SFB 649 Discussion Paper 2009-033

TFP Growth in Old and New Europe

Michael C. Burda*
Battista Severgnini*

* Humboldt-Universität zu Berlin, Germany

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

http://sfb649.wiwi.hu-berlin.de
ISSN 1860-5664

SFB 649, Humboldt-Universität zu Berlin
Spandauer Straße 1, D-10178 Berlin

SFB 649 ECONOMIC RISK BERLIN

TFP Growth in Old and New Europe*

Michael C. Burda
Humboldt Universität zu Berlin, CEPR and IZA

Battista Severgnini
Humboldt Universität zu Berlin and CEBR

June 22, 2009

Abstract

Using Solow-Törnqvist residuals as well as two alternative measurements, we present estimates of total factor productivity (TFP) growth in a sample of 30 European economies for the period 1994-2005. 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.

Key Words: Total factor productivity growth, Solow residual, product and labor market regulation.

JEL classification: D24, O47, P27.

*Presented at the 14th Dubrovnik Economic Conference, June 25-28, 2008. Thoughtful comments by Oleh Havrylyshyn, Paul Wachtel and especially Boštjan Jazbec on an earlier version of this paper are gratefully acknowledged. This research was supported by the Deutsche Forschungsgemeinschaft and the SFB 649 "Economic Risk". Michael C. Burda, Humboldt Universität zu Berlin, Institut für Wirtschaftstheorie II, Spandauer Str. 1, 10178 Berlin, email: burda@wiwi.hu-berlin.de. Battista Severgnini, Humboldt Universität zu Berlin, Institut für Wirtschaftstheorie II, Spandauer Str. 1, 10178 Berlin, email: battista.severgnini@wiwi.hu-berlin.de

1 Introduction: Eastern Europe and the New Europe

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 has averaged 5.1% compared with 1.9% in the old EU-15.[1] Yet this convergence of GDP per capita has often not been rapid enough for some critics and has stoked the political fires of 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, 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 1995 in the new market economies of Europe along the admittedly narrow dimension of technological progress and technical efficiency the rate of growth of total factor productivity (TFP). Since it is the source of all sustainable improvements in standards of living, it seems imperative to get good measurements of TFP growth and try to understand what drives them. This paper constructs three different measures of productivity growth in a set of EU economies: the standard Solow residual plus two which we have proposed elsewhere (Burda and Severgnini (2008)) as a solution to a severe measurement problem arising in transition economies. In doing so, we will assess the determinants of TFP growth in the established economies, especially as relates to old, new and Eastern European countries.

This task appears all the more important, now that it is clear that EU membership increasingly represents a Janus-faced economic challenge for the newcomers. On the one hand, trade integration has proceeded briskly among EU members 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,

[1] *Source*: Jorgenson and Vu (2007) dataset. Central and Eastern Europe consists of: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Romania, Russia, and the Ukraine. Western Europe consists of: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. The EU-15 consists of: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom

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 lions 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 EUs common external tariff and product and labor market regulations. In particular, the *acquis communautaires* have added to the regulatory burden of enterprises and possibly made convergence of the poorer nations more difficult. While the return to Europe contains much promise of economic order and stability, it also contains the prospect of adopting regulations which may, in the medium term, slow or even prevent convergence to the high standards of living already enjoyed by Old Europe. After assessing the evolution of TFP growth in Old, New and Central and Eastern Europe, we examine the role that product and labor market regulation may have had in Western Europe.

2 Central and Eastern Europe's Integration Shock and Subsequent Recovery

The fall of the iron curtain two decades ago was difficult to think about using standard models and paradigms. Siebert (1992) has aptly called it an integration shock. Economists find it convenient to speak of dimensions of integration. Following Eichengreen (1999), one can define economic integration as simply 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 can be identified:

1. **Simple convergence**, driven by internal capital accumulation, to common levels of GDP per capita given by common underlying fundamentals, as predicted by standard growth theory (e.g. Solow (1956) model);

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 abroad or from rich regions to poor 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 already available capital equipment, education, labor force and technological know-how by way of **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. While it is difficult to sort out different sources of growth, we will focus in this paper on the last two: improvements in multifactor productivity or efficiency, given redeployment of capital and labor induced either by factor mobility or redeployment of resources in the course of structural change. As Hall and Jones (1999)) have emphasized, the last two are decisive determinants of backwardness. In a telling comparison, they estimate that while per capita productivity in the US at the end of the last century was roughly 35 times that of Niger, giving the physical and human capital endowments of the former to the inhabitants of the latter would reduce raise per capita productivity to only about an eighth of US levels.

Table 1 presents raw real GDP growth rates computed using data from the Penn World Table 6.2[2] and updated through 2005 by the dataset collected by Jorgenson and Vu (2007)[3] in the period 1994-2005 for the EU-27 less Cyprus, Luxembourg, and Malta, but 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 economies which have been less prone to reform over the period; New Europe, comprised of the UK plus smaller, reform-friendlier countries and Central and Eastern Europe (CEE) which in fact refers to all new market economies of central and eastern Europe not only the new EU members but also Albania, Croatia, Ukraine and Russia.[4] Annual growth in New

[2] www.pwt.econ.upenn.edu

[3] The dataset 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 her GDP. Given its sometimes ambivalent but clearly European heritage, we have decided to keep Russia in, while remaining vigilant of potential issues of comparison.

Europe exceeded that in Old Europe by almost 1.1 percentage points over the total sample period 1994-2005, 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 two periods by 24.5% to reach 5.1% per annum over the period 1999-2005.

This divergence of outcomes is striking and supports the view that Central and Eastern Europe are on the 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 show up later in the productivity statistics? To answer this question we will need to take a closer look at total factor productivity in our sample.

3 Problems in Estimating TFP in Central and Eastern Europe and Two Alternatives

The gold standard of multifactor productivity growth measurement is the Solow-residual (Solow (1957)). This seductively simple measurement was conceived by Solow to deal with the case of two production factors, but was later extended by Denison (1962) and W.Jorgenson and Griliches (1967) to deal with any arbitrary number of production 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

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

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

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

where ω_t is estimated as a Törnquist index with $\omega_{t-1} = \frac{(s_{Kt}+s_{Kt-1})}{2}$, and s_{Kt} is the capital share in income share in period t.

Solow derived equation (1) as a first order approximation to any continuous, quasi-

Table 1: Average GDP growth rates, 1994-2005 (% per annum)

	1994-1999	*2000-2005*	*1994-2005*
Old Europe	*1.7*	*2.2*	*1.9*
Austria	2.6	1.8	2.2
Belgium	2.5	1.8	2.2
France	2.3	1.9	2.1
Germany	1.9	1.1	1.5
Greece	2.8	4.3	3.5
Italy	1.8	1.1	1.5
Portugal	3.6	1.2	2.4
Spain	3.4	3.4	3.4
Switzerland	1.3	1.4	1.4
New Europe	*3.5*	*2.4*	*3.0*
Denmark	3.2	1.7	2.4
Finland	4.2	2.7	3.4
Ireland	8.7	5.8	7.3
Netherlands	3.5	1.3	2.4
Norway	4.1	2.2	3.1
Sweden	3.2	2.6	2.9
United Kingdom	3.2	2.6	2.9
CEE	*0.2*	*5.1*	*2.6*
Albania	6.2	5.6	5.9
Bulgaria	-0.8	4.9	2.1
Croatia	4.4	4.3	4.3
Czech Republic	2.0	3.6	2.8
Estonia	3.7	7.4	5.5
Hungary	3.2	4.4	3.8
Latvia	3.5	7.8	5.7
Lithuania	1.6	6.8	4.2
Poland	5.7	3.2	4.4
Romania	0.4	5.0	2.7
Russia	-3.2	6.6	1.7
Slovak Republic	4.6	4.3	4.5
Slovenia	4.4	3.5	3.9
Ukraine	-9.1	7.1	-1.0
United States	*2.6*	*3.9*	*3.2*

Source: Jorgenson and Vu (2007). Authors' calculations.

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 total factor productivity and efficiency of factor utilization. While the dual measure of TFP growth (W.Jorgenson and Griliches (1967), Hall (1990), Röger (1995), Barro (1999)) later gained popularity because it was robust to product market imperfections, it suffers from the lack of good data on all relevant factor prices.

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, or investment. In particular, these capital stocks represent the solution of the Goldsmith difference equation or perpetual inventory method (PIM)

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

which for an initial condition K_0 is given by

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

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 and Jorgenson (1980) employed the initial observation of investment as a measure of the initial capital stock; the US Bureau of Economic Activity (BEA), multiplies the initial observation of investment by a factor $\frac{1+g}{\delta+g}$, which is a function of an assumed trend growth rate and the capital depreciation rate.

The importance of initial conditions will disappear in the limit for capital stocks constructed from longer time series for investment. Yet for the new market economies of Central and Eastern Europe, measurement errors are likely to be severe. To underscore this point, we briefly review evidence presented elsewhere (Burda and Severgnini (2008))). In that paper we set up, calibrated and simulated a stochastic growth model driven by a single trend-stationary stochastic process for total factor productivity. This model was vintage RBC (e.g. King and Rebelo (1999)) with two variations: first with constant depreciation and second, with depreciation modeled as a convex function of capacity utilitzation as in Wen (1998).

We simulated the stochastic general equilibrium model, creating 100 independent realizations of this trend-stationary model, each with 1,000 observations of output, labor, investment, consumption and the level of total factor productivity. For each data set, we constructed Solow residual measurements using instead an estimated time series of the capital stock based on the permanent inventory method (3) assuming constant depreciation, plus an initial capital stock K_0 guess *á la* Gollop and Jorgenson (1980), Griliches (1980), Caselli (2005), and BEA. These data thus resemble those available to researchers who do not know the true capital stock, but must estimate them from investment data and some initial condition.

Since the true evolution of TFP in this data set is known, it is possible to evaluate the goodness of the Solow-Törnqvist-residual measure. We report results for the BEA and Caselli measures; details can be found in Burda and Severgnini (2008). Table 2 presents 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 Table 3, a second, transition economy type is characterized by a true initial condition which has achieved less than 50% its the steady state value. For all cases, the Solow-Törnqvist residual root mean squared error is in excess of 1.6% (on an annualized basis) and ranges as high as 3.3%. As can be expected, the RMSE rises as the sample size declines. For the 50 quarter sample, the RMSE computed using the BEA method is 3.2%. Burda and Severgnini argue that a mismeasurement of the initial capital stock will take some time to lose relevance in the Solow calculation, an issue that will be especially acute for assessing progress in Central and Eastern Europe.

Burda and Severgnini (2008) 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

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

Table 2: Monte Carlo evaluation of traditional Solow residuals and alternative productive measurements, mature economy. (standard errors based on 100 realizations)

TFP Growth measurement	Root mean squared error T=50	T=200
-Solow-Törnqvist, Capital estimated using BEA method	3.20 (0.83)	1.88 (0.50)
-Solow-Törnqvist, Capital estimated using Caselli (2005)	1.65 (0.79)	1.66 (0.13)
-Direct Substitution (DS)	1.18 (0.16)	1.16 (0.11)
-Generalized Differences (GD)	1.71 (0.20)	1.67 (0.10)

Source: Burda and Severgnini (2008)

Table 3: Monte Carlo evaluation of traditional Solow residuals and alternative productive measurements, transition economy. (standard errors based on 100 realizations)

TFP Growth measurement	Root mean squared error T=50	T=200
-Solow-Törnqvist, Capital estimated using BEA method	3.16 (0.09)	1.87 (0.06)
-Solow-Törnqvist, Capital estimated using Caselli (2005)	1.63 (0.16)	1.66 (0.13)
-Direct Substitution (DS)	1.13 (0.15)	1.16 (0.12)
-Generalized Differences (GD)	1.63 (0.17)	1.67 (0.10)

Source: Burda and Severgnini (2008)

where κ is the rental rate of capital in time t. 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 GD approach, applies a generalized difference 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 it 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:

$$\hat{Y}_t = \hat{A}_{Ds,t} + \omega \hat{K}_t + (1-\omega)\,\hat{N}_t \tag{6}$$

$$\hat{K}_{t+1} = \frac{1-\delta}{1+g}\hat{K}_t + \iota \hat{I}_t \tag{7}$$

with $\iota \equiv \frac{\bar{I/K}}{1+g} = \frac{\bar{I/Y}}{\left(\bar{K/Y}\right)1+g}$ 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 generalized difference operator applied to the capital stock: $I_t = \left(1 - \frac{1-\delta}{1+g}L\right)K_t$. Multiply both sides of (5) by (6) by $\left(1 - \frac{1-\delta}{1+g}L\right)$ and rewrite to obtain:

$$\left(1 - \frac{1-\delta}{1+g}L\right)\hat{A}_{GD,t} = \left(1 - \frac{1-\delta}{1+g}L\right)\hat{Y}_t - \iota\omega\hat{I}_t - (1-\omega)\left(1 - \frac{1-\delta}{1+g}L\right)\hat{N}_t \tag{8}$$

Equation (8) can be employed to estimate generalized differences of TFP growth in each period, which in turn can be integrated from some initial condition , which must be estimated.[5]

Using the same data set, we constructed the DS and GD measures of TFP growth described above to assess the root mean squared error of the Solow-Törnqvist measure. The results are summarized in the last two lines of Tables 2 and 3: For 100 independent realizations (samples) of 200 quarters of data generated by the endogenous depreciation model, 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

[5] Burda and Severgnini (2008) propose a special form of the Malmquist index to estimate this initial condition: a unweighted average of productivity growth in period 0 assuming no capital accumulation, and labor productivity growth in period 0.

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 (2008) show that the RMSEs of Solow-Thörnqvist residuals using the conventional BEA estimates of initial capital stocks converge on average only after 400 quarters or 100 years of synthetic data.

4 Evaluating TFP Growth in Europe and Growth Accounting

We now return to the real world and apply all three measurements Solow-Törnqvist (ST), Direct Substitution (DS) and Generalized Difference (GD) to data from the Penn World Tables (PWT 6.2) and Jorgenson and Vu (2007) for the 30 nations listed in Table 1. Because the PWT data do not contain capital stock estimates, we estimate them for all countries using the BEA method with $K_0 = I_0\frac{(1+\delta)}{(g+\delta)}$. Following Bernanke and Gärkaynak (2002) we compute the values of g as annual average output growth rate during the first 10 years available, while the capital depreciation rate δ and capital elasticity ω are set to 0.06 and 0.33 respectively. The results are presented in Table 4.

First, regardless of which measure is employed, all confirm the suspicion that the anemic rate of growth in Old Europe compared with New Europe reflects a low rate of total factor productivity growth. This conclusion is supported by both the traditional Solow-Törnqvist measure as well as the two alternatives. Furthermore, all measures point to a slowdown of TFP growth in Old Europe since 2000. Although the measure here does not account explicitly for investment in information and communications technology (ICT) goods, it is well-known that this is a distinguishing feature between the United States and Europe (van Ark, O'Mahoney, and Timmer (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

[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 (2008).

in Central and Eastern Europe *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 Solow-Törnqvist measure. It is natural to expect a significant degree of heterogeneity among the Central and Eastern European 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. The transformation to a market economy involved, in the first instance, the picking of the low-lying fruit involving the reorganization of production and establishment of Western-style value added chains.

A further breakdown of the second sub-period 1998-2005 can be found in Table 6, which presents conventional Solow-Törnqvist and our own growth accounting breakdown of observed growth into components due to growth in labor, capital and TFP. Note that while the ST measure relies on capital stock estimates, the alternative DS and GD methods employ 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 Table 6.

It is tempting to speculate about the differences between the groupings and over time. For Old Europe, the slowdown coincides with a cyclical downturn for the later years of the 2000-2005 period. Yet a number of countries with cyclical upturns experienced weak or falling TFP growth, corresponding primarily to spurts of job-intensive growth (Germany, Italy, Spain and much of New Europe). One interpretation of Tables 4, 5 and 6 is that recent labor market reforms in these countries 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 (e.g., 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 (Roland and Verdier (2003), Blanchard and Kremer (1997)). 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 and Sichel (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 (2008). This would suggest that despite the growth

Table 4: TFP estimates: Solow-Törnqvist (ST), Direct Substitution (DS) and Generalized Difference (GD), growth rates, average % per annum.

	1994-1999			*2000-2005*			*1994-2005*		
	ST	DS	GD	ST	DS	GD	ST	DS	GD
Old Europe	*1.0*	*1.7*	*0.5*	*0.2*	*1.1*	*0.2*	*0.6*	*1.4*	*0.3*
Austria	1.7	2.1	-0.1	1.0	1.3	0.3	1.4	1.7	0.1
Belgium	1.2	1.8	0.4	0.5	1.1	0.2	0.9	1.4	0.3
France	1.0	1.8	0.0	0.4	1.2	0.3	0.7	1.5	0.1
Germany	1.2	1.5	0.4	0.7	0.9	0.1	1.0	1.2	0.3
Greece	1.3	1.8	-2.6	2.0	2.7	1.4	1.7	2.2	-0.6
Italy	1.0	2.1	1.4	-0.6	-0.1	-0.1	0.2	0.7	0.6
Portugal	1.5	2.3	0.8	-0.3	0.0	0.1	0.1	1.0	0.5
Spain	0.2	1.4	1.1	-0.9	-0.2	0.0	-0.3	0.2	0.6
Switzerland	0.4	0.7	-0.1	0.5	0.6	0.3	0.3	0.7	0.1
New Europe	*1.7*	*-0.1*	*0.9*	*0.9*	*2.2*	*0.0*	*1.3*	*2.2*	*0.5*
Denmark	1.5	2.4	1.3	0.7	1.5	-0.1	1.1	1.9	0.6
Finland	3.0	3.1	1.4	1.5	1.9	2.4	2.3	2.5	0.6
Ireland	3.7	5.1	0.1	1.6	3.2	-0.1	2.6	4.1	0.6
Netherlands	1.0	1.5	0.9	0.0	0.4	-0.2	0.5	1.0	0.4
Norway	2.0	3.2	1.6	1.4	2.0	-0.2	1.7	2.4	0.7
Sweden	2.5	3.2	1.1	1.4	2.2	-0.1	1.9	2.7	0.5
United Kingdom	1.5	2.7	0.7	0.9	2.1	0.1	1.2	2.4	0.4
CEE	*1.7*	*0.4*	*-5.9*	*5.5*	*4.9*	*2.7*	*3.6*	*2.7*	*-1.6*
Albania	4.0	7.0	-0.8	3.4	6.0	1.9	3.7	6.5	0.5
Bulgaria	0.4	0.3	-5.4	3.5	4.1	2.9	2.0	2.2	-1.2
Croatia	3.8	4.8	-1.4	2.0	3.0	0.9	2.9	3.9	-0.3
Czech Republic	4.8	1.1	-0.3	6.7	2.3	0.3	5.8	1.7	0.0
Estonia	5.1	5.5	-4.5	5.9	6.6	2.4	5.5	6.1	-1.1
Hungary	2.9	3.2	0.2	3.4	3.9	0.4	3.1	3.6	0.3
Latvia	6.1	5.7	-4.7	6.3	6.9	2.9	6.2	6.3	-0.9
Lithuania	2.2	2.4	-12.6	7.1	7.8	0.0	4.7	5.1	-3.6
Poland	5.1	5.7	1.7	2.9	3.4	0.0	4.0	4.6	0.8
Romania	2.7	2.4	0.5	5.1	5.1	-0.2	3.9	3.8	0.1
Russia	-0.2	-2.4	-12.8	7.8	6.1	5.2	3.8	1.8	-3.8
Slovak Republic	4.4	3.4	0.0	3.6	2.9	0.4	4.0	3.2	0.2
Slovenia	3.8	3.3	-0.1	2.3	3.1	0.7	2.8	3.3	0.3
Ukraine	-6.6	-8.2	-21.3	7.5	6.3	7.8	0.4	-0.9	-6.8
United States	*1.2*	*2.7*	*0.1*	*0.6*	*2.5*	*0.2*	*0.9*	*2.3*	*0.1*

Source: Jorgenson and Vu (2007) dataset, authors' calculations.

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 central and eastern Europe total factor productivity 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.

5 Explaining TFP Growth in Europe: Some Exploratory Results

The robust good news from Tables 4, 5 and 6 is that the new market economies of Central and Eastern Europe have experienced sustained growth in total factor productivity 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 petered out, 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 documented by the OECD and the IMF (Coe and Snower (1996), Nicoletti and Scarpetta (2005) and Belot and van Ours (2004)). 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 (van Ark, O'Mahoney, and Timmer (2008), Jorgenson, Ho, and Stiroh (2008)). While 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

Table 5: Growth accounting using the three methods, 1994-1999 (% p.a.)

	Y	N	ST	$K(ST)$	DS	$K(DS)$	GD	$K(GD)$
Old Europe	*2.2*	*0.4*	*1.0*	*0.8*	*1.7*	*0.1*	*0.5*	*1.3*
Austria	2.6	0.0	1.7	0.9	2.1	0.5	-0.1	2.7
Belgium	2.5	0.5	1.2	0.8	1.8	0.2	0.4	1.6
France	2.3	0.6	1.0	0.7	1.8	-0.1	0.0	1.7
Germany	1.9	0.0	1.2	0.7	1.5	0.4	0.4	1.5
Greece	2.8	0.9	1.3	0.6	1.8	0.1	-2.6	4.5
Italy	1.8	0.2	1.0	0.6	2.1	-0.5	1.4	0.2
Portugal	3.6	0.7	1.5	1.4	2.3	0.6	0.8	2.1
Spain	3.4	2.0	0.2	1.2	1.4	0.0	1.1	0.3
Switzerland	1.3	0.2	0.4	0.7	0.7	0.4	-0.1	1.0
New Europe	*3.5*	*1.0*	*1.7*	*0.8*	*-0.1*	*2.6*	*0.9*	*1.6*
Denmark	3.2	0.9	1.5	0.8	2.4	-0.1	1.3	1.0
Finland	4.2	1.0	3.0	0.2	3.1	0.1	1.4	1.8
Ireland	8.7	3.3	3.7	1.7	5.1	0.4	0.1	5.3
Netherlands	3.5	1.6	1.0	0.9	1.5	0.4	0.9	1.0
Norway	4.1	1.3	2.0	0.8	3.2	-0.4	1.6	1.2
Sweden	3.2	0.2	2.5	0.5	3.2	-0.2	1.1	1.9
United Kingdom	3.2	0.8	1.5	0.9	2.7	-0.3	0.7	1.7
CEE	*0.2*	*0.1*	*1.7*	*-1.6*	*0.4*	*-0.3*	*-5.9*	*5.1*
Albania	6.2	-1.0	4.0	3.2	7.0	0.2	-0.8	8.0
Bulgaria	-0.8	-0.5	0.4	-0.7	0.3	-0.6	-5.4	5.1
Croatia	4.4	-0.7	3.8	1.3	4.8	0.3	-1.4	6.5
Czech Republic	2.0	-0.2	4.8	-2.6	1.1	1.1	-0.3	2.5
Estonia	3.7	-2.1	5.1	-0.3	5.5	0.4	-4.5	10.3
Hungary	3.2	0.1	2.9	0.2	3.2	-0.1	0.2	2.9
Latvia	3.5	-2.5	6.1	-0.1	5.7	0.3	-4.7	10.7
Lithuania	1.6	-0.8	2.2	0.2	2.4	0.0	-12.6	15.0
Poland	5.7	-0.1	5.1	0.5	5.7	0.1	1.7	4.1
Romania	0.4	-2.0	2.7	-0.3	2.4	0.0	0.5	1.9
Russia	-3.2	-1.1	-0.2	-1.9	-2.4	0.3	-12.8	10.7
Slovak Republic	4.6	-0.1	4.4	0.3	3.4	1.3	0.0	4.7
Slovenia	4.4	0.9	3.8	-0.3	3.3	0.2	-0.1	3.6
Ukraine	-9.1	-1.0	-6.6	-1.5	-8.2	0.1	-21.3	13.2
United States	*3.9*	*1.2*	*1.2*	*1.5*	*2.7*	*0.0*	*0.1*	*2.6*

Y: Output Growth. N: Contribution of Labor. K: Contribution of Capital
ST: Solow Törnqvist. DS: Direct Substitution. GD: Generalized Difference
Differences due to rounding error
Source: Jorgenson and Vu (2007) dataset, authors' calculations.

Table 6: Growth accounting using the three methods, 2000-2005 (% p.a.)

	Y	N	ST	$K(ST)$	DS	$K(DS)$	GD	$K(GD)$
Old Europe	*1.7*	*0.7*	*0.2*	*0.8*	*1.1*	*-0.1*	*0.2*	*0.8*
Austria	1.8	0.0	1.0	0.8	1.3	0.4	0.3	1.5
Belgium	1.8	0.5	0.5	0.8	1.1	0.2	0.2	1.1
France	1.9	0.6	0.4	0.9	1.2	0.1	0.3	1.0
Germany	1.1	0.0	0.7	0.4	0.7	0.5	0.1	1.0
Greece	4.3	0.9	2.0	1.4	2.0	1.4	1.4	2.0
Italy	1.1	1.0	-0.6	0.7	-0.6	0.8	-0.1	0.2
Portugal	1.2	0.4	-0.3	1.1	-0.9	1.6	0.1	0.7
Spain	3.4	2.8	-0.9	-0.3	-0.2	0.9	0.0	0.6
Switzerland	1.4	0.4	0.6	0.4	0.6	0.4	0.3	0.7
New Europe	*2.4*	*0.6*	*0.9*	*0.9*	*1.1*	*0.7*	*0.0*	*1.8*
Denmark	1.7	0.0	0.7	1.0	1.5	0.2	-0.1	1.8
Finland	2.7	0.7	1.5	0.5	1.9	0.1	-0.1	2.1
Ireland	5.8	2.1	1.6	2.1	3.2	0.6	1.0	2.7
Netherlands	1.3	0.5	0.0	0.8	0.4	0.3	-0.2	0.9
Norway	2.2	0.1	1.4	0.7	2.0	0.1	-0.2	2.5
Sweden	2.6	0.5	1.4	0.7	2.2	-0.1	-0.1	3.2
United Kingdom	2.6	0.6	0.9	0.9	2.8	-0.6	0.1	3.1
CEE	*5.1*	*0.1*	*5.5*	*-0.5*	*4.9*	*0.1*	*2.7*	*2.5*
Albania	5.6	-1.6	3.4	3.6	6.0	1.2	1.9	5.3
Bulgaria	4.9	0.7	3.5	0.8	4.1	0.1	2.9	2.7
Croatia	4.3	0.6	2.0	1.7	3.0	0.7	0.9	2.8
Czech Republic	3.6	0.1	6.3	-2.8	2.3	1.2	0.3	3.2
Estonia	7.4	0.4	6.3	0.7	5.9	1.1	2.4	4.6
Hungary	4.4	0.3	2.8	1.3	3.4	0.7	0.4	3.6
Latvia	7.8	0.6	5.7	1.6	6.3	0.9	2.9	4.3
Lithuania	6.8	-1.4	7.1	1.0	7.8	0.3	5.5	2.7
Poland	3.2	-0.6	2.9	0.9	5.1	-1.3	0.0	3.8
Romania	5.0	-0.4	5.1	0.2	6.1	-0.8	-0.2	5.6
Russia	6.6	0.6	7.8	-1.8	2.9	3.1	5.2	0.8
Slovak Republic	4.3	0.4	3.6	0.3	2.9	1.0	0.4	3.3
Slovenia	3.5	0.4	1.9	1.2	2.3	0.8	0.7	2.4
Ukraine	7.1	0.7	7.5	-1.1	6.3	0.2	7.8	-1.4
United States	*2.6*	*0.6*	*0.5*	*1.5*	*2.5*	*-0.4*	*0.2*	*1.8*

Y: Output Growth. N: Contribution of Labor. K: Contribution of Capital
ST: Solow Törnqvist. DS: Direct Substitution. GD: Generalized Difference
Differences due to rounding error
Source: Jorgenson and Vu (2007) dataset, authors' calculations.

by the World Bank (*Doing Business around the World*[7]) and the OECD (OECD (2004)).

Table 7 displays GNI-weighted average values for product and labor market regulation indicators in Old, New and CEE Europe as well as the United States. The sample averages for these countries certainly suggest significant differences 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 $t \in \{1994 - 1999, 2000 - 2005\}$ of the following form:

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

where, as before, $\left(\frac{\Delta A}{A}\right)$ denotes estimates of TFP growth for $j \in \{ST, DS, GD\}$, $\frac{ICT_{i,t}}{Y_{i,t}}$ 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).[8] The disturbance term $\epsilon_{i,t}$ is assumed to satisfy the usual minimum conditions for a regression. The results are presented in Table 8, where the constant and the time dummy period are not reported.

---

[7] www.doingbusiness.org

[8] 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 7: Product and labor market regulation in Old, New and CEE Europe.

	EPL		*DUR*	*PROC*	*COST*
	1994-9	2000-5			
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
United States	0.2	0.2	6	6	0.7

Source: OECD, World Bank, authors' calculations

Table 8: TFP Growth and product and labour market regulation: Econometric evidence. (* indicates signifcance at 5%)

Dependent variable	$PROC$	DUR	$COST$	EPL	$\frac{I_{ICT}}{Y}$	R^2	*N. obs*	*N. countries*
	-0.0017*			-0.0016	0.0379	0.5026	30	15
	(0.0009)			(0.0024)	(0.0681)			
ST (Solow-Törnqvist)		-0.0001		-0.0022	0.0997	0.4078	30	15
		(0.0001)		(0.0030)	(-0.0715)			
			-0.0008*	-0.001	0.0528	0.515	30	15
			(0.0003)	(0.0027)	(0.0634)			
	-0.0023*			-0.0036	-0.0150	0.4867	30	15
	(-0.001)			(0.0034)	(0.0930)			
DS (Direct Substitution)		-0.0002*		-0.0045	0.0621	0.3777	30	15
		(0.0001)		(0.0041)	(0.0973)			
			-0.0009*	-0.0029	0.0115	0.4782	30	15
			(0.0003)	(0.0036)	(0.086)			
	-0.0003			0.0004	-0.0211	0.2376	30	15
	(0.0003)			(0.0008)	(0.0330)			
GD (Generalized Differences)		0.0000		0.0003	-0.0108	0.2298	30	15
		(0.0000)		(0.0009)	(0.0295)			
			0.0000	0.0003	-0.0059	0.2291	30	15
			(0.0001)	(0.0008)	(0.0361)			

The results support the hypothesis that impediments to competition in product markets have contributed negatively to the evolution of TFP observed in the leading nations of the OECD. (These results exclude the USA, but are robust to its inclusion in unreported results). Especially the DS measure, which is the most robust estimate according to our own work, is negatively influenced by all three measures. Using the point estimates for the DS measure, we find that raising the number of procedures needed to start a new firm by three (the distance between United Kingdom and Germany or the Netherlands and Italy for example) 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 (the distance between Netherlands and Croatia for example) we can expect 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 in which they are estimated. While this does not rule out other effects on the extensive use of labor, the results do suggest that EPL does not adversely affect the adoption of new TFP growth enhancing innovations. Interestingly, controlling for and interacting the Jorgenson and Vu (2007) measures for ICT investment did not influence our estimates at all.

6 Conclusion

The mending of the great economic, political, and social divide between East and West 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 choices made in 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 European Union. 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 over 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 total factor productivity 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 Central and Eastern Europe 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). Arguably, dynamic output markets are keys 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 with of the new technological developments of the 21st century.

References

BAH, E. M., AND J. BRADA (2008): "Total Factor Productivity Growth and Structural Change in Transition Economies," *Presented at the 14th Dubrovnik Economic Conference.*

BARRO, R., AND X. SALA-I-MARTIN (1991): "Convergence across States and Regions," *Brookings Papers on Economic Activity*, 22(1991-1), 107–182.

——— (2005): "Economic Growth," *MIT Press.*

BARRO, R. J. (1999): "Notes on Growth Accounting," *Journal of Economic Growth*, 4, 119–137.

BELOT, M., AND J. C. VAN OURS (2004): "Does the recent success of some OECD countries in lowering their unemployment rates lie in the clever design of their labor market reforms?," *Oxford Economic Papers*, 56(4), 621–642.

BERNANKE, B. S., AND R. S. GÄRKAYNAK (2002): "Is Growth Exogenous? Taking Mankiw, Romer, and Weil Seriously," *NBER Macroeconomics Annual 2001, Volume 16*, pp. 11–72.

BLANCHARD, O., AND M. KREMER (1997): "Disorganization," *Quarterly Journal of Economics*, 112(4), 1091–1126.

BURDA, M. C., AND B. SEVERGNINI (2008): "Solow Residuals without Capital Stocks," SFB 649 Discussion Papers SFB649DP2008-040, Sonderforschungsbereich 649, Humboldt University, Berlin, Germany.

CASELLI, F. (2005): "Accounting for Cross-Country Income Differences," *Handbook of Economic Growth.*

COE, D. T., AND D. J. SNOWER (1996): "Policy Complementarities: The Case for Fundamental Labor Market Reform," IMF Working Papers 96/93, International Monetary Fund.

Corrado, Carol, C. H., and D. Sichel (2005): "Measuring Capital and Technology: An Expanded Framework," *in Corrado, Haltiwanger, and Sichel, eds. Measuring Capital in the New Economy. Chicago: University of Chicago Press.*

Denison, E. (1962): "Source of Economic Growth in the United States and the Alternative before Us," *Committee for Economic Development.*

Eichengreen, B. (1999): "One Money for Europe: Lessons from the US Currency Union,," *Economic Policy*, 4, 85–104–137.

Gollop, F., and D. W. Jorgenson (1980): "United States Factor Productivity by Industry, 1947-1973," *in John W. Kendrick and Beatrice Vaccara (eds.), New Developments in Productivity Measurement and Analysis, Conference on Research in Income and Wealth, Chicago: University of Chicago Press for the National Bureau of Economic Research*, 44(3).

Griliches, Z. (1980): "R&D and the Productivity Slowdown," NBER Working Papers 0434, National Bureau of Economic Research, Inc.

Hall, R. (1990): "Invariance Properties and Solow's Productivity Residual," *in Peter A.Diamond, ed., Growth/Productivity/Employment, Cambridge, MA: MIT*, pp. 71–112.

Hall, R. E., and C. I. Jones (1999): "Why Do Some Countries Produce So Much More Output Per Worker Than Others?," *The Quarterly Journal of Economics*, 114(1), 83–116.

Jorgenson, D. W., M. S. Ho, and K. J. Stiroh (2008): "A Retrospective Look at the U.S. Productivity Growth Resurgence," *Journal of Economic Perspectives*, 22(1), 3–24.

Jorgenson, D. W., and K. Vu (2007): "Information Technology and the World Growth Resurgence," *German Economic Review*, 8, 125–145.

King, R. S., and S. Rebelo (1999): "Resuscitating Real Business Cycles," *Handbook of Macroeconomics, edited by J. B. Taylor and M. Woodford, Volume 1B, 9271007. Amsterdam: Elsevier.*

Mohnen, P., and T. ten Raa (2002): "Neoclassical Growth Accounting and Frontier Analysis: A Synthesis," *Journal of Productivity Analysis*, 18, 111–28.

Nicoletti, G., and S. Scarpetta (2005): "Product Market Reforms and Employment in OECD Countries," OECD Economics Department Working Papers 472, OECD, Economics Department.

OECD (2004): "Employment Outlook," Discussion paper, OECD.

Röger, W. (1995): "Can Imperfect Competition Explain the Difference between Primal and Dual Productivity Measures? Estimates for U.S. Manufacturing," *Journal of Political Economy*, 103(2), 316–30.

Roland, G., and T. Verdier (2003): "Law enforcement and transition," *European Economic Review*, 47(4), 669–685.

Siebert, H. (1992): "Das Wagnis der Einheit: Eine wirtschaftspolitische Therapie," *Stuttgart: Deutsche Verlags-Anstalt.*

Solow, R. M. (1956): "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, 70, 65–94.

——— (1957): "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics,39:312-320.*

van Ark, B., M. O'Mahoney, and M. P. Timmer (2008): "The Productivity Gap between Europe and the United States: Trends and Causes," *Journal of Economic Perspectives*, 22(1), 25–44.

Wen, Y. (1998): "Capacity Utilization under Increasing Returns to Scale," *Journal of Economic Theory*, 81(1), 7–36.

W.Jorgenson, D., and Z. Griliches (1967): "The Explanation of Productivity Change," *Review of Economic Studies*, 34, 249–283.

SFB 649 Discussion Paper Series 2009

For a complete list of Discussion Papers published by the SFB 649, please visit http://sfb649.wiwi.hu-berlin.de.

001 "Implied Market Price of Weather Risk" by Wolfgang Härdle and Brenda López Cabrera, January 2009.

002 "On the Systemic Nature of Weather Risk" by Guenther Filler, Martin Odening, Ostap Okhrin and Wei Xu, January 2009.

003 "Localized Realized Volatility Modelling" by Ying Chen, Wolfgang Karl Härdle and Uta Pigorsch, January 2009.

004 "New recipes for estimating default intensities" by Alexander Baranovski, Carsten von Lieres and André Wilch, January 2009.

005 "Panel Cointegration Testing in the Presence of a Time Trend" by Bernd Droge and Deniz Dilan Karaman Örsal, January 2009.

006 "Regulatory Risk under Optimal Incentive Regulation" by Roland Strausz, January 2009.

007 "Combination of multivariate volatility forecasts" by Alessandra Amendola and Giuseppe Storti, January 2009.

008 "Mortality modeling: Lee-Carter and the macroeconomy" by Katja Hanewald, January 2009.

009 "Stochastic Population Forecast for Germany and its Consequence for the German Pension System" by Wolfgang Härdle and Alena Mysickova, February 2009.

010 "A Microeconomic Explanation of the EPK Paradox" by Wolfgang Härdle, Volker Krätschmer and Rouslan Moro, February 2009.

011 "Defending Against Speculative Attacks" by Tijmen Daniëls, Henk Jager and Franc Klaassen, February 2009.

012 "On the Existence of the Moments of the Asymptotic Trace Statistic" by Deniz Dilan Karaman Örsal and Bernd Droge, February 2009.

013 "CDO Pricing with Copulae" by Barbara Choros, Wolfgang Härdle and Ostap Okhrin, March 2009.

014 "Properties of Hierarchical Archimedean Copulas" by Ostap Okhrin, Yarema Okhrin and Wolfgang Schmid, March 2009.

015 "Stochastic Mortality, Macroeconomic Risks, and Life Insurer Solvency" by Katja Hanewald, Thomas Post and Helmut Gründl, March 2009.

016 "Men, Women, and the Ballot Woman Suffrage in the United States" by Sebastian Braun and Michael Kvasnicka, March 2009.

017 "The Importance of Two-Sided Heterogeneity for the Cyclicality of Labour Market Dynamics" by Ronald Bachmann and Peggy David, March 2009.

018 "Transparency through Financial Claims with Fingerprints – A Free Market Mechanism for Preventing Mortgage Securitization Induced Financial Crises" by Helmut Gründl and Thomas Post, March 2009.

019 "A Joint Analysis of the KOSPI 200 Option and ODAX Option Markets Dynamics" by Ji Cao, Wolfgang Härdle and Julius Mungo, March 2009.

020 "Putting Up a Good Fight: The Galí-Monacelli Model versus 'The Six Major Puzzles in International Macroeconomics'", by Stefan Ried, April 2009.

021 "Spectral estimation of the fractional order of a Lévy process" by Denis Belomestny, April 2009.

022 "Individual Welfare Gains from Deferred Life-Annuities under Stochastic Lee-Carter Mortality" by Thomas Post, April 2009.

SFB 649, Spandauer Straße 1, D-10178 Berlin
http://sfb649.wiwi.hu-berlin.de

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

SFB 649 Discussion Paper Series 2009

For a complete list of Discussion Papers published by the SFB 649, please visit http://sfb649.wiwi.hu-berlin.de.

023 "Pricing Bermudan options using regression: optimal rates of convergence for lower estimates" by Denis Belomestny, April 2009.
024 "Incorporating the Dynamics of Leverage into Default Prediction" by Gunter Löffler and Alina Maurer, April 2009.
025 "Measuring the effects of geographical distance on stock market correlation" by Stefanie Eckel, Gunter Löffler, Alina Maurer and Volker Schmidt, April 2009.
026 "Regression methods for stochastic control problems and their convergence analysis" by Denis Belomestny, Anastasia Kolodko and John Schoenmakers, May 2009.
027 "Unionisation Structures, Productivity, and Firm Performance" by Sebastian Braun, May 2009.
028 "Optimal Smoothing for a Computationally and Statistically Efficient Single Index Estimator" by Yingcun Xia, Wolfgang Härdle and Oliver Linton, May 2009.
029 "Controllability and Persistence of Money Market Rates along the Yield Curve: Evidence from the Euro Area" by Ulrike Busch and Dieter Nautz, May 2009.
030 "Non-constant Hazard Function and Inflation Dynamics" by Fang Yao, May 2009.
031 "De copulis non est disputandum - Copulae: An Overview" by Wolfgang Härdle and Ostap Okhrin, May 2009.
032 "Weather-based estimation of wildfire risk" by Joanne Ho and Martin Odening, June 2009.
033 "TFP Growth in Old and New Europe" by Michael C. Burda and Battista Severgnini, June 2009.

SFB 649, Spandauer Straße 1, D-10178 Berlin
http://sfb649.wiwi.hu-berlin.de

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".