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Different Models for Regional Integration: Lessons from Total Factor Productivity in Europe

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Abstract

As the countries of Europe have successfully managed to move the region's integration forward step by step, the European experience offers three possible models for regional integration with different depths: a free trade arrangement, a single market, and a common currency area. In this paper, we examine the effect of these three different models of regional integration on total factor productivity (TFP) to assess the long-run growth implication of each model. Our findings suggest that joining a regional grouping changes the way participating economies grow, no matter which model of regional integration is used: domestically powered growth becomes less important, and regionally powered growth becomes the new source of growth. As existing theory identifies knowledge creation and its spillovers as key drivers of economic growth, regionally powered growth is expected to become relatively more important with a higher level of intra-regional dependence on research and development (R&D) spillovers. Of the three models for regional integration, the free trade arrangement is found to be the most effective in promoting intra-regional dependence on R&D spillovers. We find that largely negative windfall effects on TFP are associated with the other two models.

JEL Classification: F02, O31, O40

Contents

1. INTRODUCTION

The world today is covered by a complex web of bilateral and regional trade agreements. The proliferation of preferential trade arrangements has coincided with a lack of tangible progress in multilateral trade liberalization in the past decade as the Doha round of trade talks has stalled since 2008. A growing interest in promoting economic integration in most world regions is another factor that can explain the recent proliferation of regional trade arrangements. As no regional economic integration initiative can be sustained if it fails to raise the standards of living in member economies in the long run, the impact of integration initiatives on long-term economic growth needs to be examined.

Most economists believe that knowledge plays a central role in the improvement of standards of living. For example, historical investigations such as Rosenberg (1982) demonstrate that the creation and dissemination of knowledge are crucial in promoting long-term economic growth. Neoclassical theory, dating back to Solow (1956) and Swan (1956), has identified total factor productivity (TFP) as the key to long-term growth. The development of endogenous growth models in the 1990s (among others, Romer 1990; Grossman and Helpman 1991; and Aghion and Howitt 1992), led to the widespread acceptance that TFP depends crucially on knowledge creation and knowledge spillovers. To understand the implications of this theoretical approach for long-term economic growth, it is important to understand how regional integration affects the process in which knowledge creation and spillovers translate into higher TFP for the countries involved.

When designing a framework for regional economic integration, policymakers face different options depending on the depth of integration they wish to achieve. As European integration has progressively deepened since the end of World War II, the European experience provides different models for regional integration. European integration moved from a free trade arrangement that mainly focused on removing customs duties among member countries, to the liberalization of trade and investment as a result of the Single European Act of 1986, and culminated in the establishment of a single market in 1993 that allows the free movement of goods, services, people, and money. Some of these countries have achieved even deeper integration since their formation of a common currency area in 1999.

In this paper, we examine the effect of the different stages of European integration on TFP to assess the long-run growth implication of individual models of regional integration. Our analysis focuses on the process in which knowledge creation and its cross-border spillovers translate into TFP by building upon the empirical specifications that explain a country's TFP as a function of the domestic and foreign stocks of knowledge. In line with much of the existing literature, cumulative research and development (R&D) expenditure serves as a proxy for a stock of knowledge. Basing our research on a sample of 24 countries that are members of the Organisation for Economic Co-operation and Development (OECD), we find that different models of regional integration have clearly different effects on the extent to which a participating country's TFP depends on domestic and foreign R&D capital stocks. Of the different models, the free trade arrangement in particular is also found to have the potential to result in windfall benefits for the region's productivity.

The next section reviews the significance of total factor productivity for determining long-term economic growth. In Section 3, three models for regional integration are proposed based on the European experience. Section 4 describes empirical specifications and data used in our regression analysis, followed by a summary of our main empirical findings. Section 5 concludes.

2. TOTAL FACTOR PRODUCTIVITY

In examining different models of regional integration in terms of their effects on long-term growth, we focus on TFP instead of the growth rate of real gross domestic product (GDP), because the growth rate of TFP is the slope of an economy's steady-state growth path. In addition to its long-run implications for economic growth, TFP growth also has immediate effects on the current pace of economic growth by altering the steady-state level of capital per worker. In this section, we illustrate the role of TFP in economic growth using a standard neoclassical framework with a constant, exogenous savings rate developed by Solow (1956) and Swan (1956).[1] The aggregate production function is assumed to be described by the Cobb-Douglas function,

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \quad (1)$$

where Y is aggregate output, K is aggregate capital, and L is total employment. $A>0$ is the level of TFP and α is a constant with $0<\alpha<1$.

For simplicity, we suppose that the economy is closed and there is no government expenditure on goods and services. Hence, aggregate output is either consumed or invested in this economy. Investment is used to create new units of capital, which depreciates at the constant rate $\delta>0$. We assume a constant fraction of aggregate output is saved at the rate of s ($0 \leq s \leq 1$). Given that the amount saved equals the amount invested in a closed economy, the investment rate is also s in this economy. We assume total employment grows at a constant, exogenous rate of $n \geq 0$.

Eq. (1) can be rewritten in intensive form as

$$y_t = A_t k_t^{\alpha} \quad (2)$$

where $y \equiv Y/L$ and $k \equiv K/L$.

The steady-state value of k for the given level of TFP, A_τ, is denoted as $\bar{k}_\tau$, and satisfies the condition

$$sA_\tau \bar{k}_\tau^{\alpha} = (n+\delta) \cdot \bar{k}_\tau \quad (3)$$

If k is below $\bar{k}_\tau$, k is expected to increase over time until it reaches $\bar{k}_\tau$. The growth rate of k at t along the transition is characterized by

$$\dot{k}_t/k_t = sA_\tau k_t^{-(1-\alpha)} - (n+\delta) \quad (4)$$

It is worth noting that the growth rate of k falls as k increases, and it approaches 0 as k approaches $\bar{k}_\tau$. Using Eq. (3), the growth rate of k at t along the transition can also be expressed as

$$\dot{k}_t/k_t = (n+\delta) \cdot \left[\left(\frac{k_t}{\bar{k}_\tau}\right)^{\alpha-1} - 1\right] \quad (5)$$

Subsequently, the economy's growth rate of capital per worker at t depends on the distance between the t period level of capital per worker, k_t, and its steady-state level, $\bar{k}_\tau$. From Eq. (3), $\bar{k}_\tau$ in turn depends crucially on the level of TFP, A_τ. An improvement in TFP will raise the steady-state level of capital per worker when the economy's savings rate, depreciation rate, and employment growth rate remain constant. Hence, any changes in TFP are expected to have immediate effects on the growth rate of capital per worker.

Eq. (5) shows how a country may resist the gravity of diminishing returns to capital and achieve an accelerating pace of economic growth. Starting from capital per worker in period 0, the positive growth in capital per worker will result in a higher level of capital per

[1] For a more detailed exposition of this framework, see Barro and Sala-i-Martin (2004).

worker in a future period 1. At the fixed steady-state level of capital per worker, the economy's growth rate of capital per worker in period 1 is lower than in period 0 due to diminishing returns to capital. However, if TFP grows from period 0 to 1, this TFP growth would shift the economy's steady-state position further away and could even increase the distance between the current and steady-state levels of capital per worker in period 1 compared to period 0. That is, TFP growth, if it is sufficiently large, may induce faster growth even at a higher level of capital per worker. Therefore, TFP growth has not only long-run implications for economic growth by altering the long-run or steady-state level of capital per worker, but it also has immediate effects on the current pace of economic growth.

3. DIFFERENT MODELS FOR REGIONAL INTEGRATION: EUROPEAN EXPERIENCES

The six European countries—Belgium, Luxembourg, France, Germany, Italy, and the Netherlands—that signed the Treaty of Rome to create the European Economic Community (EEC) in 1957, started a customs union in July 1968. Accordingly, customs duties were removed among these six countries and other members that later joined the customs union (Denmark, Ireland, and the United Kingdom in 1973; Greece in 1981; Spain and Portugal in 1986). However, the removal of customs duties was not sufficient to ensure free flows of trade because considerable differences in member countries' national regulations remained in place. An extensive six-year program to examine these regulatory differences was introduced following the Single European Act of 1986, which resulted in the implementation of more than 200 laws covering a wide range of areas including tax policy, business regulation, and professional qualifications. The phasing out of technical, legal, and bureaucratic barriers to cross-border transactions and labor mobility culminated in the establishment of the single market with its four freedoms—the free movement of goods, services, people, and money—in January 1993. [2] The name "European Community" was also officially replaced by "European Union" (EU) with the coming into force of the Maastricht Treaty in November 1993, and its membership further expanded in 1995 when Austria, Finland, and Sweden joined. At the beginning of 1999, the euro was introduced in 11 EU countries: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Greece joined the eurozone in 2001.[3]

European integration has been a continuous process during which both its geographical spread and depth have gradually expanded over the years. Nonetheless, its integration process can be divided broadly into three distinct stages. The first stage started in 1968 when a customs union was created and European integration mainly took the form of a free trade arrangement that focused on promoting intra-regional trade in goods and some services. The second stage started with the establishment of a single market in 1993, by which the scope of European integration was extended to include the free movement of money and people. The third stage began with the introduction of a common currency with the adoption of the euro in 1999. Viewed as distinct stages, the European experience offers three possible models of regional integration with different depths: a free trade arrangement, a single market, and a common currency area.

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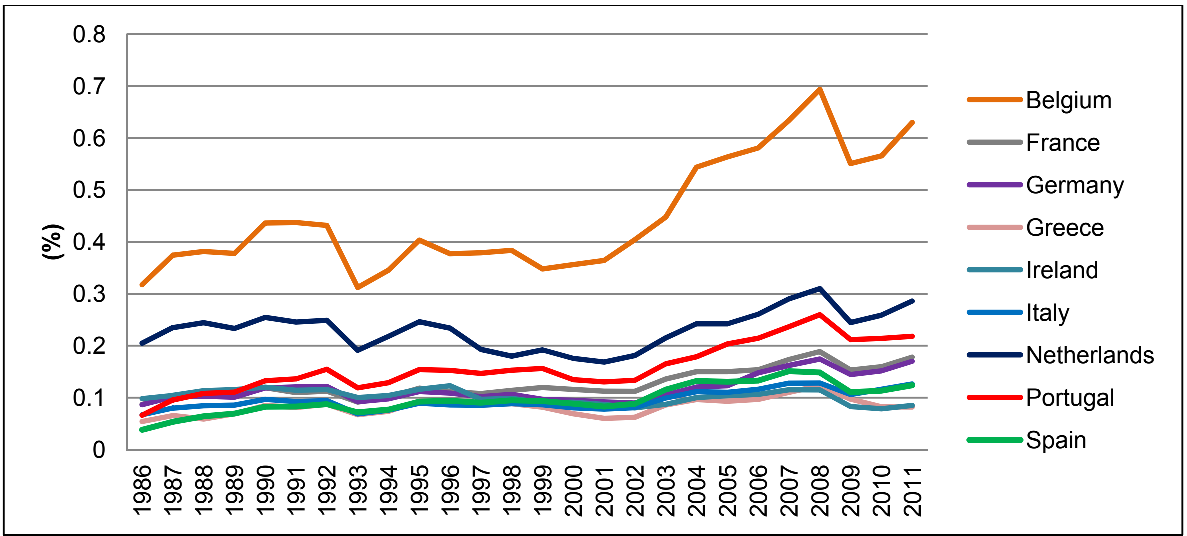
[2] European Central Bank (2013) provides a comprehensive overview of financial integration in Europe.

[3] See, among others, Alesina and Giavazzi (2010) and Kenen and Meade (2008) for a summary of the eurozone's experience.

Figure 1 shows intra-regional trade among nine eurozone countries from 1986 to 2011,[4] during which period these countries went through all three stages of European integration: a free trade arrangement (1986–1992), a single market (1993–1998), and a common currency (1999–2011). Intra-regional imports as a share of GDP increased in most eurozone countries—except for a brief downturn following the global financial crisis of 2008—as integration among these countries increasingly deepened. However, Figure 1 does not prove that intra-regional dependence on eurozone trade increased as the region's integration process progressed into deeper stages. It is possible that imports from outside the eurozone increased even faster than those from the inside over the period from 1986 to 2011.

Figure 1: Total Intra-Regional Imports as a Share of Gross Domestic Product



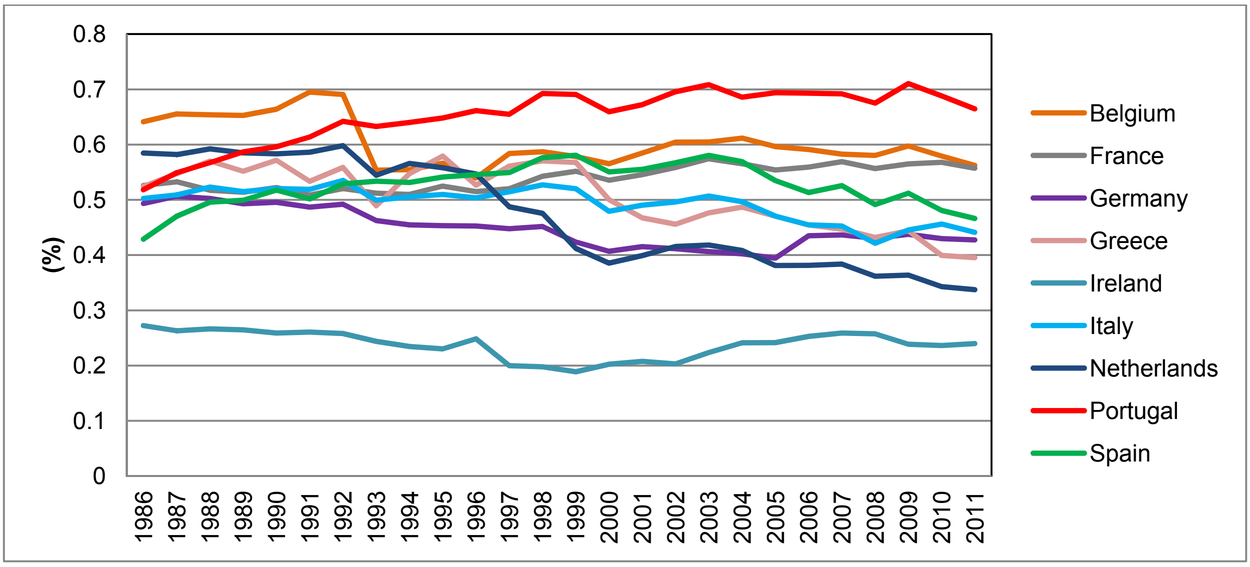
Source: IMF, Direction of Trade Statistics.

To examine intra-regional dependence on eurozone trade, we calculated the ratio of intra-regional imports to total imports for each country. The results, shown in Figure 2, fail to provide consistent evidence that intra-regional dependence increased with deepening regional integration. Although Portugal's dependence on imports from inside the region increased persistently as European integration advanced, intra-regional trade dependence did not increase in the other eurozone countries; in fact, it declined in many countries. Rather than signaling a decline in intra-regional dependence across the board, this may be a reflection of possible shifts in the patterns of trade and foreign direct investment inside the region as producers in member countries responded to deepening integration.[5] Figure 2 illustrates the limitation of any single measure to effectively capture the degree of overall intra-regional dependence, thereby highlighting the danger of simply following a single measure to gauge changes in the depth of regional integration over time.

[4] Of the original eurozone countries, Luxembourg is not included in the sample for Figure 1. We also exclude Austria and Finland that joined the EU only in 1995 because Figure 1 covers the period during which the two countries were not part of the EU.

[5] For example, liberalization may induce cross-border firm relocations in the long run (see Venables 1985, 1987; and Horstmann and Markusen 1986). Melitz and Ottaviano (2008) also show how liberalization affects firm selection and causes shifts in the pattern of entry in the long run by allowing heterogeneous firms in their models.

Figure 2: Total Intra-Regional Imports as a Share of Total Imports



Source: IMF, Direction of Trade Statistics.

4. REGIONAL INTEGRATION AND TOTAL FACTOR PRODUCTIVITY IN EUROPE

4.1 Empirical Specifications

The neoclassical framework summarized in the previous section treats TFP changes as exogenous, even though the theory recognizes TFP to be a key determinant of long-run economic growth. A wave of more recent theoretical models of economic growth has tried to endogenize technological progress so that TFP changes can be explained within the model. These so-called endogenous growth models are broadly grouped into two types: the horizontally-differentiated inputs (HDI) approach following Romer (1990) and the vertically-differentiated inputs (VDI) approach following Aghion and Howitt (1992). In these models, TFP growth is determined endogenously, instead of being exogenous, depending on the number of available intermediate inputs in the HDI approach and the number of improvements in the quality of a given input in the VDI approach.

Since R&D increases the number of available inputs (HDI approach) or improves the quality of inputs (VDI approach), both approaches imply that TFP is rising with cumulative R&D spending. If there is no international trade in intermediate inputs, changes in a country's TFP would be explained by changes in its domestic R&D capital stock. In contrast, TFP of an individual country would depend on the entire world's R&D capital stock if trade in intermediate inputs is completely free with no transportation cost. Obviously, neither of these scenarios is realistic, and sensible specifications for empirical implementation of endogenous growth models involve a mix of both tradable and non-tradable inputs. Therefore, we adopt empirical specifications proposed initially by Coe and Helpman (1995) in which variations in TFP are explained by variations in both the domestic and foreign R&D capital stocks. The baseline specification takes the following form:

$$\log A_i = \phi_i^0 + \phi_i^D \log D_i + \phi_i^F \log F_i + \varepsilon_i \qquad (6)$$

where i is a country index, A is TFP, D represents the real domestic R&D capital stock, F represents the real foreign R&D capital stock, and ε is a well-defined error.

In addition to R&D capital stocks, human capital is another key long-run determinant of TFP that has been widely recognized in the literature.[6] So we also consider the following specification that includes human capital as an additional explanatory variable:

$$\log A_i = \phi_i^0 + \phi_i^D \log D_i + \phi_i^F \log F_i + \phi_i^H \log H_i + \varepsilon_i \qquad (7)$$

where *H* is a measure of human capital proxied by average years of schooling from Barro and Lee (2013). Since the original data are reported only every 5 years, we interpolated them to acquire a series of annual data.[7] Our measure represents the average level of human capital.[8]

Based on Eqs. (6) and (7), we examine how the progress of European integration affects the region's TFP by introducing three dummy variables: *EC*, *EU*, and *EURO*. *EC* represents membership of a free trade arrangement in Europe; *EU* represents membership of a single market in Europe; and *EURO* represents membership of the eurozone. *EU* captures the effect of establishing the free movement of money and people in addition to free trade, and *EURO* captures the additional effect of establishing a common currency area inside the single market. To take Austria as an example, both *EC* and *EU* variables take the value 1 from 1995 when the country joined the EU,[9] and *EURO* takes the value 1 from 1999 when it joined the eurozone.

In our analysis, we use discrete dummy variables such as *EC*, *EU*, and *EURO* instead of continuous variable indicators to measure the depth of regional integration, mainly because we are interested in examining different models of integration rather than ascertaining the effects of economic integration per se. It is also very likely that the depth of integration measured by continuous variable indicators reflects not only the effects of regional integration, but also those of the general trend of globalization during the same period. Furthermore, Figure 2 shows the limitation of any single continuous variable measure of trade or investment in effectively capturing changes in the overall depth of regional integration over time, possibly due to dynamic adjustments taking place in trade and investment in the course of the integration process.

In our regressions, three dummy variables are included in Eqs. (6) and (7) to account for any windfall effects on TFP from the transition to a deeper model of economic integration. It is also possible that different models of regional integration have differing effects on TFP of member countries, mainly by altering the extent to which a country's TFP depends on each of the two types—domestic and foreign—of R&D capital stocks of the country. Subsequently, our three dummy variables are interacted with the domestic and foreign R&D capital stocks in Eqs. (6) and (7).

4.2 Data

For our analysis, we have chosen a sample of 24 countries from the Organisation for Economic Co-operation and Development (OECD): Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Republic of Korea, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom (UK), and the United States (US). For each country, total factor productivity *A* is defined as,

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[6] For example, see Engelbrecht (1997).

[7] The data of Barro and Lee (2013) is available only up to 2010. We extrapolated the series to 2011 by using the annual change over 2005–2010.

[8] For example, Lucas (1988) assumes that each producer benefits from the average level of human capital in the economy, rather than the aggregate, in his analysis of knowledge spillovers.

[9] In this setup, the EU can be seen as a combination of a free trade arrangement and an arrangement that allows the free movement of money and people.

$$A = Y / [K^{\propto} L^{(1-\propto)}] \quad (8)$$

where Y is constant price GDP adjusted in 2005 prices, K is productive capital stock measured in volume, and L is total hours worked (except for Austria where L is total employment). All variables are constructed as indices with 2005 = 1. The coefficient (1 – ∝) is the average share of labor income from 2005 to 2008. All data are from the OECD's Annual National Accounts database or the OECD Economic Outlook database.[10] Missing data for the productive capital stock of Germany, Greece, and Ireland in certain years are filled in using the growth rate of the government and private non-residential net capital stock estimated by Kamps (2005), while correcting for the difference in the growth rate between the productive and net capital stocks based on the past trend.[11]

R&D capital stocks are estimated using R&D expenditure data from the OECD's Science, Technology and Patents statistics. R&D expenditure is in constant price (adjusted in 2005 prices) US dollar expenditure based on the 2005 purchasing power parity exchange rate in US dollars per local currency. For a number of countries in our sample, R&D expenditure data are not available over the entire 1981–2010 period. In line with Coe et al. (2009), missing observations for R&D expenditure are estimated using the predicted values from ordinary least squares (OLS) regressions relating real R&D expenditure to real GDP and real non-residential fixed capital formation (all in logarithms). A time trend and its square, if found to be statistically significant, are also included in the regressions.

Real domestic R&D capital stocks (*D*), defined as beginning of period stocks, are calculated from real R&D expenditure (*R*) based on the perpetual inventory method.

$$D_t = (1 - \delta)\, D_{t-1} + R_{t-1} \quad (9)$$

where the depreciation rate, δ, was assumed to be 5%. The benchmark was calculated as,

$$D_0 = R_0 / (g + \delta) \quad (10)$$

where g is the annual average logarithmic growth rate of R&D expenditure (*R*) over the period for which published R&D data are available, and R_0 is R&D expenditure in the first year for which the data are available. The benchmarks for most countries are calculated for 1981 except for Belgium (1983) and Portugal (1982). For Israel and the Republic of Korea, for which R&D data are available only from 1991, the benchmarks are calculated for 1981 using the predicted values of real R&D expenditure for 1981.

The real foreign R&D capital stock is constructed using the domestic R&D capital stocks of each country's 23 trade partners. Following Coe and Helpman (1995) and Coe et al. (2009), we use a bilateral import-share weighted average of the domestic R&D capital stocks of trade partners as an estimate of the foreign R&D capital stock. The bilateral import shares are calculated for each year based on the Direction of Trade database of the International Monetary Fund (IMF). Formally, the real foreign R&D capital stock for country *i* is defined as

$$F_i = \sum_{j \neq i} \left(\frac{M_{ij}}{\sum_{j \neq i} M_{ij}}\right) D_j \quad (11)$$

where $\sum_{j \neq i}(M_{ij} / \sum_{j \neq i} M_{ij}) = 1$, and M_{ij} is country *i*'s imports of goods and services from country *j*. Table 1 provides summary statistics of the domestic and foreign R&D capital stocks as well as TFP and human capital for our sample of 24 OECD countries.

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[10] Official data for unified Germany is available only from 1991. Up to 1990, OECD estimates data for the whole of Germany based on data for West Germany.

[11] Kamps (2005) provides net capital stock estimates for 22 OECD countries over 1960–2001. Data are available from: https://www.ifw-kiel.de/forschung/datenbanken/netcap.

Table 1: Summary Statistics

	A_{11}/A_{85}	D_{11}/D_{85}	F_{11}/F_{85}	H_{11}	H_{85}
Australia	5.07	2.10	2.90	11.54	12.17
Austria	4.12	1.88	3.26	7.51	9.58
Belgium	2.32	1.99	2.88	9.04	10.65
Canada	3.11	2.35	2.74	10.00	12.07
Denmark	4.56	1.60	1.91	10.04	10.09
Finland	5.97	1.44	2.45	8.18	10.01
France	1.96	1.59	2.53	6.76	10.66
Germany	2.00	1.64	2.63	6.03	11.82
Greece	7.45	1.52	1.89	7.89	10.83
Iceland	9.74	2.89	1.91	8.30	10.86
Ireland	8.08	1.89	2.23	10.55	11.72
Israel	10.28	1.85	2.98	10.30	11.38
Italy	2.18	1.72	2.07	7.21	9.58
Japan	2.69	1.65	2.77	9.75	11.65
Republic of Korea	12.77	1.98	5.56	9.15	11.92
Netherlands	2.05	2.20	2.58	9.80	11.07
New Zealand	2.36	2.15	1.92	11.82	12.74
Norway	3.00	2.04	2.10	9.95	12.29
Portugal	8.90	0.97	4.13	6.20	8.07
Spain	6.55	1.20	5.13	6.40	10.51
Sweden	2.99	1.48	2.11	9.77	11.58
Switzerland	2.12	2.06	2.49	9.81	9.97
United Kingdom	1.47	1.96	2.04	8.00	9.84
United States	2.49	1.78	1.91	12.09	13.13
Average	4.76	1.83	2.71	9.00	11.01
Standard Deviation	3.21	0.39	0.97	1.75	1.18

Notes: *A* is total factor productivity; *D* is the real domestic R&D capital stock; *F* is the real foreign R&D capital stock; *H* is average years of schooling.

4.3 Empirical Results

Table 2 presents the results of fixed effects regressions based on the specification of Eq. (6). The regression results reported in equation (i) show that a country's TFP depends not only on the domestic R&D effort but also on R&D spillovers from abroad, consistent with theoretical predictions. Both the domestic and foreign R&D capital stocks are found to be highly significant contributors to TFP with similar effects. Based on the same sample of OECD countries as used in our study, Coe et al. (2009) find a smaller coefficient on domestic R&D capital but a larger coefficient on foreign R&D capital compared to our estimates. This difference may be due to the fact that they use a different time period (1971–2004) and focus on the business sector rather than on the entire economy. In running regressions on Eq. (6), we also included unreported year-specific constants in equations (iii). Including year-specific constants reduces the size of the estimated coefficients on both the domestic and foreign R&D capital stocks, and in particular makes the coefficient on foreign R&D capital highly insignificant.

Table 2: Total Factor Productivity Estimation (Three Stages of European Integration)

	With no year-specific constants		With year-specific constants	
	(i)	(ii)	(iii)	(iv)
EC		0.7959 (0.209)		1.0100 (0.113)
EU		-1.4628** (0.011)		-1.5590*** (0.005)
EURO		-1.3171*** (0.006)		-1.9332*** (0.000)
log *D*	0.1213*** (0.000)	0.1076*** (0.000)	0.0623*** (0.000)	0.0573*** (0.000)
EC log *D*		-0.0315** (0.013)		-0.0378*** (0.003)
EU log *D*		0.0011 (0.825)		-0.0036 (0.474)
EURO log *D*		-0.0152*** (0.007)		-0.0210*** (0.000)
log *F*	0.1126*** (0.000)	0.0666*** (0.002)	0.0067 (0.764)	-0.0421 (0.106)
EC log *F*		-0.0324 (0.515)		-0.0456 (0.355)
EU log *F*		0.1137*** (0.009)		0.1246*** (0.003)
EURO log *F*		0.1128*** (0.002)		0.1622*** (0.000)
Within $\mathbf{R}^2$	0.6063	0.6811	0.6678	0.7298
Observation	648	648	648	648
F	478.88*** (0.0000)	119.01*** (0.0000)	42.78*** (0.0000)	42.85*** (0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.

The dependent variable is $\log$(*total factor productivity*). *D* is the real domestic R&D capital stock; *F* is the real foreign R&D capital stock. *EC* represents membership of a free trade arrangement in Europe, *EU* membership of a single market in Europe, and *EURO* membership of the eurozone.

To test for the potential impact of different models of regional integration on TFP, three dummy variables each representing different models of European integration—*EC*, *EU*, and *EURO*—are included and are also interacted with R&D capital stocks in Eq. (6). The estimated constant *EC* reported in equation (ii) suggests the possibility that the membership of a free trade arrangement in Europe has produced positive windfall effects on the TFP of participating countries. However, it appears that advancing the integration process beyond the free trade arrangement has not resulted in any additional windfall benefits for TFP in individual member countries. The estimates of *EU* and *EURO* constants, respectively representing the additional effects of joining a single market and a common currency area in the region, are in fact negative and highly significant.

The results reported in equation (ii) also show that different models of regional integration affect TFP through their impact on R&D. The estimated coefficients on *EC* and *EURO* interacted with domestic R&D capital are negative and statistically significant. In contrast, *EU* and *EURO* interacted with foreign R&D capital enter equation (ii) positively and significantly. These results can be interpreted to imply that a country's TFP tends to depend increasingly less on its own R&D effort and more on international R&D spillovers as the country takes part in increasingly deeper forms of regional integration. The same trend is also detected in equation (iv) that includes unreported year-specific constants.

Table 3 reports the estimates of fixed effects regressions ran on Eq. (7) that includes the logarithm of human capital as an additional explanatory variable. The estimated coefficients on a measure of human capital—average years of schooling—in equations (i) and (ii) indicate that human capital formation has highly significant and positive effects on total factor productivity, consistent with the theoretical literature. However, our measure of human capital enters with the incorrect sign in equation (iii) or becomes insignificant in equation (iv) if we include year-specific constants. Turning to the impact of different models of regional integration on TFP, our results using equations (ii) and (iv) give more or less the same picture as the one resulting from our previous estimates based on Eq. (6). As shown in Table 3, the estimated coefficients on individual dummies of European integration and how these dummies interacted with R&D capital stocks are in close sync with their counterparts reported in Table 2.

Table 3: Total Factor Productivity Estimation (Three Stages of European Integration)

	With no year-specific constants		With year-specific constants	
	(i)	(ii)	(iii)	(iv)
EC		0.8296 (0.190)		1.0048 (0.114)
EU		-1.5031*** (0.009)		-1.5664*** (0.005)
EURO		-1.4178*** (0.003)		-1.9914*** (0.000)
log *D*	0.1132*** (0.000)	0.0975*** (0.000)	0.0616*** (0.000)	0.0524*** (0.000)
EC log *D*		-0.0332*** (0.009)		-0.0385*** (0.002)
EU log *D*		-0.0030 (0.598)		-0.0060 (0.274)
EURO log *D*		-0.0198*** (0.001)		-0.0236*** (0.000)
log *F*	0.1058*** (0.000)	0.0651*** (0.003)	-0.0012 (0.956)	-0.0408 (0.118)
EC log *F*		-0.0336 (0.499)		-0.0445 (0.367)
EU log *F*		0.1199*** (0.006)		0.1270*** (0.003)
EURO log *F*		0.1238*** (0.001)		0.1685*** (0.000)
log *H*	0.0793* (0.063)	0.1073* (0.084)	-0.0922** (0.046)	0.0648 (0.281)
Within R^2	0.6085	0.6826	0.6700	0.7303
Observation	648	648	648	648
F	321.69*** (0.0000)	109.70*** (0.0000)	41.65*** (0.0000)	41.76*** (0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.
The dependent variable is log(*total factor productivity*). *D* is the real domestic R&D capital stock; *F* is the real foreign R&D capital stock; *H* is average years of schooling. *EC* represents membership of a free trade arrangement in Europe, *EU* membership of a single market in Europe; and *EURO* membership of the eurozone.

The regression results in Tables 2 and 3 show how the adoption of a deeper model of regional integration is likely to change the extent to which an individual member country's TFP depends on each of its domestic and foreign R&D capital stocks. Our results show the declining importance of domestic R&D accompanied by the rising influence of R&D spillovers from abroad. It may be expected that the transition to a deeper form of economic integration enables a participating country to depend less on the domestic source of R&D by enjoying more opportunities to take advantage of R&D capital outside the country. However, our findings of the increasing dependence on foreign R&D capital do not necessarily imply a rise in intra-regional dependence on cross-border R&D spillovers with the advancement of regional integration. This is because our measure of the foreign R&D capital stock includes not only the R&D stocks of members of a particular European regional arrangement, but also those of non-member countries.

To examine intra-regional dependence on cross-border R&D spillovers, we break down the foreign R&D spillovers into two components: R&D spillovers from members and R&D spillovers from non-members. Subsequently, we estimate a modified specification of Eq. (7) that allows for this breakdown:

$$\log A_i = \phi_i^0 + \phi_i^D \log D_i + \phi_i^{FE} \log F_i^E + \phi_i^{FN} \log F_i^N + \phi_i^H \log H_i + \varepsilon_i \qquad (12)$$

where F_i^E represents the part of the foreign R&D capital stock, F_i, in Eq. (7) that originates from countries within a particular regional arrangement in Europe, and F_i^N represents the foreign R&D capital stock from countries outside the arrangement ($F_i = F_i^E + F_i^N$).

We also consider another specification that reflects the potential role to be played by the level of imports in determining the degree of cross-border R&D spillovers. In the existing theoretical and empirical literature, international trade is widely assumed to be a main channel of cross-border R&D spillovers. This assumption is behind the construction of our measure of the foreign R&D capital stock that is a bilateral import-share weighted average of the domestic R&D capital stock of trade partners. If international trade is the potent channel, it is also plausible that the degree of cross-border R&D spillovers may depend on the level of imports of the recipient country. That is, the country that imports more (relative to its GDP) from a certain group of countries may benefit more from their R&D. Subsequently, we estimate the following specification that allows the impact of R&D spillovers to vary with the level of imports from the source country:

$$\log A_i = \phi_i^0 + \phi_i^D \log D_i + \phi_i^{FEm} m_i^E \log F_i^E + \phi_i^{FNm} m_i^N \log F_i^N + \phi_i^H \log H_i + \varepsilon_i \qquad (13)$$

where m_i^E stands for the fraction of imports in GDP that come from a particular regional arrangement in Europe, and m_i^N stands for the share of imports that come from outside the regional arrangement. We only consider the imports of 24 countries in our sample.

In conducting regression analysis based on Eqs. (12) and (13), we divide our sample period into three sub-periods: (I) 1985–1992, (II) 1993–2011, and (III) 1999–2011. In period (I), European integration mainly took the form of a free trade arrangement focusing on intra-regional trade in goods and some services. To represent membership of the customs union in Europe during this period, we introduce a dummy variable *EC* that equals 1 if the country is a member of the customs union. The customs union in Europe moved to the next phase of regional integration with the establishment of the single market in 1993, in which the scope of European integration extended beyond intra-regional trade in goods and services to cover the movement of money and people as well. Membership of the single market during period (II) is denoted by a dummy variable *EU´* that equals 1 if the country is a member of the European single market.[12] Finally, period

[12] *EU´* is different from *EU* used in Tables 2 and 3. *EU´* measures the whole effect of the single market including the effect of its free trade component, whereas *EU* only captures the additional effect of achieving the free movement of money and people, not including the effect of the free trade component.

(III) represents the period of the eurozone, its membership represented by a dummy variable *EURO´* that equals 1 for eurozone countries.[13] For each of the three sub-periods, a relevant dummy variable enters separately and also interacted with domestic R&D capital and the two types of foreign R&D capital in regressions based on Eqs. (12) and (13).

Table 4 presents the regression results for period (I), i.e., 1985–1992. We divide foreign R&D capital into two types—R&D capital located inside the European customs union and R&D capital outside it—to separate out intra-regional R&D spillovers. To facilitate comparisons, the basic specification for equations (i) and (iv) corresponds to Eq. (7) that includes a single measure of the foreign R&D capital stock before it is broken down into the two types. Estimation results using equations (i) and (iv) indicate that members of the customs union tend to be less dependent on their own domestic R&D than non-members, but that there is no significant difference in the degree of reliance on international R&D spillovers between the two groups, which is consistent with earlier findings reported in Table 3. However, the breakdown of foreign R&D capital into the two types, as reported in equations (ii) and (v), suggests a change in the makeup of R&D spillovers into a country after the country enters a free trade arrangement. We find that the members of a free trade arrangement clearly increase their dependence on intra-regional R&D spillovers but decrease their dependence on R&D spillovers from outside the arrangement. The results in equations (iii) and (vi), which are based on Eq. (13), show that the dependence on intra-regional R&D spillovers rises with the level of intra-regional imports. A member country that tends to import more (relative to GDP) from other member countries is expected to rely more on intra-regional R&D spillovers for increasing TFP.

[13] Again, *EURO´* is different from *EURO* (in Tables 2 and 3) that only captures the additional effect of forming a common currency area inside the single market, not including the effect of the single market itself.

Table 4: Total Factor Productivity Estimation (Free Trade Arrangement in Europe)

	With no year-specific constants			With year-specific constants		
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
EC	-0.0692	-0.8052	0.4033***	-0.0331	-1.4661*	0.3954***
	(0.906)	(0.271)	(0.007)	(0.960)	(0.066)	(0.009)
log *D*	0.1739***	0.1101***	0.1520***	0.1765***	0.1589***	0.1788***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
EC log *D*	-0.0437**	-0.0468**	-0.0434***	-0.0423*	-0.0568***	-0.0429***
	(0.034)	(0.023)	(0.008)	(0.051)	(0.007)	(0.009)
log *F*	-0.0080			-0.0043		
	(0.612)			(0.795)		
EC log *F*	0.0383			0.0344		
	(0.469)			(0.568)		
log $\boldsymbol{F^E}$		0.0971***			0.1330***	
		(0.008)			(0.001)	
EC log F^E		0.1484**			0.2142***	
		(0.016)			(0.001)	
log $\boldsymbol{F^N}$		0.0138			0.0267**	
		(0.196)			(0.021)	
EC log F^N		-0.0455*			-0.0500*	
		(0.098)			(0.073)	
$\boldsymbol{m^E}$ log $\boldsymbol{F^E}$			-0.0008			0.0031
			(0.958)			(0.851)
EC m^E log F^E			0.0373**			0.0347*
			(0.050)			(0.072)
$\boldsymbol{m^N}$ log $\boldsymbol{F^N}$			0.0064			-0.0104
			(0.798)			(0.702)
EC m^N log F^N			-0.0337			-0.0369
			(0.477)			(0.447)
log *H*	0.2396***	0.1682**	0.2102***	0.2512***	0.1890**	0.2377***
	(0.003)	(0.028)	(0.004)	(0.002)	(0.012)	(0.002)
Within R^2	0.5751	0.6214	0.6094	0.5925	0.6564	0.6268
Observation	192	192	192	192	192	192
F	36.55***	32.83***	31.21***	17.34***	19.49***	17.13***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.
The dependent variable is $\log$(*total factor productivity*). *D* is the real domestic R&D capital stock; *F* is the real foreign R&D capital stock; *H* is average years of schooling. F^E represents the part of *F* that originates from countries within the free trade arrangement in Europe; F^N represents the part of *F* from countries outside the arrangement. m^E stands for the fraction of imports in GDP that comes from countries within the free trade arrangement in Europe; m^N stands for the fraction of imports from countries outside the arrangement. *EC* represents membership of a free trade arrangement in Europe.

Turning to the European single market, we report estimation results for period (II) in Table 5. The estimated coefficients on the single-market-membership dummy suggest that a single market is unlikely to result in any windfall benefits for TFP in its member countries. Indeed, the *EU´* constant tends to be strongly negative if found to be statistically significant. Using equations (i) and (iv), we find that the members of the single market tend to depend less on domestic R&D and benefit more from foreign R&D than non-members, consistent with earlier findings based on Eq. (7), using a single measure of foreign R&D capital. The breakdown into the two types of foreign R&D capital in equations (ii) and (v) shows that this rising reliance on international R&D spillovers has been driven largely by spillovers from the countries outside the European single market. The estimated coefficients on the interaction of the *EU´* dummy and foreign R&D capital from non-member countries are found to be considerably larger than the interaction with foreign R&D capital located in member countries. When the level of imports is included in measuring R&D spillovers from abroad, as in equations (iii) and (vi), the coefficients on the *EU´* dummy interacted with foreign R&D spillovers—foreign R&D capital multiplied by the level of imports—become consistently insignificant, regardless of whether R&D spillovers are from inside the European single market or not. In short, we find no evidence that the degree of intra-regional dependence on R&D spillovers increases in a single market.

Table 5: Total Factor Productivity Estimation (European Single Market)

	With no year-specific constants			With year-specific constants		
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
EU´	-1.2576** (0.037)	-2.7575*** (0.000)	0.2079 (0.222)	-1.4679*** (0.006)	-3.3942*** (0.000)	0.0915 (0.559)
log *D*	0.1337*** (0.000)	0.1218*** (0.000)	0.1132*** (0.000)	0.0995*** (0.000)	0.1500*** (0.000)	0.0536*** (0.001)
EU´ log *D*	-0.0230 (0.263)	-0.0505** (0.016)	-0.0101 (0.524)	-0.0421** (0.022)	-0.0612*** (0.001)	-0.0011 (0.939)
log *F*	-0.0339 (0.474)			-0.1890*** (0.000)		
EU´ log *F*	0.1199** (0.031)			0.1477*** (0.003)		
log $\boldsymbol{F^E}$		0.1674*** (0.000)			0.2369*** (0.000)	
EU´ log F^E		0.0593 (0.102)			0.0915*** (0.007)	
log $\boldsymbol{F^N}$		-0.1419*** (0.000)			-0.1690*** (0.000)	
EU´ log F^N		0.2091*** (0.000)			0.2340*** (0.000)	
$\boldsymbol{m^E}$ log $\boldsymbol{F^E}$			0.0273*** (0.008)			0.0041 (0.680)
EU´ m^E log F^E			-0.0106 (0.368)			0.0005 (0.963)
$\boldsymbol{m^N}$ log $\boldsymbol{F^N}$			-0.0464** (0.014)			-0.0182 (0.320)
EU´ m^N log F^N			-0.0204 (0.476)			-0.0428 (0.110)
log *H*	0.0664 (0.331)	-0.1357* (0.060)	0.0641 (0.345)	-0.2144*** (0.003)	0.1396** (0.041)	-0.1832** (0.011)
Within $\mathbf{R^2}$	0.5068	0.5858	0.5191	0.6368	0.6885	0.6314
Observation	456	456	456	456	456	456
F	72.95*** (0.0000)	74.95*** (0.0000)	57.22*** (0.0000)	29.81*** (0.0000)	34.52*** (0.0000)	26.75*** (0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.
The dependent variable is $\log$(*total factor productivity*). *D* is the real domestic R&D capital stock; *F* is the real foreign R&D capital stock; *H* is average years of schooling. F^E represents the part of *F* that originates from countries within the single market arrangement in Europe; F^N represents the part of *F* from countries outside the arrangement. m^E stands for the fraction of imports in GDP that comes from countries within the single market arrangement in Europe; m^N stands for the fraction of imports from countries outside the arrangement. *EU´* represents membership of a single market in Europe.

Finally, Table 6 summarizes the results of our fixed effects regressions for period (III) in which European integration has advanced to its third stage, a common currency area, following the previous stages of a free trade arrangement and a single market. As is the case with the two prior stages of European integration, we continue to find a trend of rising dependence on international R&D spillovers accompanied by declining dependence on domestic R&D for eurozone member countries, as reported in equations (i) and (iv). The breakdown of the source of R&D spillovers into eurozone and non-eurozone countries shows that this rising dependence on international R&D spillovers does not signify a higher level of intra-regional reliance on R&D spillovers. In equations (ii) and (v), the estimated coefficients on the *EURO´* dummy interacted with foreign R&D capital located outside the eurozone are found to be larger than those on the interaction with foreign R&D capital located inside the eurozone. The estimated coefficients on the *EURO´* constant in these equations also suggest that highly negative windfall effects are associated with eurozone membership, as in the case of membership of the European single market.

Table 6: Total Factor Productivity Estimation (Eurozone)

	With no year-specific constants			With year-specific constants		
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
EURO´	-0.8380	-1.7667***	0.9705***	-1.0640	-2.2837***	0.8492***
	(0.249)	(0.008)	(0.000)	(0.113)	(0.000)	(0.000)
log *D*	0.1414***	0.0979***	0.0756***	0.1140***	0.1374***	0.1067***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
EURO´ log *D*	-0.1257***	-0.1432***	-0.1031***	-0.1101***	-0.1430***	-0.0922***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log *F*	-0.2243***			-0.2106***		
	(0.000)			(0.000)		
EURO´ log *F*	0.1517**			0.1577***		
	(0.017)			(0.007)		
log $\boldsymbol{F^E}$		0.0490*			0.0866***	
		(0.054)			(0.004)	
EURO´ log F^E		0.0905*			0.1110**	
		(0.056)			(0.012)	
log $\boldsymbol{F^N}$		-0.1664***			-0.1509***	
		(0.000)			(0.000)	
EURO´ log F^N		0.1576***			0.1770***	
		(0.000)			(0.000)	
$\boldsymbol{m^E}$ log $\boldsymbol{F^E}$			0.0223**			0.0199*
			(0.030)			(0.059)
EURO´ m^E log F^E			0.0020			-0.0030
			(0.882)			(0.808)
$\boldsymbol{m^N}$ log $\boldsymbol{F^N}$			-0.0064			-0.0195
			(0.590)			(0.101)
EURO´ m^N log F^N			-0.0016			0.0156
			(0.944)			(0.466)
log *H*	0.1902**	0.0396	0.1609*	0.0240	0.1302	0.1610
	(0.037)	(0.675)	(0.079)	(0.809)	(0.167)	(0.111)
Within $\mathbf{R^2}$	0.3063	0.3464	0.2854	0.4616	0.4905	0.4277
Observation	312	312	312	312	312	312
F	20.75***	18.55***	13.98***	12.86***	12.90***	10.01***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.

The dependent variable is $\log$(*total factor productivity*). *D* is the real domestic R&D capital stock; *F* is the real foreign R&D capital stock; *H* is average years of schooling. F^E represents the part of *F* that originates from countries within the eurozone; F^N represents the part of *F* from countries outside the eurozone. m^E stands for the fraction of imports in GDP that comes from countries within the eurozone; m^N stands for the fraction of imports from countries outside the eurozone. *EURO´* represents membership of the eurozone.

In estimating the foreign R&D capital stock, various alternative measures are proposed in the literature in addition to our measure defined in Eq. (11). Among others, Lichtenberg and van Pottelsberghe de la Potterie (1998) define the foreign R&D capital stock for country *i* as:

$$F_i^{LP} = \sum_{j \neq i} \left(\frac{M_{ij}}{Y_j}\right) D_j \tag{14}$$

where Y_j is nominal GDP in country j.[14]

Using this alternative measure of foreign R&D capital, we repeated our regressions based on Eqs. (6), (7), (12), and (13). The regression results are presented in the Appendix. Compared with previous regressions using the measure defined in Eq. (11), the use of the alternative measure tends to enlarge the effects of foreign R&D capital on TFP with the effects of domestic R&D capital considerably reduced. However, our major findings regarding European integration remain broadly intact with the use of the alternative measure.

5. CONCLUSIONS

Until just over half a century after its inception, European integration had been widely touted as the biggest success story of regional integration, as the countries of Europe had successfully managed to move the region's integration forward step by step. At least until the onset of the current economic crisis, the steps taken in Europe were viewed as representing a model progression in evolving regional integration with the creation of a common currency area generally regarded as the ideal conclusion of the whole process. Discussions about the possibility of establishing a common currency in policy debates in other regional groupings outside Europe, including Asia, had been commonplace until recently. But any excitement about a common currency area quickly died down in the wake of the euro crisis; the new conventional wisdom appears to be that Europe got everything right except for the euro.

Can this new conventional wisdom serve as a proper lesson for various other initiatives of regional integration including the ones in Asia? This is the question that had motivated our study in the first place. In trying to derive lessons from Europe, we proposed three models of regional integration based on the European experience: a free trade arrangement, a single market, and a common currency area. To make sensible comparisons between the three different models, we used each model's effects on long-term economic growth as a basis for comparison. Long-term economic growth seems to be a reasonable yardstick given that no regional grouping is likely to be sustainable if it fails to improve participating countries' standards of living in the long run. In evaluating long-term growth implications of different models for regional integration, we focused on total factor productivity (TFP) because its growth rate determines the slope of the long-term growth path.

Existing growth theory suggests TFP and research and development (R&D) capital stocks are closely linked. Consistent with theoretical predictions, our estimation results showed that a country's TFP depends not only on its own R&D capital stocks, but also on the R&D capital stocks of its trade partners. A country's aggregate human capital measured by average years of schooling was also found to be a significant determinant of its TFP. As European integration advanced to increasingly deeper stages, we found that participating countries tended to decrease their dependence on domestic R&D, but increased their reliance on R&D spillovers from abroad. This rising reliance on foreign R&D, however, does not necessarily represent a higher level of intra-regional dependence within the regional grouping. At the free trade arrangement stage, the degree of intra-regional dependence clearly increases as participating countries increase their reliance on R&D spillovers from fellow member countries, but decrease their reliance on R&D spillovers from outside the arrangement. However, the European experience provides no evidence that intra-regional dependence on R&D spillovers

[14] Data is from the International Monetary Fund's World Economic Outlook database.

further increases as regional integration deepens beyond the free trade arrangement stage. While we found that countries benefit more from international R&D spillovers—from both inside and outside the arrangement—under the two models of the single market and the common currency area, the beneficial effects on TFP were found to be substantially larger for R&D spillovers from the outside than for those from the inside.

Our evidence suggests that joining regional groupings changes the way participating economies grow. No matter which model of regional integration the groupings adopt, domestically powered growth becomes less important, and regionally powered growth becomes the new source of growth. In fact, countries often join regional groupings with the aim of finding new engines of economic growth. However, the relative importance of regionally powered growth does not appear to linearly increase with the advancement of regional integration. As the existing theory identifies knowledge creation and its spillovers as key drivers of economic growth, regionally powered growth is expected to become relatively more important with a higher level of intra-regional dependence on R&D spillovers. Of the three models of regional integration, we found the free trade arrangement to be the most effective in promoting intra-regional dependence on R&D spillovers. The arrangement was also found to have potential to prop up the level of TFP once a country joins the arrangement. In contrast, any windfall effects on TFP tend to be largely negative for the other two models.

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APPENDIX

Table A1: Summary Statistics

	F_{11}^{LP}/F_{85}^{LP}
Australia	1.22
Austria	1.28
Belgium	1.29
Canada	1.01
Denmark	1.13
Finland	1.45
France	1.27
Germany	1.30
Greece	1.07
Iceland	1.15
Ireland	1.71
Israel	1.13
Italy	1.06
Japan	1.27
Republic of Korea	1.94
Netherlands	1.27
New Zealand	1.17
Norway	1.25
Portugal	1.34
Spain	0.98
Sweden	1.31
Switzerland	1.02
United Kingdom	1.27
United States	1.28
Average	1.26
Standard Deviation	0.21

Note: F^{LP} is the real foreign R&D capital stock.

Table A2: Total Factor Productivity Estimation (Three Stages of European Integration)

	With no year-specific constants		With year-specific constants	
	(i)	(ii)	(iii)	(iv)
EC		0.8656*** (0.000)		0.8287*** (0.000)
EU		-0.4367*** (0.004)		-0.4315*** (0.005)
EURO		0.2980*** (0.006)		0.2923*** (0.007)
log *D*	0.0699*** (0.000)	0.0432*** (0.001)	0.0473*** (0.000)	0.0167 (0.261)
EC log *D*		0.0515** (0.035)		0.0711*** (0.004)
EU log *D*		-0.0535*** (0.004)		-0.0618*** (0.001)
EURO log *D*		-0.0128 (0.393)		-0.0131 (0.378)
log $\boldsymbol{F^{LP}}$	0.1363*** (0.000)	0.1512*** (0.000)	0.0760*** (0.000)	0.1063*** (0.000)
EC log F^{LP}		-0.1457*** (0.000)		-0.1632*** (0.000)
EU log F^{LP}		0.1089*** (0.001)		0.1166*** (0.001)
EURO log F^{LP}		-0.0140 (0.558)		-0.0141 (0.552)
Within $\mathbf{R^2}$	0.6348	0.6815	0.6759	0.7091
Observation	648	648	648	648
F	540.69*** (0.0000)	119.26*** (0.0000)	44.40*** (0.0000)	38.66*** (0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.

The dependent variable is $\log$(*total factor productivity*). *D* is the real domestic R&D capital stock; F^{LP} is the real foreign R&D capital stock. *EC* represents membership of a free trade arrangement in Europe, *EU* represents membership of a single market in Europe, and *EURO* represents membership of the eurozone.

Table A3: Total Factor Productivity Estimation (Three Stages of European Integration)

	With no year-specific constants		With year-specific constants	
	(i)	(ii)	(iii)	(iv)
EC		0.8180*** (0.000)		0.7747*** (0.000)
EU		-0.4518*** (0.003)		-0.4478*** (0.004)
EURO		0.2798*** (0.010)		0.2758** (0.011)
log *D*	0.0712*** (0.000)	0.0512*** (0.000)	0.0451*** (0.000)	0.0243 (0.121)
EC log *D*		0.0460* (0.063)		0.0656*** (0.008)
EU log *D*		-0.0488*** (0.010)		-0.0566*** (0.003)
EURO log *D*		-0.0065 (0.679)		-0.0063 (0.683)
log $\boldsymbol{F^{LP}}$	0.1415*** (0.000)	0.1526*** (0.000)	0.0856*** (0.000)	0.1089*** (0.000)
EC log F^{LP}		-0.1347*** (0.000)		-0.1516*** (0.000)
EU log F^{LP}		0.1056*** (0.002)		0.1127*** (0.001)
EURO log F^{LP}		-0.0190 (0.432)		-0.0195 (0.414)
log *H*	-0.0358 (0.418)	-0.0893 (0.146)	-0.1261*** (0.006)	-0.0941 (0.124)
Within $\mathbf{R^2}$	0.6352	0.6826	0.6801	0.7102
Observation	648	648	648	648
F	360.48*** (0.0000)	109.70*** (0.0000)	43.61*** (0.0000)	37.80*** (0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.
The dependent variable is log(*total factor productivity*). *D* is the real domestic R&D capital stock; F^{LP} is the real foreign R&D capital stock; *H* is average years of schooling. *EC* represents membership of a free trade arrangement in Europe, *EU* represents membership of a single market in Europe, and *EURO* represents membership of the eurozone.

Table A4: Total Factor Productivity Estimation (Free Trade Arrangement in Europe)

	With no year-specific constants			With year-specific constants		
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
EC	0.6347***	0.7043***	0.4205***	0.6066***	0.6421***	0.4277***
	(0.001)	(0.000)	(0.006)	(0.002)	(0.000)	(0.006)
log *D*	0.1095***	0.1770***	0.1494***	0.0600	0.0697*	0.1843***
	(0.000)	(0.000)	(0.000)	(0.107)	(0.067)	(0.000)
EC log *D*	-0.0040	-0.0496	-0.0449***	-0.0095	-0.0430	-0.0461***
	(0.893)	(0.157)	(0.007)	(0.757)	(0.216)	(0.006)
log $\boldsymbol{F^{LP}}$	0.1375***			0.1430***		
	(0.000)			(0.000)		
EC log F^{LP}	-0.0693*			-0.0607		
	(0.100)			(0.161)		
log $\boldsymbol{F^{LPE}}$		0.1215***			0.1708***	
		(0.000)			(0.000)	
EC log F^{LPE}		-0.0793**			-0.0680*	
		(0.032)			(0.063)	
log $\boldsymbol{F^{LPN}}$		-0.0253			-0.0726**	
		(0.362)			(0.015)	
EC log F^{LPN}		0.0552			0.0398	
		(0.198)			(0.340)	
$\boldsymbol{m^E}$ log $\boldsymbol{F^{LPE}}$			0.0003			0.0085
			(0.988)			(0.702)
EC m^E log F^{LPE}			0.0450*			0.0395
			(0.077)			(0.126)
$\boldsymbol{m^N}$ log $\boldsymbol{F^{LPN}}$			0.0243			0.0034
			(0.535)			(0.938)
EC m^N log F^{LPN}			-0.0379			-0.0266
			(0.588)			(0.710)
log *H*	0.2106***	0.1681**	0.1943***	0.1584**	0.0768	0.2234***
	(0.003)	(0.027)	(0.009)	(0.042)	(0.329)	(0.004)
Within R^2	0.6657	0.6793	0.6107	0.6759	0.7120	0.6257
Observation	192	192	192	192	192	192
F	53.76***	42.36***	31.37***	24.86***	25.22***	17.05***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.

The dependent variable is $\log$(*total factor productivity*). *D* is the real domestic R&D capital stock; F^{LP} is the real foreign R&D capital stock; *H* is average years of schooling. F^{LPE} represents the part of F^{LP} that originates from countries within the free trade arrangement in Europe; F^{LPN} represents the part of F^{LP} from countries outside the arrangement. m^E stands for the fraction of imports in GDP that comes from countries within the free trade arrangement in Europe; m^N stands for the fraction of imports from countries outside the arrangement. *EC* represents membership of a free trade arrangement in Europe.

Table A5: Total Factor Productivity Estimation (European Single Market)

	With no year-specific constants			With year-specific constants		
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
EU´	0.0017	-0.1196	0.1716	0.0091	-0.0847	0.0382
	(0.991)	(0.426)	(0.304)	(0.951)	(0.560)	(0.804)
log *D*	0.0807***	0.0952***	0.1175***	0.0615***	0.0758***	0.0584***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
EU´ log *D*	-0.0208	-0.0371*	-0.0081	0.0051	-0.0086	0.0023
	(0.311)	(0.070)	(0.606)	(0.795)	(0.674)	(0.873)
log $\boldsymbol{F^{LP}}$	0.1076***			0.0671***		
	(0.000)			(0.002)		
EU´ log F^{LP}	0.0303			-0.0012		
	(0.231)			(0.961)		
log $\boldsymbol{F^{LPE}}$		0.1183***			0.0708***	
		(0.000)			(0.002)	
EU´ log F^{LPE}		-0.0002			-0.0090	
		(0.993)			(0.705)	
log $\boldsymbol{F^{LPN}}$		-0.0352			-0.0124	
		(0.101)			(0.581)	
EU´ log F^{LPN}		0.0713***			0.0389	
		(0.006)			(0.135)	
$\boldsymbol{m^E}$ log $\boldsymbol{F^{LPE}}$			0.0309**			0.0021
			(0.022)			(0.875)
EU´ m^E log F^{LPE}			-0.0105			0.0035
			(0.491)			(0.801)
$\boldsymbol{m^N}$ log $\boldsymbol{F^{LPN}}$			-0.0594**			-0.0218
			(0.042)			(0.442)
EU´ m^N log F^{LPN}			-0.0067			-0.0354
			(0.875)			(0.377)
log *H*	-0.1668**	-0.2189***	0.0474	-0.1931***	-0.2113***	-0.1883***
	(0.019)	(0.002)	(0.489)	(0.008)	(0.004)	(0.010)
Within R^2	0.5710	0.5889	0.5139	0.6330	0.6379	0.6260
Observation	456	456	456	456	456	456
F	94.49***	75.93***	56.03***	29.33***	27.51***	26.14***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.
The dependent variable is $\log$(*total factor productivity*). *D* is the real domestic R&D capital stock; F^{LP} is the real foreign R&D capital stock; *H* is average years of schooling. F^{LPE} represents the part of F^{LP} that originates from countries within the single market arrangement in Europe; F^{LPN} represents the part of F^{LP} from countries outside the arrangement. m^E stands for the fraction of imports in GDP that comes from countries within the single market arrangement in Europe; m^N stands for the fraction of imports from countries outside the arrangement. *EU´* represents membership of a single market in Europe.

Table A6: Total Factor Productivity Estimation (Eurozone)

	With no year-specific constants			With year-specific constants		
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
EURO´	0.2338	0.3562*	0.8969***	0.2423	0.3863**	0.8094***
	(0.248)	(0.064)	(0.000)	(0.198)	(0.036)	(0.000)
log *D*	0.0676***	0.0775***	0.0772***	0.1056***	0.1270***	0.1097***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
EURO´ log *D*	-0.1079***	-0.1207***	-0.0951***	-0.1026***	-0.1170***	-0.0879***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log $\boldsymbol{F^{LP}}$	0.0490***			0.0371*		
	(0.007)			(0.053)		
EURO´ log F^{LP}	0.0884***			0.0797***		
	(0.002)			(0.003)		
log $\boldsymbol{F^{LPE}}$		0.1283***			0.1310***	
		(0.000)			(0.000)	
EURO´ log F^{LPE}		-0.0088			-0.0330	
		(0.826)			(0.396)	
log $\boldsymbol{F^{LPN}}$		-0.0830***			-0.0955***	
		(0.006)			(0.004)	
EURO´ log F^{LPN}		0.1120***			-0.1277***	
		(0.007)			(0.001)	
$\boldsymbol{m^E}$ log $\boldsymbol{F^{LPE}}$			0.0280**			0.0267**
			(0.033)			(0.044)
EURO´ m^E log F^{LPE}			-0.0043			-0.0100
			(0.795)			(0.510)
$\boldsymbol{m^N}$ log $\boldsymbol{F^{LPN}}$			-0.0076			-0.0301
			(0.677)			(0.103)
EURO´ m^N log F^{LPN}			0.0113			0.0357
			(0.720)			(0.220)
log *H*	0.0105	-0.0444	0.1474	0.0516	0.0447	0.1505
	(0.908)	(0.617)	(0.108)	(0.581)	(0.623)	(0.134)
Within R^2	0.3349	0.3869	0.2846	0.4533	0.4917	0.4299
Observation	312	312	312	312	312	312
F	23.67***	22.09***	13.93***	12.44***	12.96***	10.10***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes: *, **, *** stand for, respectively, 10%, 5%, and 1% level of significance. The p-values are reported below the coefficient estimates.

The dependent Variable is log(*total factor productivity*). *D* is the real domestic R&D capital stock; F^{LP} is the real foreign R&D capital stock; *H* is average years of schooling. F^{LPE} represents the part of F^{LP} that originates from countries within the eurozone; F^{LPN} represents the part of F^{LP} from countries outside the eurozone. m^E stands for the fraction of imports in GDP that comes from countries within the eurozone; m^N stands for the fraction of imports from countries outside the eurozone. *EURO´* represents membership of the eurozone.