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Zentrum für Europäische Integrationsforschung
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Ronald L. Moomaw, Euy Seok Yang

Total Factor Productivity and Economic Freedom Implications for EU Enlargement

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Total Factor Productivity and Economic Freedom
Implications for EU Enlargement

Ronald L. Moomaw*
Department of Economics
Oklahoma State University

Euy-Seok Yang
Korean Energy Institute

*This paper was written in part while Moomaw was a Senior Fellow at the Center for European Integration Studies (ZEI), University of Bonn.

Total Factor Productivity and Economic Freedom
Implications for EU Enlargement

The ongoing enlargement of the European Union (EU), expanding from the initial 6 to 15 and now to 25 members with more in the wings, is at the frontier of economic and political integration. Political and economic stumbling blocks have been hurdled, but the larger number of countries and greater economic and political disparities make the process more and more difficult. In this chapter, we consider the existing disparities in economic freedom among the 25 EU countries and the evolution of total factor productivity (TFP) in the manufacturing sectors of a selected group of OECD countries, some of which were members of the EU during the period studied. We are interested both in TFP convergence and in the relationships between TFP and economic freedom.

We first use the methodology of Bernard and Jones (1996) to test for TFP convergence in the manufacturing sector and in nine disaggregated manufacturing industries in 12 OECD countries. TFP convergence at the aggregate level, at least, among countries in the EU is important for the EU's goals related to political and social cohesion. Convergence is necessary for cohesion because it implies that all countries in the union can have strong economies, while outcome diversity diminishes. Although neoclassical economics suggests that convergence is to be expected, increasing returns, in its new economic geography clothes or in its older versions, among other phenomena may yield divergence.

In a recent paper, Freeman (2002) evaluates and uses the Fraser Institute's economic freedom index (Gwartney et al. 2003) to test for differences in economic performance among OECD countries that may result from institutional differences. He concludes that the index is correlated reasonably well in the expected direction with other measures of economic freedom and with more specific measures of labor market flexibility, product market regulation, and barriers to entrepreneurial activity. Thus, the index provides a summary measure of institutional considerations associated with economic freedom. It is particularly valuable for his purposes (and ours) because it is available, starting with 1970, in five-year increments, thus permitting construction of a cross-section, time-series panel. Freeman uses panel estimators, controlling for time and country fixed effects, to estimate the association between economic freedom and economic performance. He and others find such an association, without and *with* time and

country effects, if the countries sampled have large variations in economic performance and economic freedom. If the country observations consist only of OECD countries, however, Freeman concludes that variation in the Fraser index of economic freedom is not associated with variations in economic performance. He suggests that this result occurs because OECD countries have reached a threshold of basic market freedoms necessary for advanced capitalism. Once reached, he concludes, countries can have a variety of economic institutions that cause differences in the freedom index without associated differences in performance.

The current enlargement of the EU, however, includes countries that are moving toward but may not have reached this threshold of basic market freedoms. If the EU is going to become a single market, these countries can be expected to change their institutions in ways that increase their economic freedom indices. What will be the effect, if any, of these institutional changes on the level and evolution of TFP? We believe that we can provide information pertinent to this question by examining countries that have traveled a similar path. Unlike Freeman, we find that variation in economic freedom among a selection of OECD countries is positively associated with variation in economic performance.

To pursue these arguments, it is first necessary to examine the Fraser index for OECD countries, current EU countries, and the accession countries. We will then describe our data and its construction, followed by a test of TFP convergence. Finally, we will bring the Institute's freedom index into the analysis of TFP.

Economic Freedom, the EU, and the OECD

According to its developers, the Fraser index (Gwartney et al., 2003) is derived assuming that "the key ingredients of economic freedom are personal choice, voluntary exchange, freedom to compete, and protection of person and property." In addition to what Freeman (2002) calls "a strong tradition of basic market freedoms—protection of property, rule of law, private ownership rights, viability of contracts, etc.—" the Fraser index emphasizes personal choice and voluntary exchange. It considers size of government, freedom to compete, and access to a stable currency of the same level of importance as property rights, individual markets, or international openness in measuring economic freedom. It presumes that a large government sector, for instance, is associated with less economic freedom because it implies collective, rather than individual,

choice rules over a larger sector of the economy. This is one the distinctive differences between the "Anglo-American" economic system and the "Social-Market" system of Continental Europe. Table 1 gives the Fraser index for each of the 12 OECD countries in our data set and for other relevant groups of countries. As seen in Panel A, beginning in 1975 the average index for the 12 countries increased steadily until 2001. The increase in the index from 1980 to 1990, however, is substantially greater than the increase from 1990 to 2000. Examining the individual countries, we see the remarkable convergence and steady country by country increase in the index noted by Freeman. Comparing the Anglo countries in Panel B (Canada, the United Kingdom, and the United States) with the Social-Market countries in Panel C that were in the original European trade associations (Belgium, France, Italy, and the Netherlands), we see that both sets of countries experienced increases in economic freedom, beginning in 1975. The Anglo countries, however, had greater average economic freedom in 1975 (6.5 compared to 5.9) and 2001 (8.2 compared to 7.2). Although it is risky to talk about a trend with so few observations, the data hints that both groups of countries have reached a local peak in their indices, with the Anglo countries experiencing greater economic freedom than the Social-Market countries.

The average value for the first nine countries in the EU is also shown in Table 1, Panel D. From 1980 to 1995 it increased from 6.2 to 7.3 with little apparent change from 1995 to 2000 or 2001. Since the early 1970s, six countries have joined the EU. Although we do not know the extent to which their prospective membership in the EU influenced their institutional change, the average index for these countries, as seen in Panel E, increased steadily from 5.3 in 1975 to 7.3 in 2000. The similarity between the average for these earlier accession countries and the current accession countries (the 10 approved countries plus Bulgaria, Romania, and Turkey) in Panel F lagged 20 years is remarkable. The average for the latter countries in 1995 was 5.3 and it had risen to 6.1 by 2000. Twenty years earlier, the average for the original six was 5.3 and it had risen to 5.9 by 1980. These trends may suggest that these new accession countries will continue institutional change that results in larger measured economic freedom, just as happened for the earlier accession group.

Table 1: Economic Freedom Indices for Selected Countries

Title and footnote for the table on the next page.

Source: The Fraser Institute indices were taken from Gwartney et al. (2003)

	Scores							
Countries	1970	1975	1980	1985	1990	1995	2000	2001
Panel A								
Countries Considered								
Austria	6.1	5.8	6.2	6.3	6.9	7	7.4	7.5
Belgium	7.3	6.6	6.9	6.9	7.3	7.2	7.4	7.4
Canada	7.4	6.6	7	7.1	7.7	7.8	8.1	8
Finland	6.7	5.8	6.4	6.6	7.1	7.3	7.6	7.7
France	6.2	5.5	5.7	5.8	6.9	6.8	7	6.7
United Kingdom	5.9	5.7	6.1	6.9	7.7	8.1	8.3	8.3
Italy	5.8	5.1	5.2	5.5	6.4	6.5	7.1	7
South Korea	5.1	5.1	5.4	5.5	6	6.5	7	7.1
Netherlands	7.1	6.4	6.9	7.1	7.5	7.8	8	7.8
Norway	5.9	5.4	5.7	6.2	6.9	7.4	7.2	7.1
Sweden	5.6	5.2	5.6	6.2	6.7	7.2	7.4	7.2
United States	7	7.1	7.4	7.5	8.2	8.3	8.5	8.3
Average	**6.3**	**5.9**	**6.2**	**6.5**	**7.1**	**7.3**	**7.6**	**7.6**
Panel B								
Anglo-American								
Canada	7.4	6.6	7	7.1	7.7	7.8	8.1	8
United Kingdom	5.9	5.7	6.1	6.9	7.7	8.1	8.3	8.3
United States	7	7.1	7.4	7.5	8.2	8.3	8.5	8.3
Average	**6.8**	**6.5**	**6.8**	**7.2**	**7.8**	**8.1**	**8.3**	**8.2**
Panel C								
Social-Market								
Belgium	7.3	6.6	6.9	6.9	7.3	7.2	7.4	7.4
France	6.2	5.5	5.7	5.8	6.9	6.8	7	6.7
Italy	5.8	5.1	5.2	5.5	6.4	6.5	7.1	7
Netherlands	7.1	6.4	6.9	7.1	7.5	7.8	8	7.8
Average	**6.6**	**5.9**	**6.2**	**6.3**	**7**	**7.1**	**7.4**	**7.2**

Countries	1970	1975	1980	1985	1990	1995	2000	2001
Panel D								
EU-9								
Belgium	7.3	6.6	6.9	6.9	7.3	7.2	7.4	7.4
Denmark	6.6	5.9	6.1	6.2	7	7.4	7.6	7.6
France	6.2	5.5	5.7	5.8	6.9	6.8	7	6.7
Germany	7.3	6.8	7.1	7.2	7.5	7.5	7.6	7.3
Ireland	6.5	5.8	6.2	6.2	7.1	8.2	8.1	8
Italy	5.8	5.1	5.2	5.5	6.4	6.5	7.1	7
Luxembourg	7	7	6.8	7.2	7.5	7.5	7.7	7.6
Netherlands	7.1	6.4	6.9	7.1	7.5	7.8	8	7.8
United Kingdom	5.9	5.7	6.1	6.9	7.7	8.1	8.3	8.3
Average	**6.6**	**6**	**6.2**	**6.4**	**7.1**	**7.3**	**7.5**	**7.4**
Panel E								
Earlier Accession								
Austria	6.1	5.8	6.2	6.3	6.9	7	7.4	7.5
Finland	6.7	5.8	6.4	6.6	7.1	7.3	7.6	7.7
Greece	6.2	5.7	5.5	5.2	5.8	6.3	6.8	6.7
Portugal	6	3.8	5.6	5.4	6.1	7.3	7.3	7.2
Spain	6.2	5.5	5.7	5.9	6.3	7	7.3	7
Sweden	5.6	5.2	5.6	6.2	6.7	7.2	7.4	7.2
Average	**6.1**	**5.3**	**5.9**	**5.9**	**6.5**	**7**	**7.3**	**7.2**
Panel F								
Current Accession								
Bulgaria				4.5	3.5	4.2	5.3	5.2
Cyprus		5.4	5.3	5.3	5.9	6.1	6.1	6.3
Czech Rep.						5.8	6.8	6.8
Estonia						5.4	6.9	7.4
Hungary			4.2	5	4.9	6.3	6.6	6.9
Latvia						4.6	6.5	6.6
Lithuania						4.7	6.2	6.2
Malta			5.1	4.9	5.3	6.6	6.4	6.4
Poland				3.8	3.6	5.3	5.8	6
Romania				4.7	4.2	3.7	4.6	4.6
Slovak Rep						5.3	6.1	6
Slovenia						4.7	5.9	5.9
Turkey	3.5	3.8	3.5	4.7	4.8	5.7	5.8	5.3
Average						**5.3**	**6.1**	**6.1**

TFP Convergence in Manufacturing in Selected Countries: 1980 to 1998

Productivity comparisons across countries and over time are difficult for many of the same reasons that comparisons of productivity level and growth are difficult within a country. To calculate productivity and productivity growth for industries or industry-regions within a country at a disaggregated level for, say, the manufacturing sector or a branch of the manufacturing sector such as transportation equipment, it is necessary to deflate the value of output in the industry by an appropriate price index. To be appropriate, the index must somehow incorporate quality improvements so that it is an index for a product of constant quality. In addition to accounting for changes in the quality of the product over time, the product mix ideally would also be controlled. It is also necessary to measure input use on the basis of constant input quality. Ideally, the output measure would be gross output and the inputs would consist of various types of capital, labor, and materials.

Changing the research question to comparisons of TFP levels and growth across countries introduces two new fundamental problems. The first is an index number problem that arises because of the cross-country dimension. Pairwise comparisons of a bilateral productivity index are not transitive. This makes the productivity comparisons sensitive to the base country chosen in the comparison. Caves, Christensen and Diewert (1982a and 1982b) tackle this problem by developing a multilateral productivity index that is not sensitive to the choice of base country or base year.

The other fundamental problem that arises in cross-country comparisons arises because different national currencies must be converted to a common currency. Market exchange rates are not appropriate because they typically are influenced by short-term capital movements. Furthermore, there could be huge variations in price ratios even in traded sectors across countries due to different economic conditions, such as degree of monopoly power in a specific industry or a time lag in response to exchange rate movements. A solution is to use purchasing power parity (PPP) exchange rates to bring all values to a common currency.

The relative prices of products vary across countries because of different opportunity costs of inputs and because the products themselves are not homogenous across countries, making aggregate PPPs deficient in disaggregated comparison. Otherwise similar products may be of different quality across countries and the mix of products within a certain industry may differ across countries. O'Mahony (1996) and van Ark (1996) discuss these issues in detail.

Harrigan (1997) chose to use expenditure category PPPs to convert domestic currencies into a common currency. A shortcoming of this is that it does not take account of intermediate products, which are important part of manufacturing output. The unit value ratio (UVR), which is based on industry of origin rather than final expenditure category, is the conversion factor preferred by van Ark. Unit value ratios (UVRs), however, are not available in secondary data sources, whereas PPPs by expenditure category are so available. Therefore, the pragmatic solution for input and output conversion is to use PPPs by expenditure category. Our primary data is from the new OECD STAN (Structural Analysis) Database. This database has been revised using new industrial classifications. To use this new database we had to limit the number of countries and industries in the analysis. Our data are for 12 countries—Austria, Belgium, Canada, Finland, France, Great Britain, Italy, Korea, Netherlands, Norway, Sweden, and the United States. Fortunately, this list of countries gives a sampling of OECD countries well tailored to our focus. It includes early members of the European Union and members that have joined in the 1990s; in addition it includes four countries that are not in the EU.

The industry list is also diverse. It includes the manufacturing sector and seven two-digit branches and one three-digit branch, namely—Food Products; Textiles; Wood Products; Pulp, Paper Products and Printing; Chemical Products; Non-Metallic Mineral Products; Basic Metals; Machinery and Equipment; and Transportation Equipment.

We have followed Harrigan's (1997) procedures o adjust the data. For instance, the labor input is adjusted to an hours worked measure for all countries. Wage rates for broad occupational categories in the United States are used to adjust the labor hours for labor quality. Our data provide fixed capital formation by industry instead of capital stock. We use Harrigan's parameters in the perpetual inventory approach to converting fixed capital formation flows to capital stock.[1]

Studies by Bernard and Jones (1996) and by Harrigan (1997) concentrate on cross-country comparisons of productivity in sectors of the aggregate economy. Bernard and Jones estimate convergence in broad sectors of the aggregate economy, e.g. agriculture, mining, and manufacturing, using cross-section data. Although they found evidence of convergence for other sectors of the economy, they did not find evidence of convergence in manufacturing. Harrigan's study of 2-digit ISIC manufacturing industries did not test for convergence; he showed, however,

[1] See Yang (2003) for the precise calculation methods used to calculate the multilateral total factor productivity indices used in this paper. We followed Harrigan's (1997) procedures as closely as we could.

that TFP for manufacturing industries differs across OECD countries. In a recent study, Nicoletti and Scarpetta (2003) analyze total factor productivity using annual data for 23 manufacturing and service industries over the period 1984-98. They estimate convergence coefficients for the manufacturing sector and the service sector. In their baseline estimation using this panel data, the convergence coefficient for the service sector is much larger than the one for the manufacturing sector, but both sectors exhibit convergence.

There are two distinct definitions of convergence: b -convergence and s -convergence (Barro and Sala-i-Martin, 1992). Productivity convergence across countries can be analysed based on two questions: (1) Do countries with relatively high initial levels of TFP grow relatively slowly (b -convergence)? and (2) Is there a reduction over time in the cross-sectional variance of TFP (s -convergence)? If the idea of a common technology for an industry across countries—at least in the long run— were to have validity, both types of convergence would seem to be necessary.

b -Convergence

To examine b -convergence, assume that productivity (TFP) for a manufacturing branch in country i, $A_{i,t}$, is:

$$\ln A_{i,t} = g_i + l \ln G_{i,t} + \ln A_{i,t-1} + \ln e_{i,t} \qquad (1)$$

where, l is the catch-up parameter, $G_{i,t}$ is the technology gap, and $e_{i,t}$ is a manufacturing branch and country specific error term. The technology gap, $G_{i,t}$ is the negative of the previous period's productivity in country i relative to that in base country b, the country with the highest TFP: $\ln G_{i,t} = -\ln \hat{A}_{i,t-1}$, where the hat over the variable represents the ratio of country i's to country b's variable: $\hat{A}_{i,t} = \frac{A_{i,t}}{A_{b,t}}$. $\hat{A}_{i,t}$ is the technology gap and can be expressed as a function of its past values (see Barnard and Jones, 1996):

$$\ln \hat{A}_{i,t} = (g_i - g_b) + (1 - l) \ln \hat{A}_{i,t-1} + \ln \hat{e}_{i,t} \qquad (2)$$

This says that the technology gap between country i and the base country b is a function of the lagged gap ($\ln \hat{A}_{i,t-1}$) in the same productivity measure. If both countries have the same asymptotic rate of TFP growth and if the catch-up parameter λ is between zero and one, then productivity differentials result in a higher growth rate for the country with lower productivity.

Following Bernard and Jones (1996), the estimating equation is:

$$\Delta \ln(TFP_i) = a + b \ln(TFPGap_i^{1980}) + e_i \quad (3)$$

where $\Delta \ln(TFP_i)$ is the growth rate of TFP of country i over 1980-1998, which can be expressed as $\ln(TFP_i^{1998} / TFP_i^{1980})^{1/T} = (1/T)(\ln TFP_i^{1998} - \ln TFP_i^{1980})$. The technology gap ($TFPGap_i$) is the ratio of country i's TFP to the maximum level of TFP in the initial period. The speed of convergence, l, is calculated from

$$b = -\frac{1-(1-l)^T}{T}. \quad (4)$$

A regression of the long run average growth rate on the initial technology gap tests convergence, with a negative coefficient on the initial gap required for convergence. The intuition for this is straightforward. As the productivity in a low-productivity country increases relative to that of the leader country, the catch-up opportunities available to the low-productivity country decrease.

Table 2 presents the results for b-Convergence for TFP. For each manufacturing branch, the growth rate of TFP is regressed on its initial level of the TFPGap with a constant, producing an estimate of b. The implied convergence speed, l, is calculated using equation (4). The convergence speed is the rate at which TFP level is converging to the productivity leader's TFP, which may itself be growing over time. As shown in Table 2, all branches of manufacturing and the manufacturing sector exhibit convergence. The estimated negative coefficient of the initial technology gap is significant using a one-tail test at the 10 percent level for Food, Beverages and Tobacco, at 5 percent for Basic Metals and Fabricated Metal Products, and at 1 percent for the remaining seven industries and the manufacturing sector.

The convergence rates for the manufacturing branches vary from 2.37 percent in Chemical, Rubber, Plastics and Fuel Products to 6.98 percent in Pulp, Paper and Printing & Publishing. Just as there is substantial variation in the convergence rates, the R^2s for the convergence regressions vary substantially—from 0.27 for Food, Beverages and Tobacco to 0.90 for Machinery and Equipment. Unlike Bernard and Jones (1996), we find convergence in the manufacturing sector with a 3 percent speed of convergence. They find that some evidence for labor-productivity convergence, but not TFP convergence. Their speeds of adjustment for sectors of the economy range from 1.3 to 6.5 percent per year; our adjustment speeds for manufacturing branches range from 1.6 (Food) to 5 percent (Machinery and Equipment).

Table 2: TFP Convergence Regressions by Industry

	b	t	l	R^2
Manufacturing Sector	-0.02370[!]	-2.42	0.0304	0.42
Food, Beverages and Tobacco	-0.01427[*]	-1.73	0.0164	0.27
Textiles, Leather and Footwear Products	-0.01968[!]	-5.61	0.0240	0.80
Wood and Products of Wood and Cork	-0.03199[!]	-3.22	0.0465	0.56
Pulp, Paper and Printing & Publishing	-0.04044[!]	-2.92	0.0698	0.52
Chemical, Rubber, Plastics and Fuel Products	-0.01950[!]	-2.90	0.0237	0.51
Other Non-Metallic Mineral Products	-0.02303[!]	-4.49	0.0293	0.72
Basic Metals and Fabricated Metal Products	-0.02094[#]	-2.17	0.0259	0.37
Machinery and Equipment	-0.03355[!]	-8.72	0.0501	0.90
Transport Equipment	-0.03073[!]	-5.04	0.0438	0.76

Notes: 1) This regression is based on TFP indices of 12 OECD countries (11 for wood products) by industry. With 10 degrees of freedom (9 for Wood Products), the critical values for t for a one-tailed test at 0.1, 0.5, and 0.01 are 1.37, 1.81 and 2.23. !, #, and * indicate significance at p=0.01, p=0.05. and p=0.10 with a one-tail test.

s -Convergence

One way to examine the data for s -convergence is to study the time trend of the standard deviation of the productivity indices. A declining standard deviation indicates that the TFPs for various countries are getting closer. Figure 1 presents the cross–sectional standard deviations of log TFP over time for manufacturing. The manufacturing sector exhibits a reduction in this standard deviation over time. It falls in the early 1980s, is flat until about 1990, when it again resumes its fall. In all the manufacturing branches, the standard deviations are lower at the end than at the beginning of the period.

Several patterns exist, however, within this generalization. Chemicals and Pulp and Paper both have extended periods (about a decade) of a rising standard deviation, and the pattern for Textiles is uneven. The remaining industries have declining trends with some interruption. The pattern appears consistent with the idea that s -convergence is relatively strong, but is interrupted by country-industry specific shocks.

Figure 1 Standard Deviation of (Log) TFP by Manufacturing Branch

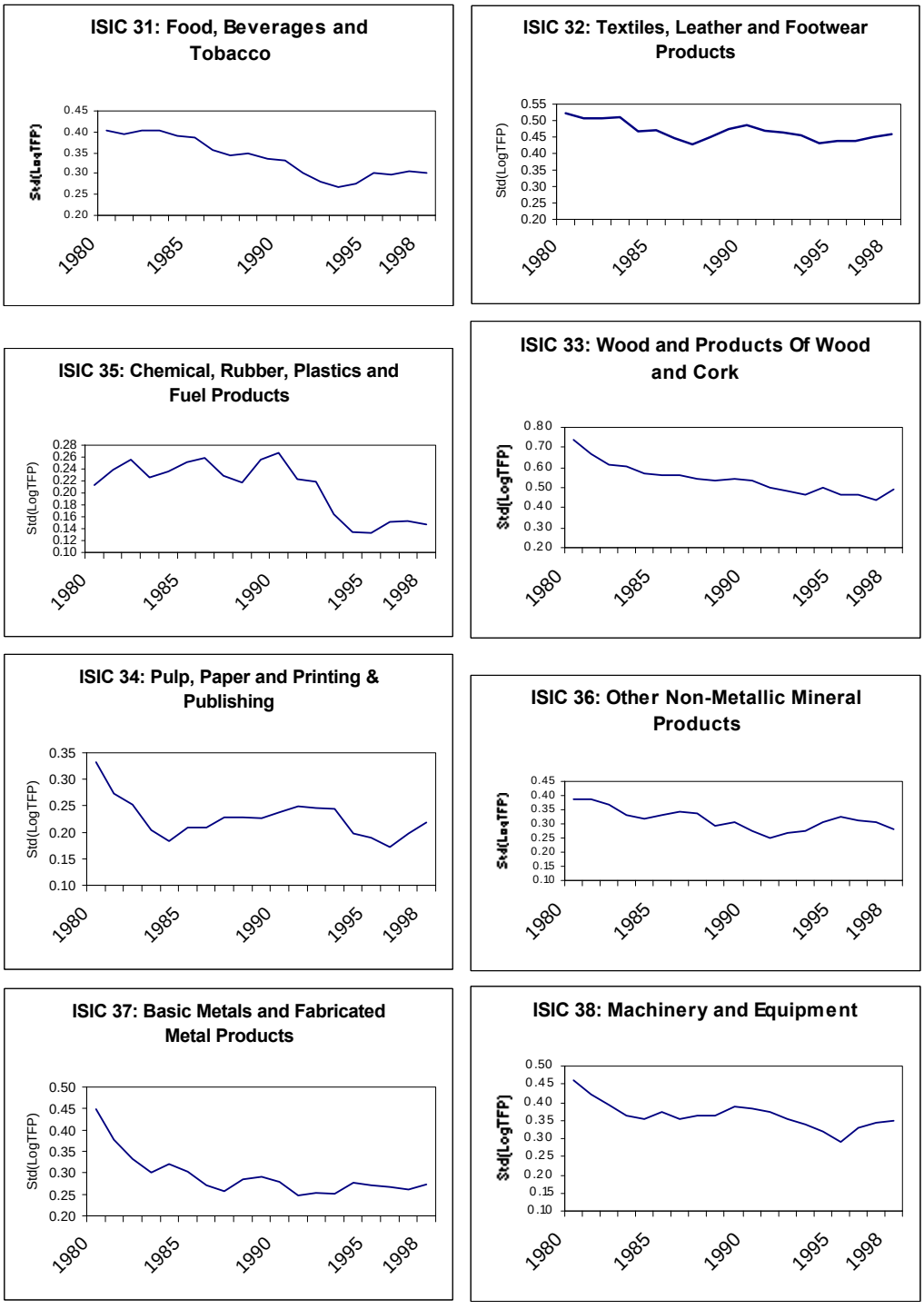
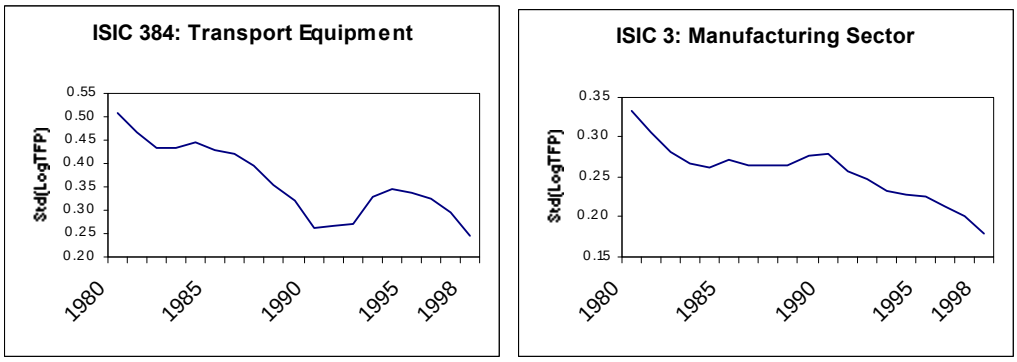


Figure 1 (~) Standard Deviation of (Log) TFP by Manufacturing Branch



The existence of relatively strong evidence of β– and σ-convergence supports the idea of technology transfers between and among countries. Countries with lower levels of productivity have faster productivity growth, which may be based on adapting frontier technologies to their situation The remainder of this chapter presents some preliminary estimates of the effects of economic freedom on relative productivity levels and growth.

Total Factor Productivity Differences and Economic Freedom

Freeman (2002) regresses levels and growth of various measures of economic performance on the economic freedom index, country dummies, and time dummies. As mentioned, he finds that economic performance is not associated with economic freedom across a selection of OECD countries when dummy variables are included to control country effects and time effects. He concludes that different sets of institutions, which for instance result in the different freedom rankings for the Anglo-American countries and the Social-Market countries, among advanced countries are equally amenable to good economic performance.

To examine the question of TFP levels and economic freedom, we regress the TFPGap—the technology gap—on the economic freedom index, including dummy variables for countries and time. We have calculated relative TFP levels from 1980 to 1998 for 12 countries and 9 manufacturing industries (See Yang, 2003), and have observed, as did Harrigan (1997), that annual TFP can vary erratically, presumably due to measurement error. Because the freedom index is only available in five-year increments, we make a virtue of necessity by averaging the TFP relative productivity indexes over the three years centered on 1980, 1985, 1990, and 1995.

For each industry, except for ICIS 33 for which data for France are not available, we have 12 countries and 4 cross sections (See the footnote in Table 3 for the list of industries by ICIS code.) This gives 48 observations for each of nine industries and 44 observations for the tenth. Our estimating equation for a particular industry is

$$TFPGap_{it} = a + b_1 \cdot EF_{it} + b_i \cdot Country_i + b_t \cdot Time_t + e_i \qquad (5)$$

Table 3 gives the results of estimating this equation for each industry. The set of estimates in columns 2 and 3 are for the ordinary least squares estimator, which pools all of the data in the panel. The coefficient of economic freedom is significant and large for nine of the ten industries. To gauge the quantitative impact of the coefficient, note that in 1995, for instance, the economic freedom index ranges from 6.5 for Italy and Korea to 8.3 for the United States. The significant coefficients for economic freedom range from 0.15 to 0.32. Now conduct a thought experiment using plausible values for the relevant parameters. Suppose a country has a freedom index of 7 and a relative productivity index of 0.6. The coefficient range predicts that an otherwise identical country with a freedom index of 8 would have a relative productivity index between 0.75 to 0.92. Such a large effect may not be plausible, but these coefficients may be biased because other factors correlated with economic freedom are not controlled.

To examine the possible effects of omitted variables, we add country dummies to the pooled model, obtaining the results given in Columns 4 and 5. In this set of estimates, 8 of the 10 industries have significant coefficients for economic freedom, but all of the coefficients are much smaller than in column 2, suggesting that omitted variables are a problem in the pooled estimate. The significant coefficients range from 0.06 to 0.16. Conducting the same thought experiment as above, we find that a freedom index of 8 rather than 7 would be associated with a productivity relative in the range of 0.66 to 0.76 rather than 0.60.

In columns 7 and 8 are the results for the full model with economic freedom and country and time dummies. The addition of the time dummies results in the freedom coefficients being significant for only two industries, 32 and 384. For these two industries the freedom coefficient is essentially the same as in column 5. Thus, just as Freeman finds, models that include country and time dummies show little association between freedom and performance. An association between economic freedom and performance exists with the models that include

Table 3: The Effects of Economic Freedom on the Relative Productivity in the Manufacturing Sector and Selected Industries

1	2	3	4	5	6	7	8	9
Fixed Effects			None		Country	Time and Country		
Industry	EF	R^2	EF	R^2	F-Statistic	EF	R^2	F-Statistic
ISIC 3	0.20	0.37	**0.07**$^{!}$	0.94	2.55	0.04	0.96	1.93
	(5.25)		**(3.46)**			(1.03)		
ISIC31	0.18	0.17	**0.06**$^{\#}$	0.93	2.59	0.09	0.93	0.33
	(3.11)		**(2.07)**			(1.54)		
ISIC32	0.32	0.32	0.08	0.95		**0.08***	0.96	3.44
	(4.70)		(2.55)			**(1.33)**		
ISIC33	0.38	0.31	0.00	0.94		**-0.14**	0.96	3.66
	(4.30)		(-0.03)			**(-1.81)**		
ISIC34	0.15	0.27	**0.06**$^{\#}$	0.81	2.09	0.03	0.84	2.29
	(4.18)		**(1.81)**			(0.52)		
ISIC35	0.01	0.00	0.04	0.62		**-0.05**	0.64	8.89
	(0.25)		(0.90)			**(-0.78)**		
ISIC36	0.22	0.30	**0.11**$^{!}$	0.94	2.57	0.06	0.94	1.15
	(4.40)		**(4.12)**			(1.11)		
ISIC37	0.23	0.30	0.15	0.88		**0.07**	0.09	9.82
	(4.44)		(3.98)			**(1.22)**		
ISIC38	0.26	0.32	0.15	0.86		**0.04**	0.93	9.40
	(4.64)		(3.36)			**(0.69)**		
ISIC384	0.25	0.25	0.16	0.88		**0.15**$^{\#}$	0.91	2.93
	(3.96)		(3.85)			**(1.93)**		

Note:
1) Bold type indicates the preferred model.
2) The number in parentheses is the t-statistic for the coefficient.
3) The coefficients for ISIC 33 were estimated from an 11-country sample (France excluded); 12 countries were available for the remaining industries.
4) !, #, and * indicate significance at p=0.01, p=0.05. and p=0.10 with a one-tail test.
5) EF is the Fraser Index of Economic Freedom.
6) ISIC coding stands for the following;
ISIC 3: Manufacturing Sector
ISIC31: Food Products, Beverages and Tobacco
ISIC32: Textiles, Textile Products, Leather and Footwear
ISIC33: Wood And Products Of Wood and Cork
ISIC34: Pulp, Paper, Paper Products, Printing and Publishing
ISIC35: Chemical, Rubber, Plastics and Fuel Products
ISIC36: Other Non-Metallic Mineral Products
ISIC37: Basic Metals and Fabricated Metal Products
ISIC38: Machinery and Equipment (Except. 384)
ISIC384:Transport Equipment

country dummies, but almost disappears with the inclusion of the time dummies. An association between economic freedom and performance exists with the models that include country dummies, but almost disappears with the inclusion of the time dummies. Given the positive trends in the freedom index, it is perhaps not surprising that the inclusion of the time dummies reduces the precision of the estimated coefficients. Consequently, the answer to the question of an association between freedom and performance depends upon model selection. If either the time or country dummies are inappropriate for the model, the efficiency of the estimator is reduced. Although the freedom coefficients would not be biased, their standard errors could be overestimated, reducing the coefficients' t statistics. Therefore, we test for the preferred model by comparing the full model to the model with country dummies and economic freedom; i.e., we test for the joint significance of the coefficients of the time dummies.

The results in columns 7 and 8 are for the unrestricted model. In column 9 we present the F-statistic for the hypothesis that the coefficients of the time dummy variables jointly equal zero. The calculated F is 1.93 and, with 4 and 30 degrees of freedom, the critical value for p = 0.05 is 2.69. We cannot reject the null hypothesis that the coefficients of the time dummies jointly equal zero in the manufacturing sector. Next, we perform the same test for the country dummies for the manufacturing sector. The critical value for p =0.05 with 12 and 34 degrees of freedom is 2.05. As shown in Column 6, the calculate F is 2.55; we reject that null hypothesis that the coefficients of the country dummies jointly equal zero. For the manufacturing sector, the specification with the country dummies and the economic freedom index is preferred; the bold type indicates that this is the preferred model. For the manufacturing sector as whole, the positive coefficient for economic freedom in the preferred model is highly significant (p=. 01), but has a much smaller coefficient than in the pooled estimate. Comparing otherwise identical countries, a country with a freedom index of 8 rather than 7 is associated with a 0.07 larger productivity relative in the manufacturing sector: 0.67 rather than 0.60.

In Table 3, we report the results obtained by using this same strategy for all of the industries; results for the preferred specification for each industry are in bold type. For the preferred specifications, two of the freedom coefficients are significantly greater than zero at the 0.01 level, three at the 0.05 level, and one at the 0.10 level. We have evidence, particularly strong for the manufacturing sector as a whole, of a positive association between economic freedom and total factor productivity. The positive association between economic freedom and time, however, makes it difficult to determine just how strong the relationship is. This correlation between

freedom and time also may account for Freeman's finding of little relationship between economic freedom and economic performance; all of his equations, except for the OLS pooled model, include time dummies. Productivity growth is just as important as the productivity level, so we now the relationship between it and economic freedom.

Total Factor Productivity Growth and Economic Freedom

To continue our analysis of productivity and economic freedom, we turn to testing the relationship between economic freedom and TFP growth. We first specify equation (6), by adding the economic freedom index and the country and time fixed effects to equation (3) to obtain:

$$\Delta \ln TFP_{i(t\,to\,t+1)} = a + b_1 \cdot \ln TFPGap_{it} + b_2 \cdot EF_{it} + b_i \cdot Country_i + b_t \cdot Time_t + e_i \quad (6)$$

We expect TFP growth to be a function of the technology gap (TFPGap) and economic freedom (EF), both measured at the beginning of the period. In this section we again use four cross sections (three at five year intervals and one at a three year interval) for estimation. We calculate TFP growth by first averaging the productivity levels for the three year period for which 1980, 1985, 1990, and 1995 are the midpoints. We then annualize the log difference in the levels for each period to get the growth rate. We use our results for 1998 to create the fourth cross section, by annualizing the log difference between 1998 and 1995. Table 4 presents three sets of estimates, one including the two continuous variables, country dummies, and time dummies, one including the continuous variables and country dummies, and one including only the continuous variables.

Examining Table 4, we again see that the specification that includes time dummies has few—three— industries (ISIC 33, ISIC 36 and ISIC 37) with freedom coefficients significantly greater than zero. In contrast in the specification with country, but not time, dummies six of the freedom coefficients are significant, while in the estimates with no dummies, seven freedom coefficients are significant. Again the strong time trend in the freedom variables may make it difficult to isolate the effects of economic freedom on economic performance in OECD countries. We again test for the preferred model, following the same procedure as before.

The coefficients of the continuous variables from the unrestricted model are in columns 9 and 10. The F statistic for the null hypothesis that the coefficients of the time dummies jointly equal zero is in column 12. The two industries for which the null cannot be rejected are

industries 35 and 384. For the eight remaining industries, the null hypothesis of no country effects is rejected in only one, industry 31 (See columns 5 and 6 for the coefficients and column 7 for the calculated F statistics.) The preferred estimates are again in bold. In six of the preferred estimates the coefficient of economic freedom is significantly greater than zero. The significant coefficients average 0.02.

Table 4. The effects of the Technology Gap and Economic Freedom on TFP Growth in the Manufacturing Sector and Selected Industries

1	2	3	4	5	6	7	8	9	10	11	12
Fixed Effects				Country				Time and Country			
Industry	TGap	EF	R^2	TGap	EF	R^2	F-Stat	TGap	EF	R^2	F-Stat
ISIC 3	**-0.07**$^{!}$	**0.01**$^{\#}$	**0.36**	-0.07	0.01	0.43	0.38	-0.06	0.00	0.47	0.47
	(-4.90	**(2.33)**		(-1.62)	(2.06)			(-1.29)	(0.30)		
ISIC31	-0.02	0.00	0.20	**-0.09**$^{!}$	**0.00**	**0.57**	**2.16**	-0.09	-0.01	0.60	1.10
	(-2.92)	(-0.25)		**(-4.07)**	**(-0.83)**			(-3.45)	(-0.91)		
ISIC32	**-0.09**$^{!}$	**0.02**$^{\#}$	**0.25**	-0.11	0.04	0.35	0.36	-0.09	0.03	0.39	0.64
	(-3.88)	**(1.75)**		(-1.21)	(1.90)			(-0.89)	(0.76)		
ISIC33	**-0.09**$^{!}$	**0.03**$^{\#}$	**0.30**	0.10	0.04	0.49	0.98	0.14	0.07	0.52	0.71
	(-4.13)	**(1.88)**		(1.38)	(2.02)			(1.60)	(1.93)		
ISIC34	**-0.08**	**0.00**	**0.29**	-0.11	0.00	0.50	1.12	-0.10	0.01	0.51	0.29
	(-3.87)	**(0.45)**		(-2.98)	(0.64)			(-2.27)	(0.66)		
ISIC35	-0.05	0.00	0.09	-0.10	-0.01	0.29		**-0.24**	**-0.03**	**0.57**	**6.20**
	(-2.12)	(-0.20)		(-2.62)	(-1.03)			**(0.04)**	**(-1.62)**		
ISIC36	**-0.07**$^{!}$	**0.02**$^{!}$	**0.33**	-0.21	0.04	0.56	1.48	-0.22	0.03	0.58	0.33
	(-4.66)	**(2.78)**		(-4.67)	(4.48)			(-4.59)	(1.94)		
ISIC37	**-0.06**$^{!}$	**0.01**$^{\#}$	**0.38**	-0.14	0.02	0.56	1.10	-0.19	0.02	0.63	1.74
	(-5.21)	**(2.21)**		(-5.00)	(3.24)			(-4.80)	(1.51)		
ISIC38	**-0.07**$^{!}$	**0.02**$^{!}$	**0.26**	-0.10	0.05	0.48	1.15	-0.12	0.01	0.56	1.81
	(-3.97)	**(2.67)**		(0.00)	(0.00)			(-2.23)	(0.65)		
ISIC384	-0.05	0.02	0.24	-0.09	0.03	0.33		**-0.16**$^{!}$	**0.01**	**0.57**	**5.24**
	(-3.80)	(2.22)		(-2.39)	(2.33)			**(-4.28)**	**(0.71)**		

Note: 1) Bold type indicates the preferred model.
2) The number in parentheses is the t-statistic for the coefficient.
3) The coefficients for ISIC 33 were estimated from an 11-country sample (France excluded); 12 countries were available for the remaining industries.
4) !, #, and * indicate significance at p=0.01, p=0.05. and p=0.10 with a one-tail test.
5) See Table 3 for industry definitions.
6) TGap is the logarithm of the technology gap, which is defined as a productivity gap of country i from a base country b, the country with the highest TFP, s.t

$TGap_{i,t} = \ln TFPGap_{i,t} =$ where TFPGap is the country's productivity as a proportion of the frontier country's productivity.

7) EF is the Fraser Index of Economic Freedom.

The one unit difference in economic freedom ratings for the Anglo-American countries relative to the Social-Market countries, other things equal, would be associated with a productivity growth rate 0.02 percentage points higher.

This remarkably large effect of economic freedom on TFP growth requires further analysis. The overall performance of the model appears reasonable. The coefficient on the technology gap variable is significant in 9 of the 10 preferred specifications, suggesting productivity convergence.

Although it is important to examine the effect of simply adding the economic freedom index to the convergence equation, the mechanism through which economic freedom induces productivity growth can be modeled more usefully by considering a specification with an interaction term. Following Nicoletti and Scarpetta (2003), among others, we first substitute the growth rate of the frontier for the time dummies in equation 6. By this mechanism, the influence of the growth rate of the frontier may be transmitted directly to the follower countries. Greater economic freedom may directly influence the productivity growth rate by providing stronger incentives for innovation. It may also increase the rate at which a follower country absorbs technology because of more flexible markets as well as greater incentives. We investigate the effect of freedom on technology transfer by interacting the technology gap with economic freedom. Adding Frontier Growth and the interaction term to equation (6), we get,

$$\Delta \ln TFP_{i(t\,to\,t+1)} = a + b_1 \cdot \ln TFPGap_{it} + b_2 \cdot EF_{it} + b_3 \cdot FrontierGrowth_t + b_4 \cdot \ln TFPGap_{it} * EF_{it} + b_i \cdot Country_i + e_i \qquad (7)$$

This model differs in two ways from the previous model. First, the frontier growth rate enters explicitly. Second, the effects of freedom and the technology gap are no longer linear. The catch-up coefficient is now $\beta_1 + (\beta_4$ EF) and the economic freedom coefficient is $\beta_2 + (\beta_4 \ln$TFPGap). We expect the coefficients of lnTFPGap and economic freedom, β_1 and β_2, to be negative and positive. β_1 is the catch-up coefficient, assuming that the economic freedom index is zero, which eliminates the interaction term. β_2, on the other hand, is the economic freedom coefficient for the frontier country. (For the frontier country, the TFP gap is one; its logarithm is zero, which eliminates the interaction term. For all other countries, the logarithm of the TFP gap is negative.) We expect economic freedom to be positively associated with the growth of the productivity frontier. In addition, we expect the coefficient of frontier growth to be positive and that of the interactive term to be negative. A negative coefficient for the interaction term means that the

catch-up coefficient, $\beta_1 + (\beta_4$ EF), is larger in absolute value, the greater the value of the freedom index. Convergence accelerates. A negative coefficient for the interaction term also means that the effect of freedom, $(\beta_2 + \beta_4 \ln$TFPGap) on productivity growth will be greater the farther the country is from the frontier. A negative interaction term means that freedom makes it easier to catch up and that the importance of freedom in catch up is greater the farther the country is from the frontier.

Columns 2-5 in Table 5, give the estimates of equation 7 with country dummies included. The F statistic for dropping the country dummies is in column 7. It fails to meet the critical value of 2.11 (p=0.05) for the manufacturing sector and for four of the branches. For these five industries, we next test the null hypothesis that the coefficients of the technology gap and economic freedom are jointly equal to zero. This null could not be rejected for three branches, 34, 35, and 384. Again the preferred estimates are in bold type.

The results for the manufacturing sector require additional consideration, particularly because the test for the joint significance of the country fixed effects at p=0.05 is right on the margin. The equation without the country fixed effects in columns 8-11 has insignificant coefficients of economic freedom and frontier growth. The coefficient of the technology gap is positive and statistically significant. This result says that if the economic freedom index is zero, TFP grows faster the smaller the technology gap. In this case the effect the technology gap on growth is the catch-up coefficient times TGap. TGap is the logarithm of the productivity ratio, resulting in its logarithm being zero or negative. As the gap increases—the productivity ratio gets smaller—the variable takes increasingly large negative values, resulting in larger reductions in growth. Recall, however, that this is for an economic freedom index of zero; because no country in the sample has a zero freedom index, the effect of economic freedom on the catch-up coefficient must be considered.

The observed range for the economic freedom index, however, is roughly from 5 to 8. To find where the catch-up coefficient switches from divergence to convergence, set $\beta_1 + (\beta_4 \cdot$ EF), equal to zero and solve for EF. The coefficient equals zero when EF = β_1 / β_4. Using the restricted results for the manufacturing sector, this is 5. So the catch-up coefficient is positive with freedom indices less than 5, in which case productivity diverges. Divergence is greater, the greater the technology gap. Convergence occurs for countries with freedom levels greater than 5. For these countries, convergence is faster the greater the technology gap. The size of the catch-up coefficient varies with the level of economic freedom; for freedom indices of 7 and 8, the

catch-up coefficients are (0.20 – (-0.04 * 7) -0.08 and –0.12. Thus, the greater the freedom index, the faster the convergence.

The restricted estimate shows that economic freedom has a positive effect on TFP growth even though the coefficient of EF is not significantly different from zero. The freedom coefficient is –0.04 times TGap. For the frontier country, freedom has no effect on growth. For productivity ratios of 0.75 and 0.50, the associated TGaps are –0.29 and –0.69, giving freedom coefficients of 0.0116 (given by (-0.04*-0.29)) and 0.0276.

The unrestricted estimate for the manufacturing gives a similar result for the catch-up coefficient; the breakeven freedom index is 5.8. If it is less than 5.8, growth rates diverge; greater, they converge. As the freedom index goes from 7 to 8, for instance the catch-up coefficient goes from –0.11 to –0.20. The economic freedom coefficient in this estimate, however, is somewhat different; it is -0.02 – 0.09 TGap. Thus, for the frontier country (TGap is zero) economic freedom reduces productivity growth. The coefficient remains negative until the productivity ratio falls to 0.8. The farther the country from the frontier, the greater the freedom coefficient. For productivity ratios of 0.75 and 0.50, the freedom coefficients are 0.006 and 0.042.

The coefficient for the technology gap is positive and significant, as we have seen for the manufacturing sector, for five of the industries (ISIC 32, ISIC 33, ISIC 34, ISIC36 and ISIC38). To interpret this, it is necessary to consider the coefficient in conjunction with the interaction coefficient. So, for industry 32, the effect of the gap on productivity growth is 1.11 – 0.17 * EF. If EF is 6.5, which is the lowest value for the index in 1996, the coefficient for catch up is 0.005. There would be no convergence. A freedom index of 8 yields a catch up coefficient of -0.25. Dividing the gap coefficient by the interaction coefficient gives the economic freedom value for which the coefficient is zero. For industries 32 and 33 the coefficients imply that the least free countries in the sample are not converging. For the remaining industries with both of these coefficients significant, the breakeven value of economic freedom is 5 or less, which implies that all of the countries in the sample have a catch-up coefficient that leads to convergence. It is important to note, also, that in all cases the greater the freedom index, the faster the convergence. For the three industries where the gap coefficient is omitted from the equation, catch up occurs regardless of the freedom index, but it is faster the larger the freedom index.

Table 5. The Direct and Indirect effects of theTechnology Gap and Economic Freedom on TFP Growth in the Manufacturing Sector and Selected Industries: The Interaction Model

1	2	3	4	5	6	7	8	9	10	11	12
	Full Model						Preferred Model if Full Model is rejected				
Industry	TGap	EF	Front	TGap·EF	R^2	F-Stat	TGap	EF	Front	TGap·EF	R^2
ISIC 3	0.52$^{!}$	-0.02$^{!}$	-0.58	-0.09$^{!}$	0.70	2.10	**0.20**$^{!}$	**0.00**	**-0.41**	**-0.04**$^{!}$	**0.48**
	(4.44)	(-2.73)	(-1.57)	(-5.33)			**(2.35)**	**(-0.74)**	**(-1.02)**	**(-3.13)**	
ISIC31	**0.05**	**-0.02**	**0.17**	**-0.02***	**0.59**	**2.26**					
	(0.56)	**(-1.40)**	**(0.61)**	**(-1.65)**							
ISIC32	**1.11**$^{!}$	**-0.08**$^{!}$	**-0.84**	**-0.17**$^{!}$	**0.71**	**3.63**					
	(5.45)	**(-3.36)**	**(-0.56)**	**(-6.20)**							
ISIC33	**0.86**$^{!}$	**-0.04***	**0.34***	**-0.14**$^{!}$	**0.72**	**2.76**					
	(5.15)	**(-1.72)**	**(1.53)**	**(-4.86)**							
ISIC34	0.30	-0.01	-0.05	-0.06	0.59	1.86			**-0.23**	**-0.01**$^{!}$	**0.30**
	(1.81)	(-1.00)	(-0.22)	(-2.46)					**(-1.04)**	**(-3.90)**	
ISIC35	-0.46	0.01	0.56	0.04	0.50	1.84			**0.29**$^{\#}$	**-0.01**$^{!}$	**0.17**
	(-1.45)	(0.76)	(3.69)	(0.82)					**(2.13)**	**(-2.78)**	
ISIC36	**0.27**$^{\#}$	**0.01**	**0.16**	**-0.07**$^{!}$	**0.70**	**3.12**					
	(2.10)	**(1.07)**	**(0.35)**	**(-3.91)**							
ISIC37	**0.13**	**-0.01**	**0.76**$^{!}$	**-0.04**$^{!}$	**0.70**	**2.45**					
	(1.27)	**(-0.69)**	**(2.52)**	**(-3.02)**							
ISIC38	0.38	0.01	0.15	-0.07	0.60	1.47	**0.25**$^{\#}$	**0.00**	**0.39***	**-0.05**$^{!}$	**0.29**
	(2.24)	(0.47)	(0.40)	(-3.02)			**(2.02)**	**(-0.39)**	**(1.45)**	**(-2.64)**	
ISIC384	0.00	0.02	0.58	-0.02	0.53	1.09			**0.34**$^{!}$	**-0.01**$^{!}$	
	(0.02)	(1.39)	(3.64)	(-1.07)					**(2.36)**	**(-3.97)**	

Note: 1) Bold type indicates the preferred model.

2) The number in parentheses is the t-statistic for the coefficient.

3) The coefficients for ISIC 33 were estimated from an 11-country sample (France excluded); 12 countries were available for the remaining industries.

4) !, #, and * indicate significance at p=0.01, p=0.05. and p=0.10 with a one-tail test.

5) See Table 3 for industry definitions.

6) TGap is the logarithm of the technology gap, which is defined as a productivity gap of country i from a base country b, the country with the highest TFP, s.t

$TGap_{i,t} = \ln TFPGap_{i,t} =$ where TFPGap is the country's productivity as a proportion of the frontier country's productivity.

7) EF is the Fraser Index of Economic Freedom.

8) Front is Frontier Growth, which is the growth rate of TFP for the leading country.

9) TGap.EF is TGap times EF.

The coefficient of economic freedom is only significant in two of the preferred specifications—for industries 32 and 33—and it takes a negative value. Taken literally, as we have seen, this says that for the frontier—the technology gap is zero—economic freedom reduces productivity growth. At the average value of the technology gap for these two industries, productivity growth is positively associated with economic freedom. But as the gap narrows, eventually the partial effect of freedom on growth is negative. This result is fairly robust for industries 32 and 33, and it is difficult to find an explanation. For the remainder of the industries, except for 35 where it is not significant, the partial effect of freedom on growth is given by the interaction coefficient times the level of the technology gap. The greater the gap, the greater the growth. Perhaps the most significant conclusion from this analysis is that freedom has its effect on productivity growth indirectly through it effect on the size of the catch-up coefficient and through an additional effect that is stronger the farther the country is from the frontier.

Finally, the effect of growth in the productivity frontier, which we expect to positive, is significantly greater than zero in five of the industries. It is significant at 0.01 in one industry, 0.05 in two industries, and 0.10 in two industries.

This section shows a reasonably strong association between economic freedom and productivity growth. Adding the level of economic freedom to a traditional convergence equation, we find that convergence is generally supported. If time effects are omitted, we also find that economic freedom is positively associated with productivity growth. Using F tests, we find that time effects are not significantly different from zero. The preferred model is the one without country and time effects for seven of ten industries. The manufacturing sector and five of the nine disaggregated industries have significant freedom coefficients in the preferred models. Expanding the model to include the interaction between economic freedom and the technology gap provides even stronger support for the role of economic freedom in productivity growth. This interaction term is significant in all industries. Its negative coefficient implies that as economic freedom increases, convergence is enhanced. It also implies that as the technology gap widens economic freedom has a greater effect on productivity growth. In two or three instances, economic freedom has a negative effect on productivity growth for countries at or close to the frontier. For these same industries, countries productivity diverges for countries at the lowest observed freedom levels.

Conclusion

This chapter examines productivity convergence and economic freedom for 12 selected OECD countries, 8 of which are in the EU. These countries experienced rising levels of economic freedom beginning in 1975. Other EU countries and current and potential accession countries have also experienced increased levels of economic freedom.

Three Anglo countries and four Social-Market countries have experienced these increases, but the Anglo countries have freedom levels above the Social-Market ones. Productivity convergence among EU countries is of particular interest because it would ease certain problems associated with deeper integration. We do not have data for current accession countries, but we do for eight EU countries, including three that joined in the 1980s, and four non-EU countries. The observed convergence among these countries suggests that the current accession countries may be experiencing convergence.

We find an association between variations in economic freedom and productivity growth that is counter to Freeman's findings. We believe that our results differ from his because we test for time fixed effects and find that they are often jointly insignificant. We also find that economic freedom and the technology interact, such that economic freedom is more important the farther a country is from the frontier and that convergence is faster the greater the level of economic freedom. If the current accession countries follow the pattern of the earlier accession countries, it can be expected that economic freedom will be increasing in those countries. Our results indicate that increases in economic freedom, in turn, will enhance productivity convergence and productivity growth.

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Zentrum für Europäische Integrationsforschung
Center for European Integration Studies
Rheinische Friedrich-Wilhelms-Universität Bonn

Walter-Flex-Strasse 3
D-53113 Bonn
Germany

Tel.: +49-228-73-1732
Fax: +49-228-73-1809
www.zei.de