Symposium Paper

TFP Growth in Old and New Europe

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Using Solow-Törnqvist residuals as well as two alternative measurements, we present the estimates of total factor productivity (TFP) growth in a sample of 30 European economies for the period 1994–2004. In most of Western Europe, we find a deceleration of TFP growth since 2000. However, the economies of ‘New Europe’ exhibit a higher level of TFP growth overall and have slowed less than those of ‘Old Europe’. In the new market economies of Central and Eastern Europe, we find both high TFP growth as well as acceleration in the second half of the sample. Regression evidence from Western Europe suggests that product market regulation may adversely affect TFP growth and may thus impair convergence.

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INTRODUCTION

The economic integration of Europe has proceeded rapidly following the disintegration of the iron curtain two decades ago, despite pessimistic expectations of standard growth theory (Barro and Sala-i-Martin, 1991, 2005). Since 1990, growth in Central and Eastern Europe (CEE) has averaged 5.1% compared with 1.8% in the EU-15.¹ Yet, this convergence of GDP

¹Source: Jorgenson and Vu’s (2007) data set. Central and Eastern Europe is comprised of Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Romania, Russia, and Ukraine. Western Europe is defined as: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland,

per capita has often not been rapid enough for some critics and has stoked the political nostalgia for the days of socialism and central planning.

Certainly, a proper assessment of the Great European Integration episode will be a long-term project involving many different dimensions, and a single indicator such as GDP per capita may not do proper justice to it suffice, even if economists are convinced that it is the correct measure. In this paper, we assess the progress that has been made in the short period since 1994 in the new market economies of Europe along the dimension of total factor productivity (TFP), which is a measure of both technological progress as well as technical efficiency. As TFP growth is the source of all sustainable improvements in standards of living, it seems imperative to get good measurements of it as well as to understand its determinants. This paper constructs three different measures of productivity growth in a set of European economies: the standard Solow residual plus two alternatives which we have proposed elsewhere as an answer to measurement problems arising in transition economies countries (Burda and Severgnini, 2009). In doing so, we will also assess the determinants of TFP growth in the established Western European countries.

This task appears all the more important, as EU membership increasingly represents a Janus-faced economic challenge for the newcomers. On the one hand, EU trade integration has proceeded briskly since the completion of the internal market in the late 1980s and has accelerated since the accession of the 'new EU-12' (Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia). As evidence of this trade integration, consider that in 1995 German exports represented 22 % of GDP, but by 2007 had risen to over 45 %. The lion's share of this increase has been to the new accession nations and the rest of the EU.

The other face of Janus is the heavy hand of the EU's common external tariff and product and labor market regulations. In particular, the *acquis communautaires* have added to the regulatory burden of enterprises and may make convergence of the poorer members more difficult. Although the return to Europe contains much promise of economic order and stability, it also contains the prospect of adopting regulations which, in the medium term, may slow or even prevent convergence to the high standards of living already

and the United Kingdom. The EU-15 refers to Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. 'Old Europe' refers to those economies which have been relatively slow to reform their labor and product markets (Austria, Belgium, France, Germany, Greece, Italy, Portugal, Spain, and Switzerland).

enjoyed in developed Western Europe. After assessing evidence from 30 European economies in the period 1994–2004, we conclude that TFP growth was consistently higher in Central and Eastern relative to Western Europe and has even risen for some latecomers to market reforms (Bulgaria, Czech Republic, Lithuania, Russia, and Ukraine). These gains probably have more to do with the elimination of inefficiencies in production, distribution, and administration infrastructure than with technological progress. We also find that TFP growth in the ‘New Europe’ – not in the sense of NATO and defence policy but rather of supply side reforms – has consistently outpaced that of ‘Old Europe’. In the last section, we present suggestive evidence that product, but not labor market regulation may have had a role in determining the evolution of TFP growth in Western Europe in a period when cross-country differences appear to have increased.

THE IMPACT OF TFP GROWTH FOR EUROPEAN INTEGRATION

The fall of the iron curtain two decades ago was difficult to think about using standard economic models and paradigms. Siebert (1992) has aptly called it an ‘integration shock’. Following Eichengreen (1990), we find it convenient to define economic integration simply as the achievement of the efficient level of production and allocation of production factors made possible by the union of two or more regions. With this definition in mind, the following mechanisms of integration can be identified:

1. *Simple convergence*, driven by internal capital accumulation, to levels of GDP per capita given by common underlying fundamentals, as predicted by standard growth theory (eg Solow, 1956).
2. *Migration of labor* from labor-rich and capital-poor regions to labor-poor, capital rich ones.
3. *Capital mobility*, meaning the transfer of physical capital from richer regions or countries to poorer ones.
4. *Factor proportions (Heckscher-Ohlin) trade* to the extent that factor allocations of the regions involved lie in the zone of non-specialization.
5. *Acquisition of technological expertise and experience* by backward regions from wealthier regions.
6. *Efficiency gains* of existing capital equipment, education, labor force and technological know-how due to *better institutions, rule of law, and credible property rights*.

All of these mechanisms have been important in generating the impressive increases in living standards observed in the new market economies of

Europe since 1990. We will focus on the last two: improvements in multifactor productivity or efficiency, given redeployment of capital associated either with factor mobility or redeployment of resources in the course of structural change. As Hall and Jones (1999) have emphasized, differences in TFP deriving from human, infrastructural, institutional and especially social capital are decisive determinants of backwardness. In a telling comparison, they estimate that while per capita productivity in the USA at the end of the last century was roughly 35 times that of Niger, endowing the inhabitants of the latter with the physical and human capital endowments of the former would reduce raise their per capita productivity to only about an eighth of US levels.

Table 1 presents real GDP growth rates computed using data from the Penn World Table 6.2² and updated through 2005 by Jorgenson and Vu (2007).³ We consider the EU-27 less Cyprus, Luxembourg, and Malta, while adding Norway, Switzerland, Albania, Croatia, Russia, and Ukraine. Somewhat provocatively, we have divided up these nations into three groups: Old Europe, consisting of the larger continental economics which have been less prone to reform over the past 15 years; New Europe, comprised of those economies which have more aggressively deregulated product and labor markets over the same period; and CEE which in fact refers to all market economies of CEE – not only the new EU members but also Albania, Croatia, Ukraine, and Russia.⁴ Annual growth in New Europe exceeded that in Old Europe by almost 1.1 percentage points over the total sample period 1994–2004, but narrowed in the second half to 0.2%. In Eastern Europe, in contrast, real growth matched that of New Europe but accelerated over the decade 1994–2004 to 5.1% per annum over the period 1999–2004.

This divergence of outcomes is striking and supports the view that the economies of CEE are on a path to recovery from the initial integration shock of the first half of the 1990s. To what extent have these countries moved closer to the technological frontier, defined by the leading nations of the industrialized world? To what extent has structural change, while painful in the first instance, released factors of production to more efficient uses which

² See www.pwt.econ.upenn.edu.

³ The data set and a description of the variables can be downloaded using the following links: <http://dvn.iq.harvard.edu/dvn/dv/jorgenson/faces/study/StudyPage.xhtml?studyId=18798&rvn=5> and http://www.economics.harvard.edu/faculty/jorgenson/files/handbook_worldgrowthresurgenc_appendix_050810.pdf.

⁴ Including Russia is problematic due to the role of oil production and oil prices in GDP. Given its sometimes ambivalent but clearly European heritage, we have decided to keep Russia in, while remaining vigilant of potential issues of comparison.

Table 1: Average GDP growth rates, 1994–2004 (% per annum)

	1994–1999	2000–2004	1994–2004
<i>Old Europe</i>	2.2	1.8	2.0
Austria	2.6	1.8	2.2
Belgium	2.5	2.0	2.2
France	2.3	2.0	2.2
Germany	1.9	1.2	1.6
Greece	2.8	4.5	3.5
Italy	1.8	1.4	1.6
Portugal	3.6	1.3	2.5
Spain	3.4	3.4	3.4
Switzerland	1.3	1.3	1.3
<i>New Europe</i>	3.5	2.5	3.1
Denmark	3.2	1.4	2.4
Finland	4.2	2.8	3.6
Ireland	8.7	5.9	7.4
The Netherlands	3.5	1.3	2.5
Norway	4.1	2.2	3.2
Sweden	3.2	2.5	2.9
United Kingdom	3.2	2.7	3.0
<i>CEE</i>	0.2	5.1	2.4
Albania	6.2	5.6	5.9
Bulgaria	−0.8	4.8	1.7
Croatia	4.4	4.3	4.3
Czech Republic	2.0	3.1	2.5
Estonia	3.7	7.0	5.2
Hungary	3.2	4.5	3.8
Latvia	3.5	7.5	5.3
Lithuania	1.6	6.7	3.9
Poland	5.7	3.1	4.5
Romania	0.4	5.2	2.6
Russia	−3.2	6.6	1.3
Slovak Republic	4.6	4.0	4.3
Slovenia	4.4	3.4	3.9
Ukraine	−9.1	8.0	−1.3
<i>United States</i>	3.9	2.6	3.3

Source: Jorgenson and Vu's (2007) data set, authors' calculations

show up later in the productivity statistics? To answer these questions, we will need to take a closer look at TFP in our sample.

PROBLEMS IN ESTIMATING TFP IN CEE AND TWO ALTERNATIVES

The gold standard of multifactor productivity growth measurement is the Solow residual (Solow, 1957). This seductively simple measurement was

conceived for the case of two production factors, but was later extended by Denison (1962), and Jorgenson and Griliches (1967) to deal with any arbitrary number of inputs. Let Y_t , K_t , and N_t be real GDP, capital input and labor input measured in period t . Then the Solow residual measure is given by

$$\left(\frac{\Delta A}{A}\right)_{\text{Solow},t} = \frac{\Delta Y_t}{Y_{t-1}} - \omega \frac{\Delta K_t}{K_{t-1}} - (1 - \omega) \frac{\Delta N_t}{N_{t-1}} \quad (1)$$

where ω is the elasticity of output with respect to capital. We will implement generally in the ‘Solow-Törnqvist’ (ST) form:

$$\left(\frac{\Delta A}{A}\right)_{\text{ST},t} = \frac{\Delta Y_t}{Y_{t-1}} - \omega_{t-1} \frac{\Delta K_t}{K_{t-1}} - (1 - \omega_{t-1}) \frac{\Delta N_t}{N_{t-1}} \quad (2)$$

where $\omega_{t-1} = (s_{Kt} + s_{Kt-1})/2$, and s_{Kt} is the share of capital in national income in period t .

Solow derived equation (1) as a first order approximation to any continuous, quasi-concave, constant returns aggregate production function under the assumption of competitive factor and output markets. As the literature in productivity analysis as stressed, the Solow residual assumes full efficiency (Mohnen and Ten Raa, 2002), and thus in fact represents a mix of changes in TFP and efficiency of factor utilization. While the ‘dual’ measure of TFP growth (Jorgenson and Griliches, 1967; Hall, 1990; Röger, 1995; Barro, 1999) later gained popularity because it was robust to product market imperfections, the lack of reliable factor price data renders it impractical for a large number of countries.

An important weakness of both primal and dual TFP growth measures is that they require estimates of the capital stocks time series. Capital stocks are measured with significant error because they are fundamentally unobservable and rely on a particular theoretical model which links net increments to the capital stock to gross fixed domestic capital formation (investment expenditures). In particular, these capital stocks represent the solution of the ‘Goldsmith difference equation’ or perpetual inventory method (PIM).

$$K_{t+1} = (1 - \delta_t)K_t + I_t \quad (3)$$

which for an initial condition K_0 is given by

$$K_{t+1} = \left[\prod_{i=0}^t (1 - \delta_{t-i}) \right] K_0 + \sum_{j=0}^t \left[\prod_{i=0}^j (1 - \delta_{t-i}) \right] I_{t-j} \quad (4)$$

While measurements of investment are generally above reproach, the depreciation rate may be time varying and may even depend on the state of the business cycle. Most important in the current application, K_0 is not observed, and is in fact measured with significant error. Gollop (1980) employed the initial observation of investment as a measure of the initial capital stock; the US Bureau of Economic Analysis (BEA) (see Reinsdorf and Cover, 2005 and Sliker, 2007), multiplies the initial observation of investment by a factor $(1+g)/(\delta+g)$, which is a function of an assumed trend growth rate (g) and the capital depreciation rate (δ).

The importance of initial conditions will disappear in the limit for capital stocks constructed from longer investment time series for investment. Yet for the new market economies of CEE, measurement errors are likely to be severe. To underscore this point, we briefly review Monte Carlo evidence presented elsewhere (Burda and Severgnini, 2009). In that paper we set up, calibrated and simulated a stochastic growth model driven by a single trend-stationary stochastic process for TFP. This model was vintage RBC (eg King and Rebelo, 1999) with endogenous depreciation modeled as a convex function of capacity utilization as in Wen (1998). We used the synthetic data from this trend-stationary economy to evaluate the precision of the Solow residual by creating 100 independent realizations, each with 1,000 observations of output, labor, investment, consumption, and the level of TFP. For each data set, we constructed Solow residual measurements based on estimated capital stock times series generated using the PIM (3) with constant depreciation, plus an initial capital stock K_0 following either the BEA, a simple linear function of investment expenditures at the beginning of the sample, or Caselli (2005), who estimates the capital stock using a leading economy benchmark. These data thus resemble those available to researchers who do not know the true capital stock, but must estimate it from investment data and some initial condition.

As the true evolution of TFP in this data set is known, it is possible to evaluate the ‘goodness’ of the ST residual measure. In Table 2, we report results for the BEA and Caselli measures; details can be found in Burda and Severgnini (2009). In particular, we present root mean squared error (RMSE) statistics applied to our 100-realization experiment which corresponds to a ‘mature’ economy with a capital-output ratio close to the steady state value. In the second panel of Table 2, we report results for a second, ‘transition’ economy which is characterized by an initial condition for the capital stock which has been reduced to 50% of its steady state value. In the case of mature economy, both the ST residual RMSEs are in excess of 3.6% and range as high as 5.6% in the case of transition economy. As can be expected, the RMSE rises as the sample size declines. For the 200-quarter sample, the RMSE

Table 2: Monte Carlo evaluation of the accuracy of TFP estimates (RMSE, %)

TFP growth estimates	T=50	T=200
<i>Mature economy (100 realizations, standard errors in parentheses)</i>		
Solow residual/BEA estimate of K_0	3.6 (0.0)	2.0 (0.0)
Solow residual/Caselli (2005)/BEA estimate of K_0	3.6 (0.3)	2.0 (0.1)
Direct Substitution (DS)	0.9 (0.1)	0.9 (0.1)
Generalized differences (GD)	2.6 (0.2)	2.6 (0.1)
<i>Transition economy (100 realizations, standard errors in parentheses)</i>		
Solow residual/BEA estimate of K_0	4.6 (0.2)	2.9 (0.2)
Solow residual/Caselli (2005)/BEA estimate of K_0	5.3 (0.3)	2.8 (0.1)
Direct substitution (DS)	3.2 (0.2)	1.8 (0.1)
Generalized differences (GD)	4.9 (0.4)	3.4 (0.2)

Source: Burda and Severgnini (2009)

computed using the BEA method is 2.0% in the mature economy and 2.9% in the transition one. Evidently, mismeasurement of the initial capital stock will take some time to lose relevance in the Solow calculation, a problem that will be especially acute when assessing TFP growth in CEE countries.

Burda and Severgnini (2009) propose two alternatives to the Solow residual measure of TFP growth. The direct substitution measure (DS) is based on the same neoclassical production and market assumptions made by Solow(1957). Rewrite (3) and substitute in (1) to obtain

$$\left(\frac{\widehat{\Delta A}}{A}\right)_{DS,t} = \frac{\Delta Y_t}{Y_{t-1}} - \kappa_{t-1} \frac{I_{t-1}}{Y_{t-1}} - \omega_{t-1} \delta_{t-1} - (1 - \omega_{t-1}) \frac{\Delta N_t}{N_{t-1}} \quad (5)$$

where κ is the rental rate of capital. In effect, the DS approach eliminates the capital stock by reducing its presence to its (possibly time varying) depreciation element.

The second alternative measurement of TFP growth, the Generalized Difference (GD) approach, applies this transformation to data from an economy which is already relatively close to its steady state, in which it grows at constant rate g . Denote the log deviation of variable X_t from its steady

state $\bar{X}_t$ as $\hat{X}_t$, and write the production function and state equation for the capital stock as log-linearized relationships governing deviations from steady states values:

$$\hat{Y}_t = \hat{A}_t + \omega \hat{K}_t + (1 - \omega) \hat{N}_t \quad (6)$$

$$\hat{K}_{t+1} = \frac{1 - \delta}{1 + g} \hat{K}_t + i \hat{I}_t \quad (7)$$

with $i = \frac{(I/K)}{(1+g)L} = \frac{(I/Y)}{(K/Y)(1+g)}$ and g is the steady-state growth rate of the economy. Under constant depreciation and with the use of the lag operator L , equation 7 can be inverted to express investment as a GD operator applied to the capital stock: $I_t = (1 - (1 - \delta)/(1 + g) L) K_t$. Multiply both sides of (6) by $(1 - (1 - \delta)/(1 + g) L)$ and rewrite to obtain

$$\begin{aligned} \left(1 - \frac{1 - \delta}{1 + g} L\right) \hat{A}_{GD,t} &= \left(1 - \frac{1 - \delta}{1 + g} L\right) \hat{Y}_t - i \omega \hat{I}_t \\ &\quad - (1 - \omega) \left(1 - \frac{1 - \delta}{1 + g} L\right) \hat{N}_t \end{aligned} \quad (8)$$

Equation 8 can be employed to estimate GDs of TFP growth in each period, which in turn can be integrated from some initial condition, which must be estimated.⁵

Using the same synthetic data, we constructed the DS and GD measures of TFP growth described above to assess the RMSE of the ST measure. The results are summarized in the last two lines of the panels of Table 2: for 100 independent realizations (samples) of 200 quarters of data, the RMSE was improved significantly in all cases by the DS measure and in almost all cases by the GD method. In the shorter sample and for the transition economy, the improvement was sometimes dramatic; for example, the RMSE of the Solow residual constructed using BEA estimates of the initial capital condition were sometimes almost three times that of the DS approach, which was roughly 1.5%.⁶ Burda and Severgnini (2009) show that the precision of the ST residual using the conventional BEA capital stock estimates approach that of the DS measure only after about 400 quarters or 100 years.

⁵ Burda and Severgnini (2009) propose a special form of the Malmquist index to estimate this initial condition: an unweighted average of productivity growth in period 0 assuming no capital accumulation, and labor productivity growth in period 0.

⁶ Furthermore, this reduction of RMSE is statistically significant, based on standard errors estimated using the same realizations from the data-generating process. Detailed results are tabulated in Burda and Severgnini (2009).

EVALUATING TFP GROWTH IN EUROPE AND GROWTH ACCOUNTING

We now return to the real world and apply all three measurements – ST, DS, and GD – to Jorgenson and Vu’s (2007) data set of 30 nations listed in Table 1. Because the Jorgenson and Vu’s (2007) data do not contain aggregate capital stock estimates, we estimate them for all countries using the BEA method with $K_0 = I_0 / ((1 + g)/(g + \delta))$. Following Bernanke and Gärkaynak (2002), we compute the values of g as annual average output growth rate during the first 10 years available (ie 1960–1969)⁷ under the assumption that capital and output grow at the same rate in the long-run, while the capital depreciation rate δ and capital elasticity ω are set to 0.06 and 0.33, respectively, as suggested by Hall and Jones (1999). We then construct the capital series following (3). The DS and GD measurements do not require capital stock estimates but employ the same assumptions used to generate the Solow residuals. For the GD approach, we use 1994 as the starting year for TFP growth in order to avoid the sharp swings in measured output associated with the economic transformation. The results are presented in Table 3.

First, all measures confirm the suspicion that the anemic rate of growth in Old compared with New Europe largely reflects a low rate of TFP growth. This conclusion is supported by both the traditional ST measure as well as the two alternatives. Furthermore, all measures point to a slowdown of TFP growth in all of Europe since 2000. Although our analysis does not account for it explicitly, investment in information and communication technology (ICT) goods has been significantly lower in Europe than in the USA over most of the sample period (Van Ark *et al.*, 2008). It is all the more striking that TFP growth has also declined in the economies of New Europe, on all three measures, even in Scandinavian countries and the Netherlands, which are known to be heavy users and investors in ICT. In contrast to the Western European experience, average TFP growth on all measures in CEE *increased* over the two sub-samples, by 8.6% per annum for the GD approach to 3.8% per annum on the basis of the ST measure. (Given that the GD measure is conceived for economies close to their steady states, it is likely to be inappropriate for use in the CEE countries) It is natural to expect a significant degree of heterogeneity among the CEE estimates, and indeed for Croatia, Estonia, Hungary, Latvia, and Poland, individual estimates point to slowdown just as in the West. Yet for a great many countries we observe a quickening of TFP growth, which is consistent with efficiency gains and movement towards the technological frontier. Evidently, the first years of transformation to a

⁷ One exception is represented by Poland: because of shorter time series, we compute g for this country over the period 1994–2004.

Table 3: TFP estimates: Solow-Törnqvist (ST), direct substitution (DS), and generalized difference (GD), growth rates, average % per annum

	1994–1999			2000–2004			1994–2004		
	ST	DS	GD	ST	DS	GD	ST	DS	GD
<i>Old Europe</i>	1.2	1.5	1.5	0.3	0.8	1.0	0.8	1.2	1.3
Austria	1.7	2.1	1.3	1.0	1.3	0.9	1.4	1.7	1.1
Belgium	1.2	1.8	1.9	0.6	1.2	1.2	1.0	1.5	1.6
France	1.1	1.8	1.0	0.5	1.2	0.7	0.8	1.5	0.9
Germany	1.2	1.5	1.7	0.7	1.0	1.1	1.0	1.3	1.4
Greece	1.5	1.8	0.2	2.3	2.9	0.2	1.8	2.3	0.2
Italy	1.1	1.6	2.2	−0.4	0.1	1.5	0.4	0.9	1.9
Portugal	1.7	2.3	1.9	−0.5	0.0	1.2	0.7	1.2	1.6
Spain	0.4	0.9	1.3	−0.8	−0.2	0.8	−0.1	0.4	1.0
Switzerland	0.5	0.7	0.6	0.3	0.4	0.5	0.5	0.6	0.5
<i>New Europe</i>	1.8	2.6	1.5	0.9	1.9	1.0	1.4	2.3	1.3
Denmark	1.6	2.4	1.7	0.6	1.3	1.1	1.1	1.9	1.4
Finland	3.2	3.1	2.6	1.7	2.0	1.6	2.5	2.6	2.2
Ireland	4.0	5.1	1.9	1.7	3.3	1.2	2.9	4.3	1.6
The Netherlands	1.1	1.6	1.0	−0.3	0.3	0.5	0.5	1.0	0.8
Norway	2.2	2.7	2.0	1.4	2.1	1.1	1.8	2.4	1.6
Sweden	2.7	3.2	2.6	1.4	2.1	1.5	2.1	2.7	2.1
United Kingdom	1.6	2.7	1.3	1.0	2.2	1.0	1.3	2.5	1.2
<i>CEE</i>	1.7	0.6	−0.9	5.7	4.9	−0.5	3.5	2.5	−0.7
Albania	4.1	7.0	6.0	3.8	6.4	3.7	4.0	6.7	4.9
Bulgaria	0.5	0.4	0.6	4.0	4.2	0.9	2.1	2.1	0.7
Croatia	4.0	4.8	4.4	2.3	3.2	2.7	5.5	4.0	3.6
Czech Republic	4.8	1.1	1.7	6.3	2.0	1.5	2.7	1.5	1.6
Estonia	6.3	5.1	2.8	6.4	5.7	2.1	6.3	5.4	2.5
Hungary	2.7	2.9	2.9	2.9	3.4	1.8	2.8	3.1	2.4
Latvia	6.5	6.2	7.3	5.9	6.1	4.4	6.2	6.1	6.0
Lithuania	2.4	2.5	−0.8	7.8	8.2	0.8	4.8	5.1	−0.1
Poland	5.3	5.7	4.0	3.0	3.6	2.4	4.2	4.8	3.3
Romania	2.7	2.4	4.6	5.6	5.4	2.6	4.0	3.8	3.7
Russia	−0.2	−2.4	−5.5	8.0	6.3	−3.7	3.6	1.6	−4.7
Slovak Republic	4.5	3.4	4.3	3.5	2.7	2.4	4.0	3.1	3.4
Slovenia	3.1	3.3	2.7	1.9	2.3	1.6	2.5	2.8	2.2
Ukraine	−6.7	−8.2	−13.4	9.5	8.1	−7.6	0.6	−0.8	−10.8
<i>United States</i>	1.3	2.7	0.7	0.7	2.1	0.5	1.0	2.4	0.6

Source: Jorgenson and Vu's (2007) data set, authors' calculations

market economy offered substantial low-lying fruit involving the reorganization of production and establishment of Western-style business infrastructure and value added chains.

In Tables 4 and 5, we present conventional growth accounting exercises using three different TFP estimates for the two sub-periods 1994–1999 and 2000–2004. Note that while the ST residual measure relies on capital stock

Table 4: Growth accounting using the three methods, 1994–1999 (% per annum)

	Y	N	ST	K(ST)	DS	K(DS)	GD	K(GD)
<i>Old Europe</i>	2.2	0.4	1.2	0.6	1.5	0.2	1.5	0.3
Austria	2.6	0.1	1.7	0.8	2.1	0.5	1.3	1.3
Belgium	2.5	0.5	1.2	0.8	1.8	0.2	1.9	0.1
France	2.3	0.6	1.1	0.7	1.8	0.0	1.0	0.7
Germany	1.9	0.0	1.2	0.7	1.5	0.3	1.7	0.2
Greece	2.8	0.9	1.5	0.4	1.8	0.1	0.2	1.7
Italy	1.8	0.2	1.1	0.6	1.6	0.1	2.2	−0.5
Portugal	3.6	0.7	1.7	1.2	2.3	0.6	1.9	1.0
Spain	3.4	2.0	0.4	1.0	0.9	0.5	1.3	0.1
Switzerland	1.3	0.2	0.5	0.6	0.7	0.4	0.6	0.5
<i>New Europe</i>	3.5	1.0	1.8	0.7	2.6	−0.1	1.5	1.0
Denmark	3.2	0.9	1.6	0.7	2.4	−0.1	1.7	0.6
Finland	4.2	1.0	3.2	−0.1	3.1	0.0	2.6	0.6
Ireland	8.7	3.4	4.0	1.3	5.1	0.3	1.9	3.5
The Netherlands	3.5	1.6	1.1	0.8	1.6	0.3	1.0	0.8
Norway	4.1	1.3	2.2	0.6	2.7	0.0	2.0	0.8
Sweden	3.2	0.3	2.7	0.3	3.2	−0.2	2.6	0.4
United Kingdom	3.2	0.8	1.6	0.8	2.7	−0.3	1.3	1.0
<i>CEE</i>	0.2	−0.7	1.8	−0.8	0.6	0.3	−0.9	1.9
Albania	6.2	−1.0	4.1	3.0	7.0	0.2	6.0	1.2
Bulgaria	−0.8	−0.5	0.5	−0.8	0.4	−0.7	0.6	−0.9
Croatia	4.4	−0.7	4.0	1.1	4.8	0.3	4.4	0.7
Czech Republic	2.0	−0.2	4.7	−2.5	1.1	1.1	1.7	0.5
Estonia	3.7	−2.1	6.3	−0.5	5.1	0.7	2.8	3.0
Hungary	3.2	0.1	2.7	0.4	2.9	0.2	2.9	0.2
Latvia	3.5	−2.5	6.4	−0.5	6.2	−0.2	7.3	−1.3
Lithuania	1.6	−0.9	2.4	0.1	2.5	0.0	−0.8	3.3
Poland	5.7	−0.1	5.3	0.5	5.7	0.1	4.0	1.7
Romania	0.4	−2.0	2.7	−0.4	2.4	0.0	4.6	−2.2
Russia	−3.2	−1.1	−0.2	−1.9	−2.4	0.3	−5.5	3.5
Slovak Republic	4.6	−0.1	4.5	0.2	3.4	1.3	4.3	0.4
Slovenia	4.4	0.9	3.1	0.3	3.3	0.2	2.7	0.7
Ukraine	−9.1	−1.0	−6.7	−1.4	−8.2	0.1	−13.4	5.3
<i>United States</i>	3.9	1.2	1.3	1.3	2.7	−0.1	0.7	1.9

Abbreviations: Y: output growth; N: contribution of labor; K: contribution of capital; ST: Solow-Törnqvist; DS: direct substitution; GD: generalized difference.

Note: Differences due to rounding error.

Source: Jorgenson and Vu's (2007) data set, authors' calculations

estimates, the DS and GD methods employ only annual investment data. They imply a residual-like estimate of the contribution of growth in the capital stock which is reported in the sixth and eighth columns of Tables 4 and 5. While all measures point to a slowdown of TFP growth over the period, the alternative measures are less volatile, implying sharper drops in capital input growth.

Table 5: Growth accounting using the three methods, 2000–2004 (% per annum)

	<i>Y</i>	<i>N</i>	<i>ST</i>	<i>K(ST)</i>	<i>DS</i>	<i>K(DS)</i>	<i>GD</i>	<i>K(GD)</i>
<i>Old Europe</i>	1.8	0.7	0.3	0.8	0.8	0.3	1.0	0.1
Austria	1.8	0.0	1.0	0.8	1.3	0.4	0.9	0.9
Belgium	2.0	0.5	0.6	0.8	1.2	0.3	1.2	0.3
France	2.0	0.7	0.5	0.9	1.2	0.1	0.7	0.7
Germany	1.2	−0.1	0.7	0.5	1.0	0.3	1.1	0.1
Greece	4.5	0.9	2.3	1.2	2.9	0.6	0.2	3.3
Italy	1.4	1.0	−0.4	0.8	0.1	0.3	1.5	−1.2
Portugal	1.3	0.5	−0.5	1.3	0.0	0.9	1.2	−0.4
Spain	3.4	2.7	−0.8	1.5	−0.2	0.9	0.8	0.0
Switzerland	1.3	0.5	0.3	0.6	0.4	0.5	0.5	0.4
<i>New Europe</i>	2.5	0.6	0.9	1.0	1.9	0.0	1.0	0.9
Denmark	1.4	−0.1	0.6	1.0	1.3	0.2	1.1	0.5
Finland	2.8	0.6	1.7	0.5	2.0	0.2	1.6	0.5
Ireland	5.9	2.0	1.7	2.3	3.3	0.6	1.2	2.7
The Netherlands	1.3	0.7	−0.3	0.8	0.3	0.3	0.5	0.1
Norway	2.2	0.1	1.4	0.7	2.1	0.0	1.1	1.0
Sweden	2.5	0.5	1.4	0.7	2.1	−0.1	1.5	0.5
United Kingdom	2.7	0.6	1.0	1.1	2.2	−0.1	1.0	1.2
<i>CEE</i>	5.1	−0.1	5.7	−0.5	4.9	0.3	−0.5	5.7
Albania	5.6	−1.9	3.8	3.7	6.4	1.1	3.7	3.8
Bulgaria	4.8	0.6	4.0	0.2	4.2	0.0	0.9	3.3
Croatia	4.3	0.5	2.3	1.5	3.2	0.7	2.7	1.1
Czech Republic	3.1	−0.1	6.3	−3.1	2.0	1.2	1.5	1.7
Estonia	7.0	0.2	6.4	0.3	5.7	1.0	2.1	4.7
Hungary	4.5	0.4	2.9	1.2	3.4	0.7	1.8	2.3
Latvia	7.5	0.5	5.9	1.1	6.1	0.8	4.4	2.5
Lithuania	6.7	−1.8	7.8	0.7	8.2	0.3	0.8	7.7
Poland	3.1	−0.9	3.0	1.1	3.6	0.4	2.4	1.6
Romania	5.2	−0.4	5.6	0.0	5.4	0.2	2.6	3.0
Russia	6.6	0.4	8.1	−1.8	6.3	−0.1	−3.7	9.9
Slovak Republic	4.0	0.3	3.5	0.3	2.7	1.0	2.4	1.4
Slovenia	3.4	0.3	1.9	1.2	2.3	0.8	1.6	1.5
Ukraine	8.0	−0.2	9.5	−1.3	8.1	0.1	−7.6	15.9
<i>United States</i>	2.6	0.4	0.7	1.5	2.1	0.1	0.5	1.7

Abbreviations: *Y*: output growth; *N*: contribution of labor; *K*: contribution of capital; *ST*: Solow–Törnqvist; *DS*: direct substitution; *GD*: generalized difference.

Note: Differences due to rounding error.

Source: Jorgenson and Vu's (2007) data set, authors' calculations

It is tempting to speculate about the differences between the groupings and over time. For much of Old Europe, the TFP slowdown coincides with a cyclical downturn during the 2000–2004 period. Yet a number of countries with strong growth in the second interval experienced a mediocre evolution of TFP, implying episodes of job-intensive growth (France, Italy, Spain, and much of New Europe). One interpretation of Tables 3–5 is that recent labor

market reforms in countries with rigid labor markets have begun to show success in bringing low productivity workers back into the labor market. In contrast, the CEE countries have continued to see employment declines despite high real GDP growth. A second interpretation of the results is sustained efficiency gains for the late movers (eg, Albania, Bulgaria, Romania, Russia). In these countries, significant gains from reorganization of production continue to be realized. A number of theoretical models would predict an effect of such investments made early on in the transition (Blanchard and Kremer, 1997; Roland and Verdier, 2003). It may well be the case that TFP growth is overestimated due to lack of more complete data on investment in intangibles such as organizational capital (see Corrado *et al.*, 2005). In any case, the estimates for the DS and GD methods are generally smoother than the original Solow residual measure, a result consistent with lower RMSE and mean average error results in the Monte Carlo results reported by Burda and Severgnini (2009). This would suggest that despite the growth slowdown experienced in the second half of the sample, the DS and GD point to robust overall TFG growth, strengthening one of the major claims of this paper: in CEE, TFP is a major contributor to economic growth. It also implies that growth in the capital stock was larger during the sample period than is implied by the Solow residual calculation.

EXPLAINING TFP GROWTH IN EUROPE: SOME EXPLORATORY RESULTS

The robust good news from Tables 3–5 is that the new market economies of CEE have experienced sustained growth in TFP since the onset of transformation in the early to mid-1990s (this is also the finding of Bah and Brada, 2008). Especially for the alternative measures, most countries show a marked increase in the latter period, despite an economic slowdown in the OECD countries and especially Western Europe. In contrast, the surge in TFP growth in Western Europe observed in the late 1990s appears to have lost steam, with economic growth coming increasingly from gains in factor input, especially labor. This is consistent with recent efforts in ‘Old Europe’ to reform labor markets and achieve the goals of the Lisbon agenda, which have brought long-term unemployment back into work.

Yet, it is important to understand the technological distance to the leading economies in the OECD, especially as it is linked to ICT technologies and globalization. One of the leading explanations of sluggish growth in Europe – in particular Old Europe – is the predominance of labor and product market inflexibilities as documented by the OECD and the IMF (Coe and Snower, 1996; Belot and van Ours, 2004; Nicoletti and Scarpetta, 2005). One leading

view is that the adoption of key general purpose technologies associated with the ICT revolution has been slowed or impeded by excessive regulations of the employment relationship or the freedom to do business (Jorgenson *et al.*, 2008; Van Ark *et al.*, 2008). Although our data do not allow a direct investigation of this hypothesis, we are able to look for suggestive econometric evidence of correlation between indicators of product and labor market regulation in established market economies of Western Europe. In particular, we examine the explanatory power of summary indicators promulgated by the World Bank (*Doing Business around the World*⁸ and the OECD (OECD, 2004).

Table 6 displays gross national income (GNI)-weighted average values for product and labor market regulation indicators in Old, New and CEE Europe as well as the US. The sample averages for these countries confirm significant differences implied by our distinction between ‘Old’ and ‘New’ Europe, and furthermore they place the CEE economies closer to the former than the latter grouping. In what follows, we will use available data on Western (Old and New) Europe to study the association of product and labor market regulations with TFP growth as can be assessed using the ST, DS, and GD measurements. For all three indicators of TFP presented above, we will examine simple econometric models of data from 15 West European countries (Austria, Belgium, Switzerland, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, and United Kingdom) indexed by i over time intervals $t \in \{1994\text{--}1999, 2000\text{--}2005\}$ of the following form:

$$\left(\frac{\Delta A}{A}\right)_{i,j,t} = \alpha_0 + \alpha_1 \frac{ICT_{i,t}}{Y_{i,t}} + \alpha_2 EPL_{i,t} + \alpha_3 PMR_{i,t} + \varepsilon_{i,t} \quad (9)$$

where, as before, $(\Delta A/A)$ denotes estimates of TFP growth for $j \in \{\text{ST, DS, GD}\}$, $ICT_{i,t}/Y_{i,t}$ denotes the ratio of ICT investment to output, EPL denotes a measure of employment protection and PMR denotes one of three product market regulation indicators from the World Bank: *PROC* (number of procedures necessary to start a business) *COST* (the cost of starting a business measured in percent of annual GNI per capita), and *DUR* (the time in days needed to start a business).⁹ The disturbance term $\varepsilon_{i,t}$ is assumed to satisfy the usual minimum conditions for a regression. The results are

⁸ See www.doingbusiness.org.

⁹ The measures capture ‘bureaucratic and legal hurdles an entrepreneur must overcome to incorporate and register a new firm. It examines the procedures, time, and cost involved in launching a commercial or industrial firm with up to 50 employees and start-up capital of 10 times the economy’s per-capita gross national income (GNI)’. See <http://www.doingbusiness.org/ExploreTopics/StartingBusiness/>.

Table 6: Product and labor market regulation in Old, New and CEE Europe

	<i>EPL</i>		<i>DUR</i>	<i>PROC</i>	<i>COST</i>
	1994–1999	2000–2005			
Old Europe	2.8	2.5	17	8	8.2
New Europe	1.3	1.3	12	5	1.6
CEE	n.a.	n.a.	26	8	9.4
<i>United States</i>	0.2	0.2	6	6	0.7

Source: OECD, World Bank, authors' calculations; n.a. = not available.

presented in Table 7, where the constants and the time dummy coefficients are not reported.

The results lend support to the hypothesis that impediments to competition in product markets have contributed negatively to TFP growth in the leading nations of the OECD. (These results exclude the USA, but are robust to its inclusion.) Especially the DS measure is negatively influenced by all three product market regulation indicators (Table 7). Using the point estimates for the DS measure, we find that raising the number of procedures needed to start a new firm by three (for example, the distance between United Kingdom and Germany or the Netherlands and Italy) leads to about a 0.7% per annum reduction in TFP growth. Similarly, raising the number of days needed to start a business by 30 (for example, the distance between the Netherlands and Croatia) is associated with a reduction of TFP growth of about 0.3% per annum. Raising the cost of starting a new business as measured in percentage of GNI/capita by 10 (the difference between Denmark and Greece) would lead to a drop in annual TFP growth of 0.9%.

In contrast, the EPL measure is never estimated to have significant effects on TFP growth, regardless of the specification. While this does not rule out other effects on the extensive use of labor, the results are consistent with the view that EPL does not adversely affect the adoption of new TFP growth enhancing innovations. We have recently learned of work at the European Commission, which reaches similar conclusions (McMorrow *et al.*, 2009). Interestingly, controlling for and interacting the Jorgenson and Vu (2007) measures for ICT investment did not influence our estimates at all.

CONCLUSION

The mending of great divide between Eastern and Western Europe is a project that will continue for decades. Its ultimate success will depend on the economic integration between the two regions, and in particular on policy

Table 7: TFP Growth and product and labor market regulation: Econometric evidence

Dependent variable	<i>PROC</i>	<i>DUR</i>	<i>COST</i>	<i>EPL</i>	$\frac{I_{ICT}}{Y}$	R^2	No. of observations	No. of countries
Solow-Törnqvist (ST)	−0.0017* (0.0009)			−0.0016 (0.0024)	0.0379 (0.0681)	0.5026	30	15
		−0.0001 (0.0001)		−0.0022 (0.0030)	0.0997 (−0.0715)	0.4078	30	15
			−0.0008* (0.0003)	−0.001 (0.0027)	0.0528 (0.0634)	0.515	30	15
Direct substitution (DS)	−0.0023* (−0.001)			−0.0036 (0.0034)	−0.0150 (0.0930)	0.4867	30	15
		−0.0002* (0.0001)		−0.0045 (0.0041)	0.0621 (0.0973)	0.3777	30	15
			−0.0009* (0.0003)	−0.0029 (0.0036)	0.0115 (0.086)	0.4782	30	15
Generalized differences (GD)	−0.0003 (0.0003)			0.0004 (0.0008)	−0.0211 (0.0330)	0.2376	30	15
		0.0000 (0.0000)		0.0003 (0.0009)	−0.0108 (0.0295)	0.2298	30	15
			0.0000 (0.0001)	0.0003 (0.0008)	−0.0059 (0.0361)	0.2291	30	15

* indicates significance at 5%.

choices made by the newcomers to the global market economy. Among these is a choice between forms of market dynamism in New Europe and that of Old Europe. Part of this policy choice will involve the promotion of factor mobility and trade, and will rely on the positive integrative forces of the EU. Other aspects will tend to involve moving factors to their best uses and the more efficient use of given factors. Most important, new technologies need to be adopted, leapfrogging older, less efficient ones. Here, it is not always clear that the EU has acted to promote more efficiency.

Whether interpreted as technological improvement or increased factor efficiency, as the acquisition and implementation of new technologies, structural reallocation, or simply a move to the efficient frontier, sustained TFP growth represents a key to long-run economic development. In the context of the new market economies, it is imperative to understand the evolution of multifactor productivity growth and anticipate its evolution. Using measures better adapted to deal with severe measurement error present in the transition economies, we present evidence that the new economies of CEE have achieved high and increasing rates of TFP growth in their transition to market. Measurement error, which is inevitably present in capital stock data can cause under – or over – estimation of the true underlying gains in multifactor productivity, but the measures we propose take this problem into account. Indeed, TFP growth in the CEE countries is lower when capital stock-free measures are used, implying that employed capital grew faster than the rate implied by official capital stocks estimates.

Finally, we present some preliminary evidence that moving to the frontier may be inhibited by product market regulations, while the evidence employment protection is ambiguous (as is the case theoretically). Dynamic output markets appear to be central to adaptation to new challenges of technology and globalization. It remains to be seen which of the post-transition countries will pursue strategies that keep them apace of the new developments of the 21st century.

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