income and growth. We traversed three different layers of visibility. Within the first layer of easily recognisable trails, an apparent co-movement in time involving aggregate income and certain selected types of industry motivated our further investigations. In the second layer, the application of Harberger's visualisation not only demonstrated that differential productivity growth is an undeniable fact, but also revealed some interesting time patterns in its relationship to aggregate development. Specifically, the boom in the U.S. New Economy in the late 1990s, preceded by a phase of painful but creative destruction in the years prior to 1992, invites a very Schumpeterian interpretation. In the final layer, (dynamic) panel estimations of a standard empirical growth model augmented by various structural variables for 28 OECD countries during the period 1990 to 2000, revealed that variations in industrial structure do have a significant impact on both aggregate income levels and growth. While (consistent with Baumol's cost disease argument) the share of the services sector in total value added exerted a negative influence, the coefficients for the value added share of business services and the export shares of particularly technology driven manufacturing industries were positive and significant. Potential explanations range from differential growth between industries to their different propensities to generate producer-related spillovers. For technology-driven industries, we additionally found a positive impact of relative import shares, indicating the presence of user-related spillovers from embodied technology flows.

The essential message of this study is that variations in industrial structure are significant determinants of aggregate income levels and growth. The empirical evidence thus substantiates the evolutionary emphasis on Schumpeterian *development*, which in addition to the endogeneity of innovation in Schumpeterian *growth* models, comprises growth and structural change as two inseparable elements.

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APPENDIX

Figure A.1: Harberger's visualisation for individual EU countries

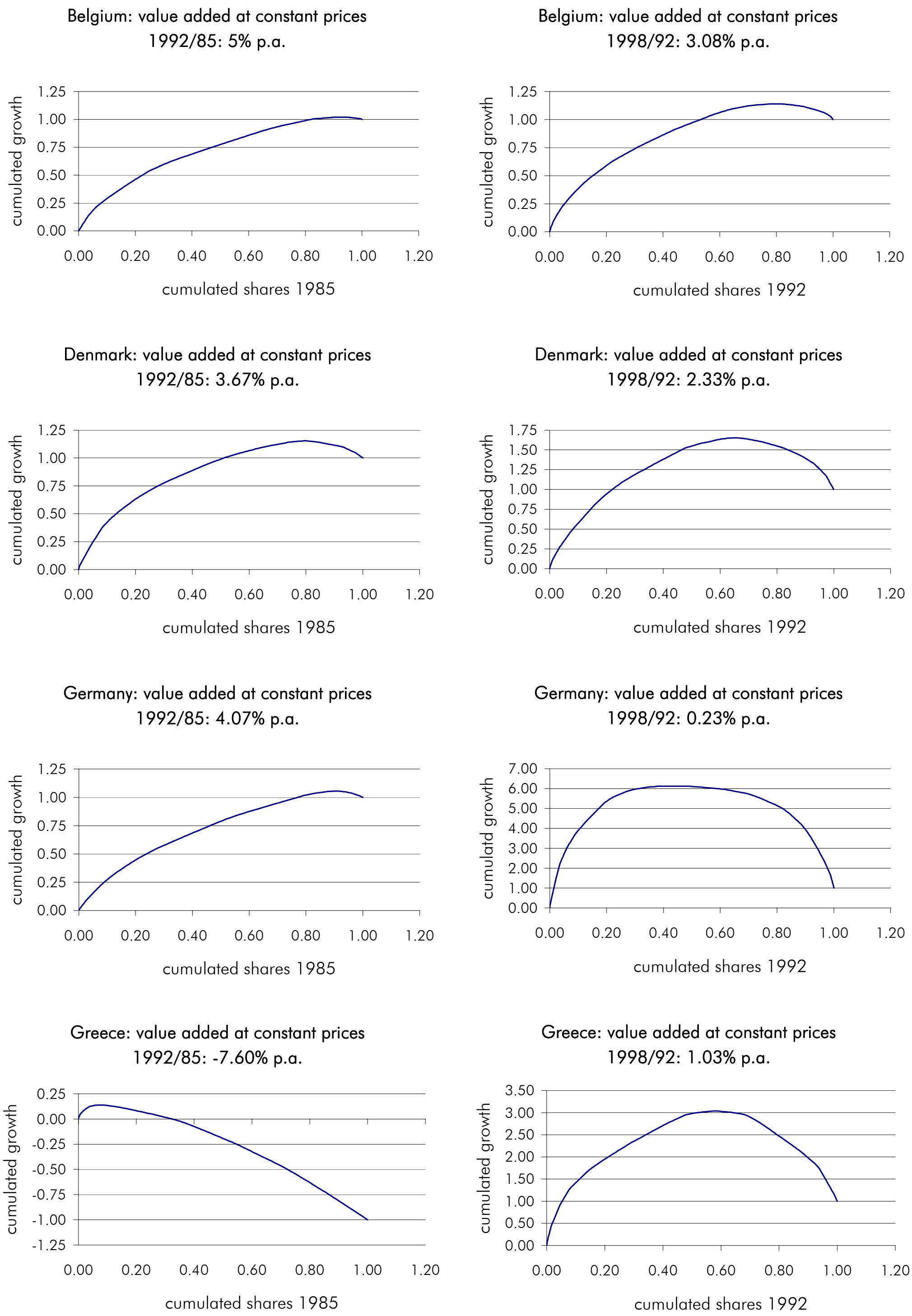
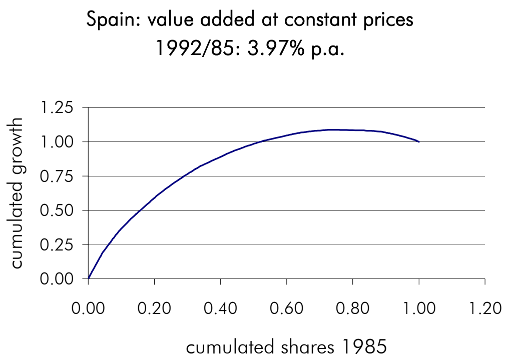
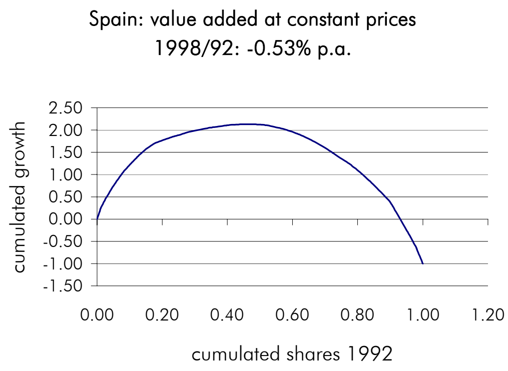
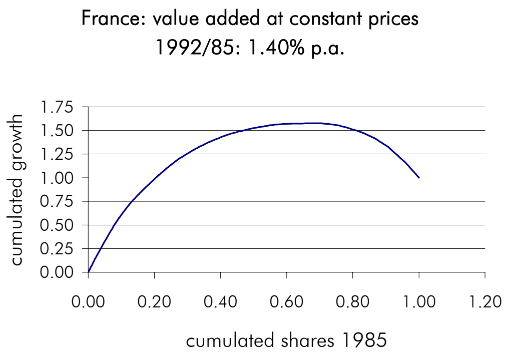
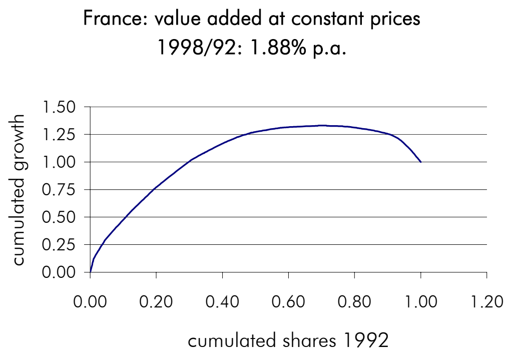


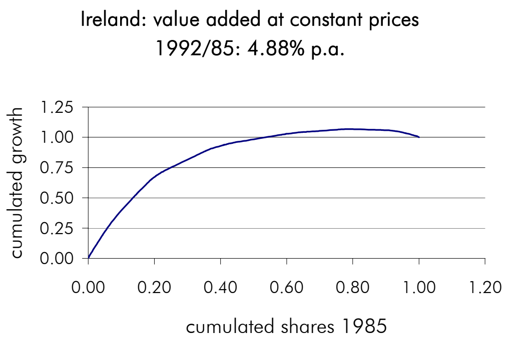
Figure A.1: Harberger's visualisation for individual EU countries (continued)

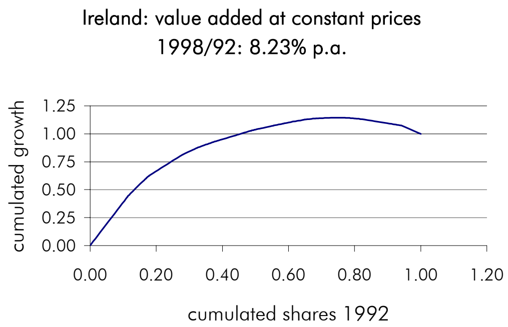


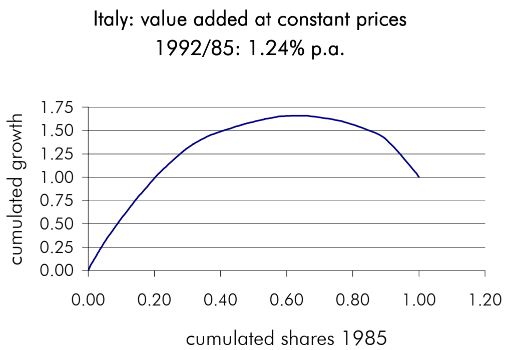


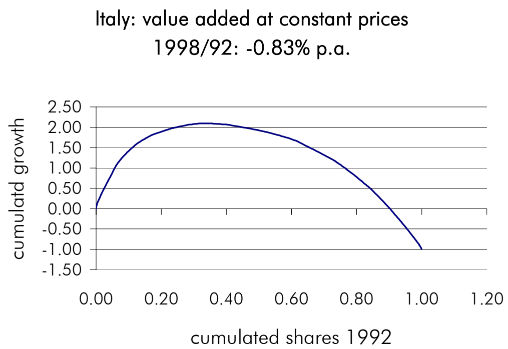












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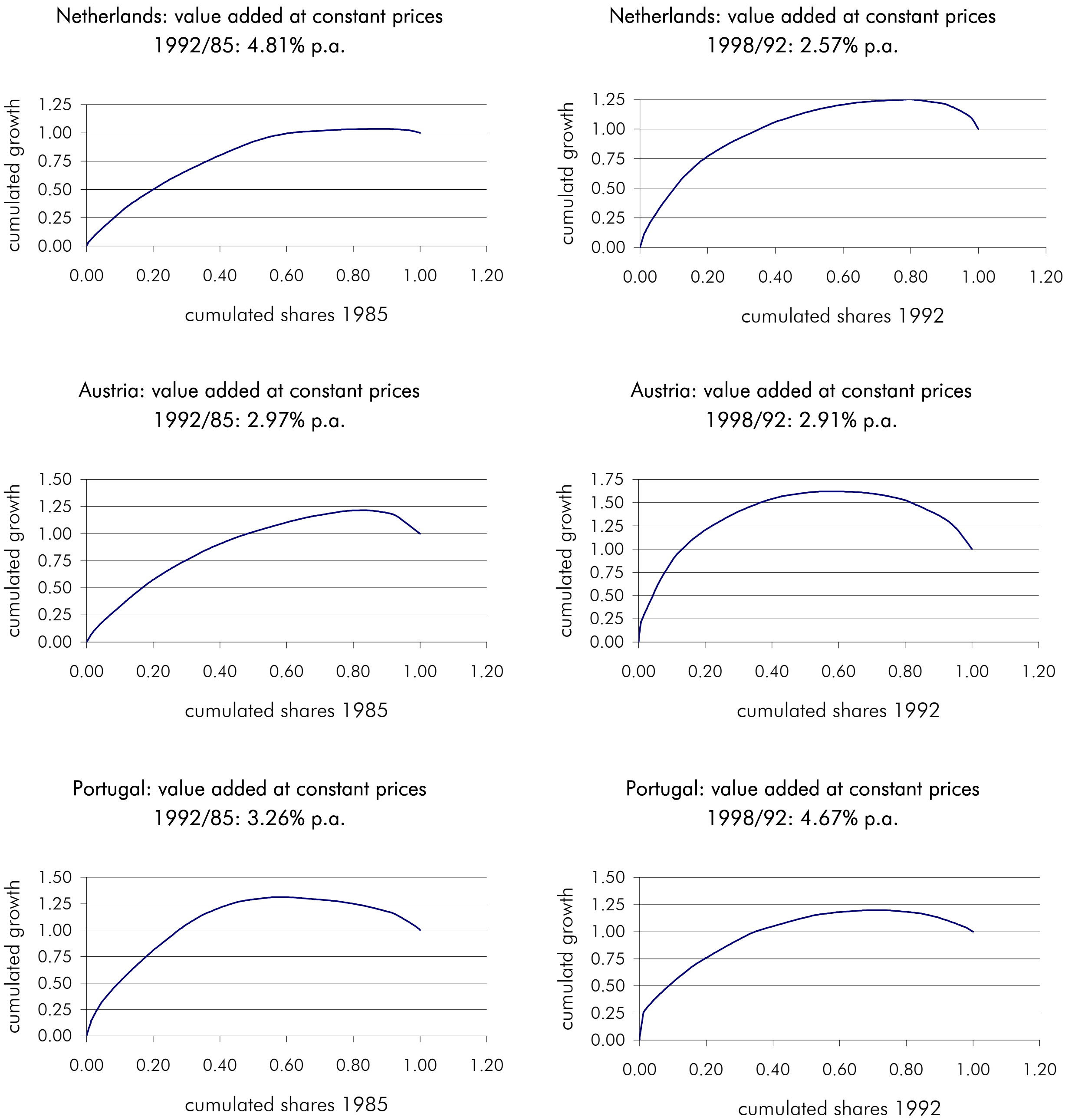
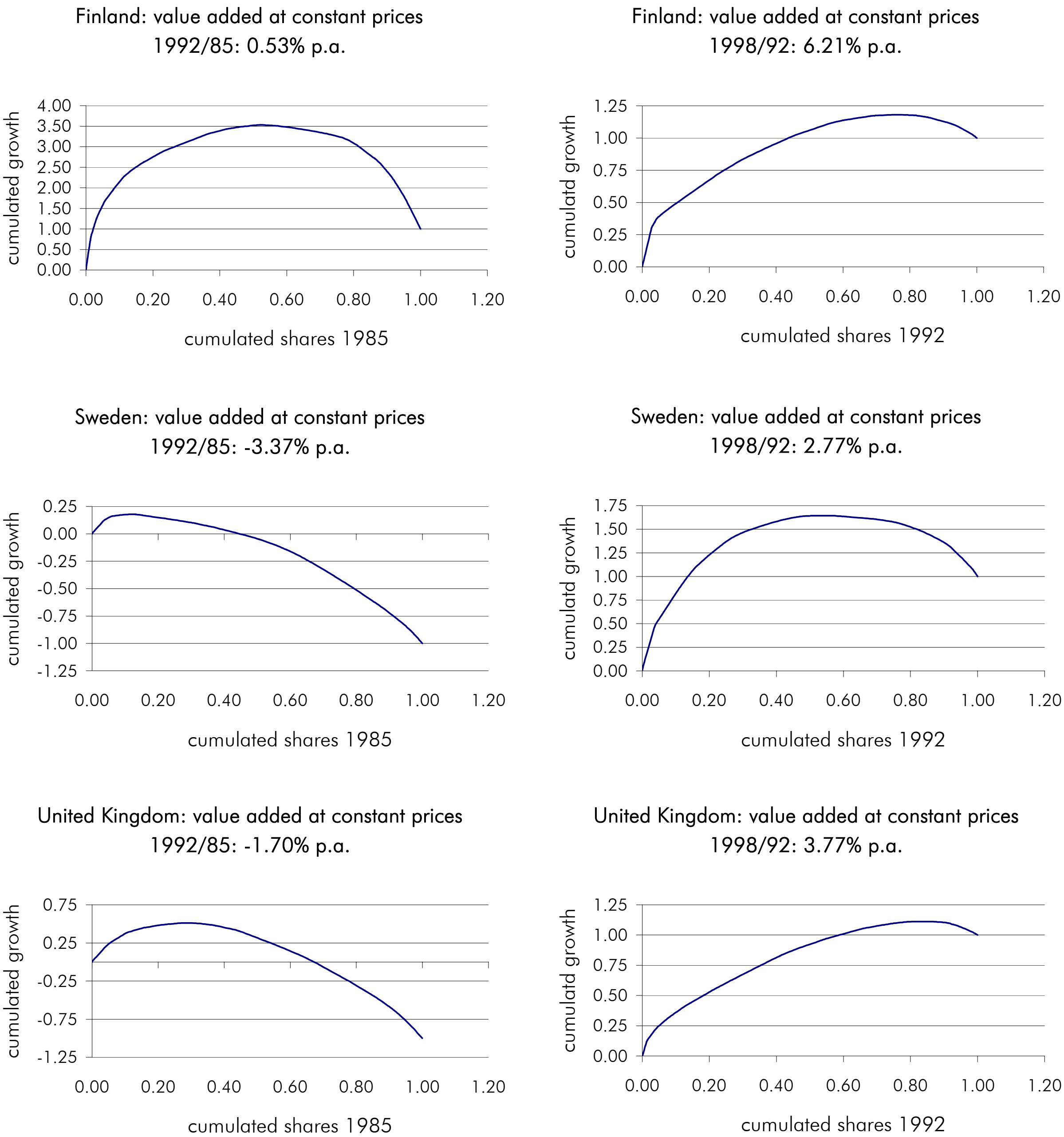


Figure A.1: Harberger's visualisation for individual EU countries (continued)



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