*2 Title page with author details

Total Factor Productivity Convergence in German States since Reunification: Evidence and Explanations☆

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Abstract

A quarter-century after reunification, labor productivity in the states of eastern Germany continues to lag systematically behind the West. Persistent gaps in total factor productivity (TFP) are the proximate cause; conventional and capital-free measurements confirm a sharp slowdown in TFP growth after 1995. Strikingly, eastern capital intensity, especially in industry, exceeds values in the West, casting doubt on the embodied technology hypothesis. TFP growth is negatively associated with rates of investment expenditures. The stubborn East-West TFP gap is best explained by low concentration of managers, low startup intensity and the distribution of firm size in the East rather than R&D activities.

Key Words: Development accounting, productivity, regional convergence, German reunification

JEL classification: D24, E01, E22, O33, O47

☆We are grateful to Katrin Schmelz for comments and to Jörg Heining for providing us with access to the IAB-establishment data. This project is part of the InterVal project which is funded by the German Ministry of Education and Research and was also supported by Collaborative Research Center (SFB) 649. Niklas Flamang, Tobias König and Judith Sahling provided excellent research assistance. Address: Michael C. Burda, Humboldt Universität zu Berlin, Spandauer Str. 1, 10099 Berlin, Germany. Address: Battista Severgnini, Copenhagen Business School. Address: Porcelænshaven 16A. DK - 2000 Frederiksberg, Denmark.

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1. Introduction

A quarter-century after reunification, living standards in the new German states have largely converged to those of former West Germany, with income disparities across eastern and western households approaching those found within the richer western half of the country.[1] The convergence of average incomes stands in stark contrast to that of labor productivity, which continues to lag significantly behind the West. The market value of output per capita in 2015 in the East including Berlin was only about 77% of the German average, and only 71% when Berlin is excluded. Output per employed person is somewhat higher at 84% (including Berlin) and 80% (excluding Berlin); on a per hour basis, productivity falls to 80% and 76%, respectively. After an initial post-unification decade of strong output and productivity growth, the convergence process of the new German states has stalled, leaving Eastern income convergence to be financed by long-term regional transfers.[2]

The German reunification episode thus continues to pose a challenge to economists. Under ideal conditions for economic integration - free trade, capital and labor mobility, and similar human capital endowments and economic institutions - the productivity of regions should converge, albeit slowly, at a rate determined by the mobility of capital and labor and the savings rate of the regions as well as the productivity of capital.[3] In the German case, regional integration took place under ideal conditions in which language, cultural, institutional and legal differences should be of second order importance. While

[1] By 2014, consumption per capita in the Eastern states Mecklenburg-West Pomerania and Saxony had reached 85% and 88% of the national average compared with 90% and 96% in Berlin and Saarland, respectively. By comparison, consumption in Bavaria, the richest state, was 8% above the national average.

[2] Source: *Arbeitsgemeinschaft Volkswirtschaftliche Gesamtrechnung der Länder*, 2014.

[3] Barro and Lee (2010) estimate convergence rates among US states and European regions of roughly 2% per annum.

per-capita GDP growth in the immediate aftermath of unification was remarkable, after 1995 it slowed below rates of total factor productivity (TFP) growth in leading western states. Why has East-West convergence stalled?

In this paper, we present evidence on the existence and persistence of regional productivity differences across East and West Germany. We document the role of TFP and its evolution over time. In particular, we show evidence of conditional convergence in the East to a lower level of total factor productivity in the second half of the post unification episode. By using TFP measurements that are robust to capital stock mismeasurement, we confirm that TFP growth stalled around 1995. Eastern German regions have seen an overaccumulation of capital relative to output, even if residential and nonresidential structures are excluded. Because technology or institutions are unlikely to explain different levels of conditional convergence across the German *Bundesländer*, we focus in our econometric analysis on agglomeration, startups and human capital endowments, using information from a large dataset of establishments as well as publicly available sources. Our results point to an influence of firm size and startup activity on productivity; we also do not find strong evidence that agglomeration, urbanization or population density matters. Consistent with the findings of Griffith et al. (2004), the effect of R&D activities is highly dependent on the distance to the frontier. Most significantly, we find a strong influence of the concentration of managers and technical personnel as well as a negative influence of the investment rate on TFP growth. The latter finding suggests that at least in the German context, investment is a substitute for multifactor productivity, rather than a complement.

The paper is organized as follows. Section 2 frames the relevance of the German unification episode and presents evidence on disparate regional productivity developments between Eastern and Western Germany on the basis of point-in-time TFP level estimates using the Denison-Hall-Jones (DHJ) decomposition (Denison (1962), Hall and Jones (1999)). Section 3 corroborates our findings using three different measures of TFP growth in the German states. In Section 4, we present an econometric analysis of the level and dynamics of

TFP levels which follows the influential work of Griffith et al. (2004). Section 5 concludes with an interpretation of our findings and presents some tentative policy implications.

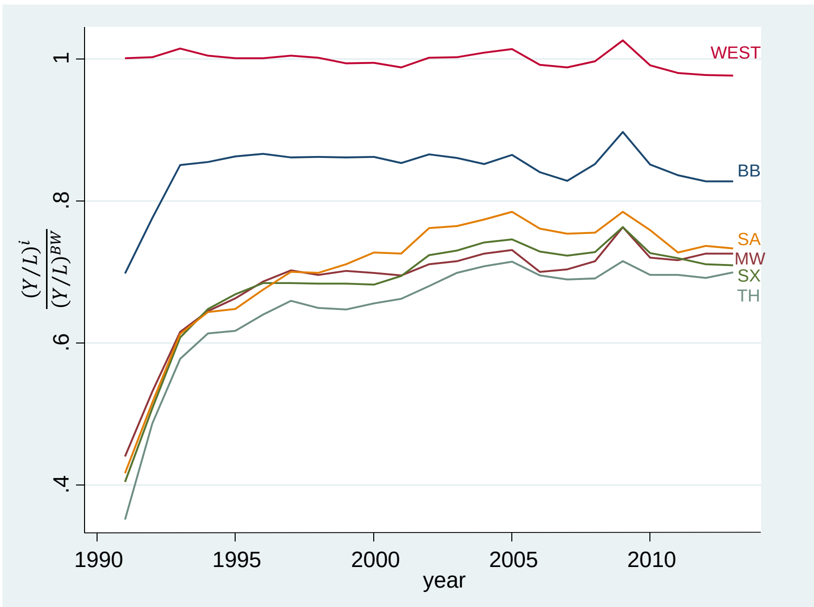
2. Labor Productivity and Total Factor Productivity after German Unification

2.1. The east-west productivity gap, a quarter century later

German unification presents a unique natural experiment for a number of important economic hypotheses. Early on, it was recognized as an episode of intense regional economic integration (Collier and Siebert (1991), Burda (1990, 1991)) with significant labor productivity differentials at the outset between East and West (Akerlof et al. (1991)). A capital-poor East integrating with a capital-rich west triggered a factor mobility race between the two regions (Burda and Hunt (2001) and Burda (2008)) in which migration was strongly responsive to push and pull factors, yet along demographically sensitive lines (Hunt (2006)). A number of factors make the German unification episode an attractive laboratory for economic hypotheses: uniform and standardized data collection methods implemented early on, a common legal institutional framework and underlying economic system and similar if not identical preferences of households (Alesina and Fuchs-Schündeln (2007)).

The process of economic integration should lead output per unit of labor input to converge faster than rates predicted by the neoclassical growth model (e.g. Barro and Sala-i-Martin (2003)). This is because movements of capital and labor tend to equalize factor returns and, in the case of otherwise identical production technologies, capital-labor ratios across regions (Burda (2006)). Figure 1 presents the trajectory of GDP per employee for the new states individually as well as the West German average and shows that, despite an initial surge, eastern labor productivity continues to lag systematically behind the West, even 25 years after the reunification. The trajectory of the Berlin-Brandenburg region as an intermediate outcome is due solely to the presence of West Berlin; taken alone, the state of Brandenburg is little different from the other eastern German States.

Figure 1: **Labor productivity, as a fraction of Baden-Württemberg's (BW), 1993-2013**



Source: Authors' calculations based on Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen. BB: Berlin and Brandenburg. MW: Mecklenburg-West Pomerania. SX: Saxony. SA: Saxony-Anhalt. TH: Thuringia. WEST: West Germany.

We document the regional labor productivity gap in more detail in Table 1, using a more accurate productivity measure in 13 "region-states", measured as gross domestic product in nominal terms per hour worked in 2014.[4] The

[4]Due to a lack of hours data in the new states from the 1990s, our subsequent econometric

region-states correspond to the *Bundesländer*, except that the city-states Berlin, Bremen and Hamburg have been merged with the states that surround them. The total economy exhibits significant regional productivity differences and have given rise to controversial discussions about a "Mezzogiorno syndrome" in eastern Germany.[5]

[Table 1 about here]

2.2. Proximate causes of East-West productivity differences

What could be the source of persistent regional differences in labor productivity in Germany more than a quarter-century after unification? A natural first place to look is structural change, i.e. compositional effects. The last three columns of Table 1 reveal significant and systematic differences in productivity per employed person between eastern and western Germany. While the West continues to dominate the East in manufacturing, construction and other "productive sectors", it does not in agriculture, forestry and fishing, where an hour worked in Saxony-Anhalt or Mecklenburg-West Pomerania is twice as productive as in the western states of Bavaria or Hesse. Yet even in these *Bundesländer*, only 2% of total GDP derives from agriculture, forestry and fishing. Much more significant in the East is the low-productivity public sector, which continues to

work uses employed persons rather than hours. Details on the data used in this paper can be found in the Appendix.

[5]See Boltho et al. (1997), Sinn and Westermann (2001), and Sinn (2002). While these regional differences are significant and economically interesting, they are not unusual. By way of comparison, Germany has a surface area comparable to the US region of New England plus the states of New York and New Jersey. Among those states, annual GDP per civilian employed person ranged in 2010 from \$78,000 and 82,000 in Vermont and Maine to 135,000 in Connecticut and New York, respectively. This is much more dispersed than the extreme values in Germany (€71,000 in Hessen versus €49,000 in Mecklenburg-West Pomerania). What makes the German episode so interesting is the apparent history-dependence of these differences, especially considering that some eastern regions were among the most productive in Germany before the Second World War.

play a much larger than high value-added services.

To examine the role of heterogeneity and changing sectoral composition, we disaggregated value added per capita into six sectoral activities using definition common to the sample period 1991-2014.[6] Holding constant the fraction of employment in each of the six sectors at 1991 levels, aggregate labor productivity per person in Eastern German states (excluding Berlin) would have been consistently *lower* than observed, meaning that sectoral change in fact accelerated convergence. Furthermore, the distribution of the labor productivity gap is fairly uniform across the important sectors: Structural change - or a lack of it - cannot be the main suspect for poor Eastern German productivity since 2000.

The standard neoclassical explanation of the productivity gap relies on different endowments of physical capital. Indeed, most early analyses of the unification episode assumed that the new states had access to the same physical, institutional and political infrastructure, human capital endowments, and technical sophistication available in the rest of Germany. The assumption of identical TFP was defensible *a priori* on a number of grounds: Human capital endowments of formal education in eastern and western Germany were very similar (Burda and Schmidt (1997)) and a large fraction of human capital was transferable (Fuchs-Schündeln and Izem (2012)). Nevertheless, it is an enormous leap of faith to assume that aggregate production functions were identical at the outset.[7] In the sections that follow, we consider TFP as a source of persistent productivity differences, twenty-five years later.

[6]The categories are agriculture, forestry and fishing; productive industries (manufacturing, mining, quarrying, and energy); construction; trade, hospitality and transport; finance and business services; public services and private household services.

[7]Another variant would be to assume an identical production function with more structure, leading to a different interpretation of total factor productivity and implying conditional convergence to different steady states. We discuss this argument in more detail in Section 4.

2.3. A comparison of TFP levels using the Denison-Hall-Jones decomposition

We begin our analysis of regional German labor productivity using a point-in-time approach associated with Hall and Jones (1999), and is traceable back to Christensen et al. (1981) and ultimately Denison (1962).[8] Under the assumption of identical constant returns production technology and an appropriate benchmark, efficiency in the aggregate use of productive factors can be summarized in a convenient way.

Consider a constant returns production function expressing output in period t (Y_t) as resulting from production factors capital (K_t) and labor (L_t) as well as Harrod-neutral (labor augmenting) technology (A_t):

$$Y_t = K_t^{\alpha} \left(A_t L_t\right)^{1-\alpha} \tag{1}$$

with $0 < \alpha < 1$.[9] Rewrite (1) in intensive form expressing labor productivity as a function of capital intensity (the capital coefficient) as follows:

$$\frac{Y_t}{L_t} = A_t \left(\frac{K_t}{A_t L_t}\right)^{\alpha} = A_t \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}$$

Output per worker can be accounted for as the product of a term involving the observable capital intensity of production $\left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}$ and unobservable labor augmenting technical progress A_t. Over longer periods, the former can be linked in a natural way to the investment rate (the ratio of investment I to Y).[10] The

[8] This technique is also referred to in the literature as development accounting (Caselli (2005) and Hsieh and Klenow (2010)).

[9] The assumption of Harrod-neutral technical change is strong but necessary for this decomposition (Acemoglu (2009)) and used in studying growth of developing economies as well as regions or countries in transition (Blanchard and Kremer (1997) and Castanheira and Roland (2000)). The Cobb-Douglas specification is essential, however, for studying economies far from the benchmark country, which is generally the case.

[10] In the steady state of a competitive economy with constant factor shares, capital and output grow at the same rate, g. If capital depreciates at rate δ, then the steady state capital-output ratio is $(I/Y)/(g+\delta)$.

DHJ procedure expresses differences in labor productivity in region or economy i to some "frontier" benchmark (superscript F) as

$$\frac{(Y/L)_t^i}{(Y/L)_t^F} = \frac{A_t^i}{A_t^F}\left(\frac{(K/Y)_t^i}{(K/Y)_t^F}\right)^{\frac{\alpha}{1-\alpha}}$$

where the benchmark is normalized to equal 1 in each year.

Table 2 displays the DHJ decomposition in the year 2011 for the thirteen region-states, the eastern six and the western seven as aggregates, and Germany as a whole. The state of Baden-Württemberg serves as the frontier for the analysis. A constant value of 0.33 is assumed for the capital elasticity coefficient α.[11] The data used, including the capital stocks, are described in the Appendix.

[Table 2 about here]

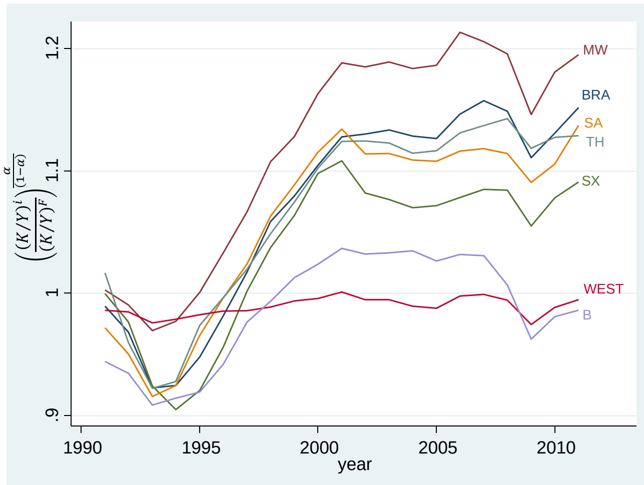
Two immediate conclusions follow from the first three columns of Table 2. First, TFP and labor productivity are highly positively correlated. Second, TFP levels can account for East-West differences; variation within East and West is dwarfed by differences between the two regions. Figure 2 shows that the first ten years following unification were characterized by rapid TFP catch-up, followed by stagnation, while convergence of labor productivity in later years is mostly due to capital intensity. The two panels of Figure 2 present the time series of the contribution to labor productivity for TFP levels for each of the individual Eastern states and the West German average. The first panel shows that TFP measures in East Germany reached a stable level around 1995 and remained almost constant thereafter. In contrast, the capital intensity of Eastern Germany relative to the West has continued to rise until 2000 in manufacturing and other production sectors. In fact, capital-output ratios as measured by the statistical agencies appear to have overshot their West German counterparts.

[11] The assumption of a constant capital elasticity/labor share in the context of growth accounting is standard (Hall and Jones (1999)) and supported by international evidence (see Weil (2012)).

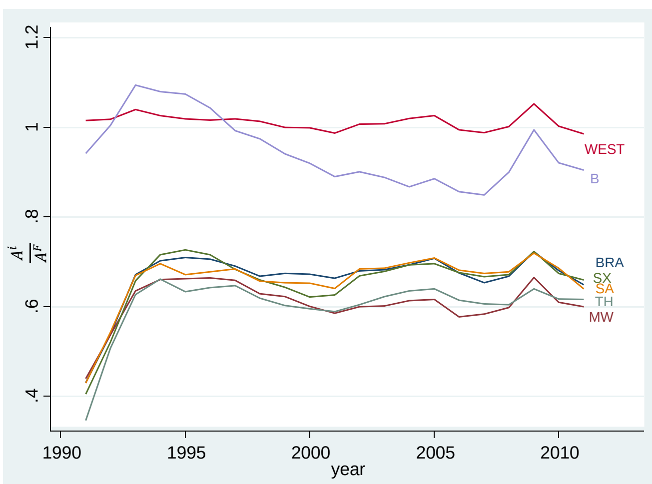
In line with the discussion above, the remaining columns of Table 1 decompose labor productivity in the same manner for the three sectors: agriculture (agriculture, forestry, fisheries), industry (manufacturing, mining, energy) and services (business services, personal services, wholesale and retail trade, finance). The production sector appears largely to determine the overall behavior of the total economy, with a more murky picture in services; moreover, the conclusion is reversed in agriculture, where by far the most productive workers are located in the Eastern states. The temporal behavior of these series (not reported) confirms the pattern in Table 2: TFP growth in the new states has slowed to a trickle, and in particular for industry, the East appears more capital intensive than the West. In Figure 3 we plot the contribution to labor productivity of capital against that of TFP (the value for the West is equal to 1.00 in 2000) over the period 1993-2011. Variability of capital intensity in the eastern states is markedly higher and moves inversely with estimated TFP as it does in the West, but with remarkably greater swings over the period. Flagging TFP in the eastern German regions in the latter half of the sample was offset by significant increases in capital intensity. Rather than complementing or embodying technical progress, the negative correlation of TFP and capital intensity rather suggest that the two may be substitutes for each other. We return to this point in the econometric analysis and subsequent discussion.

Figure 2: **Denison-Hall-Jones Decomposition of labor productivity 1993-2011.**

Contribution of capital to labor productivity $(K/Y)^{\alpha/(1-\alpha)}$**.**



Contribution of total factor productivity (TFP)**.**



Source: Authors' calculations based on Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen. B: Berlin. BRA: Brandenburg. MW: Mecklenburg-West Pomerania. SX: Saxony. SA: Saxony-Anhalt. TH: Thuringia. WEST: West Germany.

Figure 3: Contributions of capital and TPF in the East-West. Denison-Hall-Jones Decomposition 1991-2011.

Source: Figure Authors' calculations based on Statistische Bundesamt, VGR der Länder. Legend: BB: Berlin / Brandenburg. MW: Mecklenburg-West Pomerania. SX: Saxony. SA: Saxony-Anhalt. TH: Thuringia. WEST: West Germany.

Our finding might reflect fundamental mismeasurement. The size and value of eastern Germany's capital stock was difficult to assess in the initial part of the sample, and the data were largely driven by new investment for many years. Only over time will decommissioning and obsolescence of equipment and structures render its capital stock comparable to West Germany's.

3. Robust TFP Growth Measurement: Three alternatives

3.1. Solow-Törnqvist TFP growth measurement (ST)

DHJ estimates presented in the last section indicate striking and persistent East-West level TFP differences as well as an abrupt end in TFP convergence after 1995. In this section, we examine three different measurements of TFP growth to corroborate this finding. In doing so we draw on previous work that proposes two measures which avoid use of poor capital stock data.[12]

We first consider the standard Solow residual, a TFP growth measure requiring measurements of output, capital and labor. Let a_t^{ST} be the rate of TFP growth as captured by the Törnqvist (1936) concept:

$$a_{it}^{ST} = \Delta \ln Y_{it} - \bar{\alpha}_{it-1} \Delta \ln K_{it} - (1 - \bar{\alpha}_{it-1}) \Delta \ln L_{it} \tag{2}$$

where $\bar{\alpha}_{t-1} = \frac{\alpha_{t-1} + \alpha_t}{2}$. Following common practice, we employ a single common value of $\bar{\alpha}$ across time and space to be specified below.

Burda and Severgnini (2014) show that the "Solow-Törnqvist residual" is subject to substantial measurement error in short time series when the capital stock is poorly measured. In benchmark scenarios, about 40% of this error in short datasets is due to the estimated initial capital stock (K_0), while the rest is due to unobservable depreciation and capacity utilization. This measurement error will be significant when 1) the depreciation rate is low and 2) the time series under consideration is short. For conventional rates of depreciation, errors in

[12]See Burda and Severgnini (2014) for more details.

estimating the initial condition can have long-lasting effects on estimated capital stocks. It is widely recognized that the economic transformation of the formerly planned economies led to systematic depreciation of physical, human and match capital,[13] and this problem is likely to have been important in the new German states. It is for this reason that we consider two alternative measures of TFP growth which do not use capital stocks (Burda and Severgnini (2014)).

3.2. Direct Substitution (DS)

The DS measure a_{it} uses direct substitution to eliminate capital from the Solow residual calculation. Substitution of the perpetual inventory equation for the capital stock yields the DS generates, a_{it}^{DS} :

$$a_{it}^{DS} = \Delta \ln Y_{it} - \kappa_{t-1} \frac{I_{it-1}}{Y_{it-1}} + \alpha_{it-1}\delta_{it-1} - (1 - \alpha_{it-1}) \Delta \ln L_{it}, \tag{3}$$

where κ is the user cost of capital and δ_{it-1} is the depreciation rate applied to the capital stock in *Bundesland* i in period $t-1$. The DS is a better measurement of TFP growth if 1) the capital stock is unobservable or poorly measured; 2) capital depreciation varies and can be measured better using other sources; 3) the most recent increments to the capital stock are more likely to be fully utilized than older capital. The DS measure implies a contribution of capital to growth equal to $\frac{\Delta Y_t}{Y_{t-1}} - a_t^{DS} - (1 - \alpha_{t-1}) \frac{\Delta L_t}{L_{t-1}}$. While the cost of capital may vary over the sample, data at the regional level are unavailable, so as with the depreciation rate we will assume a single value for the purposes of TFP growth estimation.

3.3. Generalized Differences (GD)

If an economy, region or sector is close to a known, stable steady state growth path, it may be more appropriate to measure total factor productivity growth as deviations from a long-run deterministic trend path estimated using

[13]See Blanchard and Kremer (1997) and Roland and Verdier (1999) for theoretical models of capital depreciation during the transition process. Burda and Hunt (2001) show that eastern Germans working in the West suffered a significant wage penalty with respect to comparable western works which had disappeared by 1995.

the entire available data set, e.g. trend regression estimates, moving averages or Hodrick-Prescott filtered series. Suppose that a region has attained, but fluctuates around a steady state path in which all observable variables grow at a common rate g. Denoting the deviation of a variable X_t around its steady state value $\overline{X}_t$ by $\hat{X}_t$, it is possible to write the Solow decomposition as

$$\widehat{Y}_t = \widehat{A}_t + \alpha\widehat{K}_t + (1-\alpha)\,\widehat{L}_t, \tag{4}$$

and approximate the perpetual inventory equation as

$$\widehat{K}_t = \frac{(1-\delta)}{(1+g)}\widehat{K}_{t-1} + \iota\widehat{I}_{t-1}, \tag{5}$$

where $\iota = \frac{\overline{(I/K)}}{(1+g)}$, the capital elasticity α, depreciation rate δ and $\overline{(I/K)}$ are constant in the steady state. If L is the lag operator, premultiplication of both sides of (4) by $\left(1-\frac{(1-\delta)}{(1+g)}L\right)$ and substitution of (5) results in

$$\left(1-\frac{(1-\delta)}{(1+g)}L\right)a_t^{GD} = \left(1-\frac{(1-\delta)}{(1+g)}L\right)\widehat{Y}_t - \iota\alpha\widehat{I}_{t-1} - \left(1-\frac{(1-\delta)}{(1+g)}L\right)(1-\alpha)\,\widehat{L}_t \tag{6}$$

The sequence $\{\widehat{a}_t^{GD}\}$ can be recovered recursively for $t = 1, ..., T$ given an estimate of the initial condition, $\widehat{a}_0^{GD}$, and using the approximation $a_t^{GD} \approx \ln(\frac{A_t}{A_{t-1}})$.[14] The GD measure imputes the contribution of capital as $\frac{\Delta Y_t}{Y_{t-1}} - a_t^{GD} - (1-\alpha_{t-1})\,\frac{\Delta L_t}{L_{t-1}}$. As with the DS measure, we assume a single values of δ, g and ι across geographic units and time.

3.4. Results

In Tables 3, and 4, we present Solow-Törnqvist residuals and our stock-free TFP measurements for new and old German states as well as for the aggregate

[14]To see this, note that: $a_t \approx \ln(\frac{A_t}{A_{t-1}}) = \ln(\frac{A_t/\overline{A}_t}{A_{t-1}/\overline{A}_t}) = \ln(\frac{(1+a)A_t/\overline{A}_t}{A_{t-1}/\overline{A}_{t-1}}) \approx \bar{a}_t + \ln(\widehat{A}_t) - \ln(\widehat{A}_{t-1})$, where $\bar{a}_t \equiv \ln\left(\frac{\bar{A}_t}{\bar{A}_{t-1}}\right)$ is the underlying trend growth rate. If TFP grows at constant rate a, then we have: $a = g - n$ and $a_t^{GD} \approx a + \ln(\widehat{A}_t) - \ln(\widehat{A}_{t-1}) = (1-\alpha)(g - n) + \ln(\widehat{A}_t) - \ln(\widehat{A}_{t-1})$. Our initial condition is based on the Malmquist index and is given by $\widehat{a}_0^{GD} = \ln\left(A_0/\bar{A}_0\right)$; in Burda and Severgnini (2014) it is computed as the geometric mean of labor productivity growth and output growth in the first period.

of eastern states, western states and all of Germany, for the period 1993-2011 and the two sub-periods 1993-2001 and 2002-2011. The Solow residual estimates employ capital stocks estimated by the German statistical agency (*Statistisches Bundesamt*). We assumed $\alpha = 0.33$ and an annual rental rate of capital (κ) of 0.11. The depreciation rate δ was set to 0.055, which corresponds to the coefficient regressing the difference between capital and investment is regressed on the last period capital's stock. For the GD approach, the trends were constructed using H-P filter ($\lambda = 100$). The assumed steady state trend growth rate (relevant for the GD method) was average real output growth in each state over the entire period. Lacking series on hours worked, we used total employment as a measure of labor input.

We first turn to TFP growth estimates for the eastern and western states and Germany. The behavior of the DS measure is similar to that of the Solow-Törnqvist residual, and indicates a clear slowdown of TFP growth in the second half of the sample, while the western states show little change over the two periods. Our results are thus broadly consistent with Keller (2000), who uses both econometric and conventional growth accounting techniques and finds an acceleration of East German TFP growth in the period 1990-1996. We also find a higher rate of TFP growth in the initial period (1993-2000), but we also find a significant slowdown in the latter period, starting in 1997. Keller (2000) explains the slowdown of TFP growth driven by West-East diffusion of embodied technologies. In contrast, we find significant capital accumulation in the East relative to output throughout the period, regardless of the measure used. This finding militates against the technology embodiment hypothesis, a subject we revisit in Section 4.

The cross-sectional dimension of our TFP growth estimates sheds light on the appropriateness of the two alternative measures. The prior expectation is that measurement error should be more severe in the new states, due to the limited statistical basis for computing capital stocks. Given the common institutional background and common access to technology, wide variation across space within the East or West during during these seven-year intervals is likely to be associated with measurement error. For the Eastern states, the unweighted standard deviation of the DS measure is slightly lower than that of the Solow-Törnqvist (ST) residual (0.545 versus 0.551); for the GD measure the standard deviation is much higher (0.970). Given initial conditions at reunification, the GD measure appears inappropriate for the eastern German states. For the western states, in contrast, the GD estimates are much more tightly distributed (standard deviation of 0.217 for a^{GD}, versus 0.365 and 0.401 for a^{ST} and a^{DS} respectively). Because the dispersion of TFP growth in the Western states is likely to be low, the GD measure provides a more credible estimate than in the East, which is presumably far from its steady state growth path.

The DS and GD estimates can be used to back out an implied growth contribution of capital input. These estimates are presented in Tables 5a and 5b. They suggest a larger degree of fluctuation than otherwise implied by official capital stock estimates. The GD and DS measures will reduce that mismeasurement to the extent that the utilization of more recent capital formation more closely tracks the "true" utilization rate. Both alternative measurements imply a sharply reduced contribution of growth in capital input to the evolution of eastern German GDP in the latter period, in contrast to the 1990s. Nevertheless, it is greater than that of TFP growth in that period, confirming our findings of capital deepening stressed above.

[Tables 3, 4, 5a, 5b, and 6 about here]

4. Accounting for differences in East-West TFP growth and levels

The last two sections established that 1) aggregate TFP levels in eastern German states remain persistently lower than in the West, and 2) convergence of TFP ground to a halt in all Eastern states after 1995. We also found that capital intensity has compensated for low total factor productivity, partially offsetting the impact of low TFP on labor productivity. To explore possible factors behind these convergence dynamics, we present an econometric analysis of the level and the dynamics of TFP in our panel of German regions, using a convenient framework for analyzing determinants of productivity growth in OECD countries (Griffith et al. (2003, 2004)). This approach is a natural bridge linking the Denison-Hall-Jones analysis of level differences of Section 2 and growth dynamics described in Section 3.

4.1. TFP growth regression specification

We employ the following "convergence to the frontier" empirical framework, with baseline specification takes the form

$$a_{it}^{ST} = \beta_0 + \beta_1 a_{Ft}^{ST} + \beta_2 \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}} + \left(\beta_3 + \beta_4 \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}} \right) \ln \left(\frac{R\&D_{it-1}}{Y_{it-1}} \right) + \beta_5 Z_{it-1} + u_{it} \quad (7)$$

This specification is derived and explained in detail in Griffith et al. (2004). TFP growth dynamics of each state ($a_{it}^{ST} = \ln \frac{A_{it}^{ST}}{A_{it-1}^{ST}}$) is a function of growth in the technological frontier ($\ln \frac{A_{Ft}^{ST}}{A_{Ft-1}^{ST}}$), defined as TFP in the *Bundesland* with the highest level in each period, as well as the distance to the frontier ($\ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$), along the lines of the standard growth convergence literature. It also relates TFP growth to other controls Z_{it-1}, to the intensity of R&D expenditure $\frac{R\&D_{it-1}}{Y_{it-1}}$, and to its interaction with the distance to the frontier $\ln \left(\frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}} \right) \ln \left(\frac{R\&D_{it-1}}{Y_{it-1}} \right)$, affecting the speed at which convergence occurs. u_{it} is a standard disturbance term with mean zero and finite variance. Following Griffith et al. (2004) we distinguish between direct innovation effects of R&D spending (β_3) and the creation of "absorptive capacity" for adopting innovations at the frontier (β_4).

4.2. Data and Sources

The TFP series have been described in previous sections. The R&D measure is constructed from the total intramural R&D expenditure (GERD) at the level of *Bundesland* provided by EUROSTAT.[15] Elements of Z were ob-

[15]The statistics can be found at the following link `http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_e_gerdreg&lang=en`. Data are available for the odd-numbered years 1991,...,2013. For the missing years, we interpolate the time series.

tained from a number of different datasets. The *Establishment History Panel* (BHP), collected by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB), tracks all German establishments with at least one employee liable for social security contributions (until 1999) and with at least one marginal part-time employee (after 1999).[16] From the BHP we extract for each *Bundesland* and year the total number of establishments (*establishments*), startups (*startup*), and employees liable for social security contributions (*employees*) in establishments of various sizes. In addition, we consider the number of technical workers (*technicians*), semi−professionals ($semiprofessionals$), professionals ($professionals$), and managers ($managers$).[17] Total and urban population in levels serve as controls for agglomeration effects; total population (*population*) is taken from the *Statistisches Bundesamt*, while urban population (*population*100), defined as population residing in cities with more than 100,000 inhabitants, is taken from several *Bundesland* and regional statistical offices. Descriptive statistics for these variables can be found in the Appendix.

Given these sources, elements of Z are the following: the ratio of startups to all establishments ($ratiostartup$), the fraction of establishments with less than 50 employees ($fractionest < 50$), the ratio of establishments with more than 250 employees to the total ($fractionest > 250$), population density ($\ln \frac{population}{km^2}$),

[16]This change in definition implies a level jump in the data starting in 1999, which we control for with a dummy in that year. Additional information on the dataset can be found at `http://fdz.iab.de/en.aspx`

[17]The job classification followed by IAB follows Blosfeld's (1985) classification. Professionals are defined as all the positions requiring a university degree (*Freie Berufe und hochqualifizierte Dienstleistungsberufe*), semi−professionals includes jobs characterized by a specialization degree (*Dienstleistungsberufe, die sich durch eine Verwissenschaftlichung der Berufspositionen auszeichnen*), and managers are defined as employees in charge of either production or organizational processes (*Berufe, die die Kontrolle und Entscheidungsgewalt über den Einsatz von Produktionsfaktoren besitzen sowie Funktionäre in Organisationen*). Technicians correspond to occupations devoted as *Techniker*.

degree of urbanization measured as fraction of total population living in cities with more than 100,000 inhabitants ($fractionurban$), the ratio of managers to total number of employees ($\frac{managers}{employees}$), the ratio of semi−professional workers to the total number of employees ($\frac{semi\ professionals}{employees}$), the ratio of technicians to the total number of employees ($\frac{technicians}{employees}$).

4.3. OLS Results

Table 7 presents the first set of OLS regressions with the Solow-Törnqvist residuals as the dependent variable (effectively, first differences of Denison-Hall-Jones estimates described in Section 2). The results are presented with robust standard errors clustered by states. Relative to the first column, the second includes controls for the composition of employment; in the the third and fourth columns, annual time dummies proxy for the growth of the technological frontier $\left(a_{Ft}^{ST}\right)$. Consistent with findings elsewhere in the literature, all four specifications show a positive and significant influence of distance to the frontier. In specifications (1) and (2), growth of the frontier itself has a similarly strong and statistically significant effect on *Bundesland* TFP growth.

In the fifth and sixth columns of Table 7, we include the logarithm of R&D expenditure as well as its interaction with the distance to the frontier. The outcome is not significant and might be affected by several sources of bias. We postpone discussion on those regressors until we analyze the IV results.

[Table 7 about here]

Of the controls employed, the prevalence of startups and small establishments appear to have a consistently positive effect, while in the preferred specification the presence of large establishments has a negative influence on TFP growth. The reference group is represented by unskilled workers. Most striking are our findings related to personnel structure in enterprises. Workers with technical training and university degrees have little consistent explanatory power for TFP growth, while in the most extensive OLS specification semi-professional worker have a positive effect. The presence of managers exhibits a powerful and consistently positive influence on TFP growth. In our preferred OLS specification, an increase in the ratio of managers to total employees of 0.1 (10 percentage points), or - in the mean *Bundesland* of 2.64% to 2.90% - increases TFP growth by 0.68%.

In all specifications, the lagged investment rate is negatively associated with total factor productivity dynamics. This finding is robust with respect to the measurement used.[18] We also estimated equation (7) using the alternative DS and GD TFP growth measures presented in Section 3. The results for DS are similar to those displayed in Table 7 and are reported in Table A.3 in the Appendix. The results for the GD measure were markedly different, yet investment-output ratios retain a negative sign.[19]

4.4. Robustness checks: Endogeneity concerns, alternative specifications, split samples

One concern, also raised by Griffith et al. (2004), is the potential endogeneity of R&D spending or other variables in the regressions reported in Table 7. Spending on research and development might react to variables which determine future TFP growth, but because these are omitted from the equation and possibly unobservable to the econometrician, will lead to endogeneity and biased coefficient estimates. An important discovery today can cause an increase in research activity today and later, as a result of the spending, appear to "cause" an increase in TFP tomorrow. Similarly, division bias may induce spurious correlation between TFP growth and distance from the frontier. The negative sign

[18] Regressions using DS measures were broadly similar but are not reported. The GD measure, which assumes proximity to the steady state, is probably not appropriate for the episode under consideration.

[19] Given that the central assumption of proximity of the economy to the steady state does not hold for the episode under consideration, the GD estimates are not reported but are available from the authors upon request.

on investment may be due to the fact that investment today affects the capital stock in the next period used for TFP growth measures.

We deal with endogeneity in two different ways. First, following Griffith et al. (2004), we instrument our R&D spending variable and the interaction with distance to the frontier with lagged values, including the interaction with the TFP gap, under the orthogonality assumption that further lags are no longer correlated with spending. The Sargan test provides evidence on the validity of this assumption. A second critique involves the investment variable. Potential endogeneity and correlation with the disturbance term arise for two reasons: Investment affects the capital stock tomorrow, which is used to compute TFP growth tomorrow. In addition, higher output today also implies lower I/Y today. At the same time high output today means high TFP today and possibly lower TFP growth tomorrow, *ceteris paribus.* To deal with these potential biases, we use as instrument investment by population instead of GDP. The results remain robust to these specification changes.

The IV results using alternative instruments are displayed in Table 8. The results are robust to many changes in specification, is that the direct effect is negative and significant taken in isolation, but as an interaction with the distance to the frontier is positive, implying that the most backward states may benefit from R&D spending. Looking at the indirect effect, at the mean distance in the sample (0.23), a 10% increase in R&D spending can be anticipated to have a 0.32% effect on TFP growth. For states that are closer than 29% to the frontier, however, the point estimates imply that additional R&D spending *reduces* TFP growth. The negative direct effect of R&D spending could be rationalized by the shift of workers from the production sector to research activities (Barro and Sala-i-Martin (1997). Our findings are thus only partially consistent with Griffith et al. (2004). In our preferred specification (7), distance to the frontier plays a central role, and both startups and large firms continue to show respective positive and negative influences on TFP growth. Most important, managers and semi-professional employees remain strongly significant, as does of R&D spending. Results for the DS measure of TFP growth, presented in

Table A.4 in the Appendix, are comparable to those in Table 8.

In separate regressions,[20] we test whether the concentration of headquarters can have a significant contribution to TFP growth. Not being available a complete series, we construct a proxy of this measure based on survey data.[21] The measure is available since 1998. The inclusion of this regressor is not significant in most of these specifications.

[Tables 8 about here]

A second perspective on robustness is to assume that the variables of interest are more accurately captured by an error correction model (ECM) specification. This would be the case if TFP at the frontier is integrated of order 1 and that one or more linear combinations of logarithms of state-level TFP, the frontier level, R&D spending, managerial and other personnel inputs, and other variables are stationary.[22] Exploiting nonstationarity of the relevant variables should deliver consistent estimates of the parameters of interest even if simultaneity of the type described above is present. Let X_{it} denote the deviation of the integrated variables from one particular cointegrating relationship. Following Griffith et al. (2003, 2004), convergence patterns can be studied following error-correction formulation of the model above, somewhat specialized in the following form:

$$\Delta a_{it}^{ST} = \alpha_1 a_{it-1}^{ST} + \alpha_2 \left(\ln \frac{A_{Ft-1}^{j}}{A_{it-1}} - \beta X_{it-1} - \gamma_i \right) + \alpha_3 \Delta X_{it-1} + u_{it} \qquad (8)$$

In this setup, the change in TFP growth is modeled as an autoregressive process driven by stochastic shocks, changes in X (ΔX), which are represented by the

[20]Output available upon request.

[21]We construct the ratio of the headquarters over the total number of establishments from the IAB establishment Panel, which is a representative employer survey and covers about 16,000 establishments in Germany.

[22]The series are too short for Dickey-Fuller or related tests of integration or cointegration, so these results should be viewed as explorative.

variables Z and $\ln \frac{R\&D}{Y}$, deviations of $\ln A_{it-1}^{ST}$ from its steady state value and a stochastic shock. This steady state corresponds to constant and equal growth rates of A_{it-1}^{j} and A_{Ft-1}, so it thereby expresses the steady state value of the former as a linear combination of common determinants X_{it-1}, including the frontier A_{Ft-1}, plus a state fixed effect captured by γ_i :

$$\ln \bar{A}_{it-1}^{ST} = \ln \bar{A}_{Ft-1}^{ST} + \beta \bar{X}_{it-1} + \gamma_i$$

The results of the "nonstructural" ECM specifications are presented in Table 9. These results are consistent with those of Tables 7 and 8.

[Table 9 about here]

4.5. Discussion

Our empirical analysis confirms the usefulness of the "distance to the frontier" approach of Griffith et al.(2003, 2004) for studying TFP convergence in unified Germany. A robust and economically significant pull effect for both distance to the TFP frontier and growth of that frontier was estimated over the two decades studied. We fail to confirm the effect of R&D spending however, except for regions and periods in which distance to the frontier was great enough to overcome the negative direct effect of R&D spending on TFP growth. As reported in Table 10, these findings are often significant and survive various specifications and instrument sets, as well as separate in East and West subsamples.

[Table 10 about here]

Consistent with our descriptive evidence in Section 2, investment rates are robustly associated with lower TFP growth, *ceteris paribus*. In one interpretation, this is a signal of measurement error; in another interpretation, physical capital is a substitute for TFP with the latter having a causal role. It is straightforward to sketch a model of two regions with perfect labor and capital mobility in which differential TFP levels are causal for investment and capital formation.[23] Other factors such as agglomeration, small firms, new startups contribute positively, and the prevalence of large firms negatively, to the evolution of TFP but these effects are not robust to all specifications and instrument sets. While we do not find a role for firm headquarters (Ragnitz (1999)), we do find a positive, robust and significant association of TFP growth with the density of managers. This finding is consistent with agency theory and new empirical evidence from the US relating productivity to monitoring and selective personnel policies (Kalnins and Lafontaine (2013)). It is also consistent with findings of Bloom et al. (2012) which attributes superior productivity performance of US subsidiaries in Europe to personnel policies.

Despite our relative success in explaining East-West TFP difference, it remains a challenge to explain why large portions of southern Eastern Germany, once a powerhouse of German industry before World War II are disadvantaged as the less industrialized Mecklenburg-West Pomerania and Brandenburg. One tantalizing possibility is that due to its past, eastern Germany is characterized by lower level of social capital, that is useful in the market economy context. In particular, self-efficacy or the belief in a person's own ability to affect outcomes is an important determinant of economic success (Guiso et al. (2016)) and there is evidence that life under state socialism might have deformed those behavioral attributes.[24]

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[23]Suppose technical progress is capital−augmenting, perhaps as a reaction to extremely high wages paid to Eastern workers in the 1990s. Given the restriction of equality of marginal products of labor across the regions, capital and TFP will appear to be substitutes for each other.

[24]In a comparative study performed shortly after reunification, Oettingen (1995) found that East Berlin schoolchildren consistently scored lower self-efficacy scores than their West Berlin counterparts; they were also more likely to conform to expectations and performance evaluations of their teachers.

5. Conclusion

In their widely cited study of international cross-country differences in output per worker, Hall and Jones (1999) stressed the role of social infrastructure, taken to mean institutions which encourage market transactions involving labor services and investing in human and physical capital with the expectation of appropriating gains from those activities. They link cross-sectional variation in TFP to corruption and confiscatory taxation by governments, impediments to trade, the absence of rule of law, disruptive racial and ethnic diversity, and civil strife. TFP differences may also be due to other factors such as as regional agglomeration, Marshallian externalities, learning by doing, or even climate. In the case of Germany, persistent productivity gaps arising from regional variation in these factors seem unlikely. This makes the post-unification episode of particular scientific interest for uncovering the determinants of total factor productivity, a fundamental source of the wealth of nations.

Using a standard two-factor production function approach, we show that persistent East-West labor productivity differentials explained by a significant and persistent TFP gap in the East. Most of this gap can be attributed to manufacturing, construction and other production sectors; the difference is less pronounced in services and even reversed in agriculture. Yet the evolution of TFP convergence cannot be attributed to structural shifts over the period. Our findings are confirmed using measures which do not depend on capital stocks, with the slowdown beginning roughly a decade after reunification. It is noteworthy that eastern German capital intensity has overshot western levels, and that level TPF is negatively correlated with capital intensity in both eastern and western German states, albeit with significantly less variability over time and space in the latter. Using a framework associated with Griffith et al. (2004), we confirm a significant role for growth at the technological frontier and distance to the frontier, but find that of the two channels or "faces" of R&D spending, only the absorptive capacity channel is operative in East German context, helping backwards states the most. This holds even in "West only" regressions. While we cannot explain this finding, it does not speak policies of greater government R&D spending or personnel deployment in the East. If anything our results militate for understanding the motives of firms to allocate less managerial and semi−professional personnel, and more capital to the eastern states.

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Table 1: **Hourly productivity in German regions, 2014 (nominal GDP/hour, in euros)**

Region/State	Total Economy	Agriculture	Industry	Services
Baden-Württemberg	53.4	16.4	56.6	44.3
Bavaria	52.9	15.0	54.9	45.7
Berlin / Brandenburg	43.6	21.2	44.6	38.3
Lower Saxony / Bremen	48.3	18.8	53.3	40.9
Hamburg / Schleswig-Holstein	53.3	16.8	54.3	47.2
Hessen	55.2	15.9	52.4	49.3
Mecklenburg-West Pomerania	36.8	28.6	35.5	32.6
North Rhine-Westphalia	51.5	19.0	51.4	45.0
Rheinland-Palatinate	48.3	21.9	50.8	41.2
Saarland	48.4	14.5	50.6	40.7
Saxony	37.5	19.6	36.5	32.9
Saxony-Anhalt	38.4	30.0	39.9	32.4
Thuringia	35.6	21.8	33.1	31.9
Eastern Germany including Berlin	39.6	23.8	38.5	34.9
Western Germany excluding Berlin	52.0	17.3	53.7	44.9
All Germany	49.7	18.5	51.1	42.9

Source: *Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen, Reihe 1, Band 1.*

Note: Agriculture refers to farming, forestry and fishing.

Table 2: **Denison-Hall-Jones decomposition of labor productivity in German region-states, 2011, relative to Baden-Württenberg**

Region/State	**Total Economy**			**Agriculture**			**Industry**			**Services**		
	$\frac{Y}{L}$	$\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}}$	TFP	$\frac{Y}{L}$	$\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}}$	TFP	$\frac{Y}{L}$	$\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}}$	TFP	$\frac{Y}{L}$	$\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}}$	TFP
Baden-Württemberg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bavaria	1.01	1.05	0.95	0.98	1.12	0.87	1.01	1.02	0.99	1.03	1.03	1.00
Berlin / Brandenburg	0.84	1.05	0.80	0.94	1.03	0.91	0.84	1.29	0.65	0.89	0.94	0.94
Lower Saxony / Bremen	0.91	1.01	0.90	1.36	0.88	1.55	0.96	1.10	0.87	0.93	0.95	0.98
Hamburg / Schleswig-Holstein	1.04	0.99	1.05	0.98	1.01	0.97	0.95	1.13	0.84	1.14	0.87	1.30
Hessen	1.07	0.95	1.13	0.99	1.07	0.93	0.95	1.05	0.91	1.15	0.87	1.33
Mecklenburg-West Pomerania	0.72	1.20	0.60	1.69	0.94	1.79	0.59	1.66	0.36	0.79	1.05	0.76
North Rhine-Westphalia	0.96	0.93	1.03	1.34	0.87	1.53	0.94	1.10	0.85	1.00	0.86	1.16
Rheinland-Palatinate	0.89	1.08	0.82	1.22	0.80	1.52	0.94	1.08	0.87	0.89	1.06	0.84
Saarland	0.89	1.04	0.86	0.86	1.13	0.76	0.91	1.13	0.80	0.90	1.01	0.89
Saxony	0.72	1.09	0.66	1.16	0.91	1.28	0.68	1.52	0.45	0.75	0.99	0.76
Saxony-Anhalt	0.73	1.14	0.64	1.80	0.90	1.99	0.72	1.56	0.46	0.74	1.03	0.72
Thuringia	0.70	1.13	0.62	1.29	0.89	1.44	0.66	1.42	0.46	0.72	1.07	0.68
Eastern Germany including Berlin	0.76	1.09	0.69	1.33	0.93	1.42	0.72	1.45	0.50	0.80	0.99	0.81
Western Germany excluding Berlin	0.98	0.99	0.99	1.13	0.97	1.16	0.97	1.06	0.92	1.02	0.94	1.08
All Germany	0.94	1.01	0.93	1.17	0.96	1.21	0.93	1.12	0.83	0.98	0.95	1.03

Source: Authors' calculations based on *Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen.*

Table 3: **TFP growth in German federal states: A comparison of three measures. 1993-2011.**

	ST	DS	GD
East Germany	**0.8**	**0.7**	**0.3**
Berlin / Brandenburg	0.5	0.4	0.4
Mecklenburg-West Pomerania	1.0	0.3	0.4
Saxony	1.4	1.1	0.4
Saxony-Anhalt	1.2	0.7	0.2
Thuringia	1.3	0.8	0.2
West Germany	**0.5**	**0.5**	**0.5**
Baden-Württemberg	0.6	0.6	0.5
Bavaria	0.9	0.7	0.5
Hesse	0.3	0.6	0.5
Lower Saxony / Bremen	0.3	0.3	0.5
North Rhine-Westphalia	0.4	0.5	0.4
Rheinland-Palatinate	0.2	-0.0	0.5
Saarland	0.5	0.4	0.5
Hamburg / Schleswig-Holstein	0.2	0.4	0.4
Germany	**0.5**	**0.5**	**0.4**

Source: Authors' calculations based on *Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen.*

Table 4: **TFP growth in German federal states: A comparison of three measures. 1993-2001 and 2002-2011.**

	ST		DS		GD	
	1993-2001	2002-2011	1993-2001	2002-2011	1993-2001	2002-2011
East Germany	**1.0**	**0.7**	**1.1**	**0.2**	**0.0**	**0.6**
Berlin / Brandenburg	0.5	0.5	0.6	0.3	0.1	0.6
Mecklenburg-West Pomerania	1.3	0.7	0.7	-0.1	0.1	0.6
Saxony	2.1	0.9	1.9	0.3	0.2	0.6
Saxony-Anhalt	1.9	0.5	1.6	-0.0	-0.1	0.5
Thuringia	1.8	0.8	1.6	0.2	-0.5	0.8
West Germany	**0.4**	**0.5**	**0.6**	**0.4**	**0.4**	**0.5**
Baden-Württemberg	0.7	0.5	0.8	0.5	0.5	0.5
Bavaria	0.9	1.0	0.7	0.7	0.3	0.7
Hesse	0.8	-0.1	1.2	0.0	0.4	0.5
Lower Saxony / Bremen	-0.2	0.8	-0.1	0.6	0.3	0.6
North Rhine-Westphalia	0.2	0.5	0.5	0.6	0.4	0.5
Rheinland-Palatinate	-0.3	0.6	-0.4	0.3	0.2	0.7
Saarland	0.3	0.7	0.2	0.5	0.4	0.6
Hamburg / Schleswig-Holstein	0.8	-0.4	1.2	-0.4	0.6	0.3
All Germany	**0.5**	**0.5**	**0.7**	**0.4**	**0.3**	**0.6**

Source: Authors' calculations based on *Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen.*

Table 5a: **Growth accounting using the three methods. 1993-2011 (% per annum).**

		Solow-Törnqvist			**Direct Substitution**			**Generalized Difference**		
	GDP	**Contribution of**			**Contribution of**			**Contribution of**		
	Growth	**TFP**	**Labor**	**Capital**	**TFP**	**Labor**	**Capital***	**TFP**	**Labor**	**Capital***
East Germany	**2.0**	**0.8**	**-0.1**	**1.2**	**0.7**	**-0.1**	**1.3**	**0.3**	**-0.1**	**1.7**
Berlin / Brandenburg	1.3	0.5	0.1	0.7	0.4	0.1	0.8	0.4	0.1	0.9
Mecklenburg-West Pomerania	2.2	1.0	-0.1	1.4	0.3	-0.1	2.0	0.4	-0.1	2.0
Saxony	2.7	1.4	-0.0	1.2	1.1	-0.0	1.6	0.4	-0.0	2.3
Saxony-Anhalt	2.1	1.2	-0.4	1.3	0.7	-0.4	1.7	0.2	-0.4	2.3
Thuringia	2.7	1.3	-0.0	1.4	0.8	-0.0	1.9	0.2	-0.0	2.5
West Germany	**1.2**	**0.5**	**0.3**	**0.4**	**0.5**	**0.3**	**0.4**	**0.5**	**0.3**	**0.4**
Baden-Württemberg	1.3	0.6	0.3	0.4	0.6	0.3	0.4	0.5	0.3	0.5
Bavaria	1.9	0.9	0.4	0.6	0.7	0.4	0.7	0.5	0.4	1.0
Hesse	1.0	0.3	0.2	0.4	0.6	0.2	0.1	0.5	0.2	0.2
Lower Saxony / Bremen	1.1	0.3	0.4	0.4	0.3	0.4	0.4	0.5	0.4	0.2
North Rhine-Westphalia	0.9	0.4	0.3	0.3	0.5	0.3	0.1	0.4	0.3	0.2
Rheinland-Palatinate	1.0	0.2	0.4	0.3	-0.0	0.4	0.5	0.5	0.4	0.1
Saarland	1.0	0.5	0.3	0.2	0.4	0.3	0.4	0.5	0.3	0.2
Hamburg / Schleswig-Holstein	1.1	0.2	0.3	0.6	0.4	0.3	0.4	0.4	0.3	0.3
Germany	**1.3**	**0.5**	**0.3**	**0.5**	**0.5**	**0.3**	**0.5**	**0.4**	**0.3**	**0.6**

Note: Components may not add exactly due to rounding error.

* Imputed contribution conditional on TFP calculations described in text.

Source: Authors' calculations based on *Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen.*

Table 5b: **Growth accounting using the three methods. 1993-2001 (% per annum).**

		Solow-Törnqvist			**Direct Substitution**			**Generalized Difference**		
	GDP	**Contribution of**			**Contribution of**			**Contribution of**		
	Growth	**TFP**	**Labor**	**Capital**	**TFP**	**Labor**	**Capital***	**TFP**	**Labor**	**Capital***
East Germany	**3.0**	**1.0**	**-0.2**	**2.2**	**1.1**	**-0.2**	**2.1**	**0.0**	**-0.2**	**3.2**
Berlin / Brandenburg	1.6	0.5	-0.2	1.4	0.6	-0.2	1.2	0.1	-0.2	1.7
Mecklenburg-West Pomerania	3.7	1.3	-0.1	2.5	0.7	-0.1	3.1	0.1	-0.1	3.8
Saxony	4.3	2.1	-0.1	2.3	1.9	-0.1	2.4	0.2	-0.1	4.2
Saxony-Anhalt	3.8	1.9	-0.6	2.5	1.6	-0.6	2.8	-0.1	-0.6	4.5
Thuringia	4.4	1.8	0.0	2.6	1.6	0.0	2.8	-0.5	0.0	4.9
West Germany	**1.3**	**0.4**	**0.4**	**0.5**	**0.6**	**0.4**	**0.3**	**0.4**	**0.4**	**0.6**
Baden-Württemberg	1.5	0.7	0.4	0.4	0.8	0.4	0.3	0.5	0.4	0.7
Bavaria	1.9	0.9	0.4	0.7	0.7	0.4	0.8	0.3	0.4	1.3
Hesse	1.6	0.8	0.3	0.4	1.2	0.3	0.1	0.4	0.3	0.9
Lower Saxony / Bremen	0.7	-0.2	0.4	0.5	-0.1	0.4	0.4	0.3	0.4	0.0
North Rhine-Westphalia	1.0	0.2	0.4	0.4	0.5	0.4	0.1	0.4	0.4	0.2
Rheinland-Palatinate	0.6	-0.3	0.5	0.5	-0.4	0.5	0.6	0.2	0.5	-0.0
Saarland	1.2	0.3	0.4	0.4	0.2	0.4	0.6	0.4	0.4	0.3
Hamburg / Schleswig-Holstein	1.6	0.8	0.2	0.6	1.2	0.2	0.2	0.6	0.2	0.8
Germany	**1.5**	**0.5**	**0.2**	**0.7**	**0.7**	**0.2**	**0.6**	**0.3**	**0.2**	**1.0**

Note: Components may not add exactly due to rounding error.

* Imputed contribution conditional on TFP calculations described in text.

Source: Authors' calculations based on *Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen.*

Table 6:**Growth accounting using the three methods. 2002-2011 (% per annum).**

		Solow-Törnqvist			**Direct Substitution**			**Generalized Difference**		
	GDP	**Contribution of**			**Contribution of**			**Contribution of**		
	Growth	**TFP**	**Labor**	**Capital**	**TFP**	**Labor**	**Capital***	**TFP**	**Labor**	**Capital***
East Germany	**1.0**	**0.7**	**0.1**	**0.3**	**0.2**	**0.1**	**0.7**	**0.6**	**0.1**	**0.3**
Berlin / Brandenburg	1.0	0.5	0.3	0.2	0.3	0.3	0.4	0.6	0.3	0.2
Mecklenburg-West Pomerania	0.9	0.7	-0.1	0.3	-0.1	-0.1	1.1	0.6	-0.1	0.4
Saxony	1.2	0.9	0.1	0.3	0.3	0.1	0.8	0.6	0.1	0.6
Saxony-Anhalt	0.5	0.5	-0.2	0.2	-0.0	-0.2	0.7	0.5	-0.2	0.2
Thuringia	1.1	0.8	-0.1	0.4	0.2	-0.1	1.0	0.8	-0.1	0.4
West Germany	**1.2**	**0.5**	**0.3**	**0.3**	**0.4**	**0.3**	**0.4**	**0.5**	**0.3**	**0.3**
Baden-Württemberg	1.2	0.5	0.3	0.4	0.5	0.3	0.4	0.5	0.3	0.4
Bavaria	1.9	1.0	0.4	0.5	0.7	0.4	0.7	0.7	0.4	0.8
Hesse	0.4	-0.1	0.2	0.3	0.0	0.2	0.2	0.5	0.2	-0.3
Lower Saxony / Bremen	1.4	0.8	0.4	0.2	0.6	0.4	0.4	0.6	0.4	0.4
North Rhine-Westphalia	0.9	0.5	0.2	0.2	0.6	0.2	0.1	0.5	0.2	0.2
Rheinland-Palatinate	1.2	0.6	0.4	0.2	0.3	0.4	0.5	0.7	0.4	0.1
Saarland	0.8	0.7	0.1	0.0	0.5	0.1	0.2	0.6	0.1	0.0
Hamburg / Schleswig-Holstein	0.6	-0.4	0.4	0.7	-0.4	0.4	0.6	0.3	0.4	0.0
Germany	**1.1**	**0.5**	**0.3**	**0.3**	**0.4**	**0.3**	**0.4**	**0.6**	**0.3**	**0.3**

Note: Components may not add exactly due to rounding error.

* Imputed contribution conditional on TFP calculations described in text.

Source: Authors' calculations based on *Statistische Bundesamt, Volkswirtschaftliche Gesamtrechnungen.*

Table 7: **Determinants of TFP Growth in German *Bundesländer*, OLS Regressions**

Dependent Variable: a_{it}^{ST}	(1)	(2)	(3)	(4)	(5)	(6)
$\ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$	0.22***	0.29***	0.24***	0.30***	0.14	0.22*
	(0.06)	(0.07)	(0.07)	(0.05)	(0.13)	(0.11)
a_{Ft}^{ST}	1.11***	1.11***				
	(0.15)	(0.15)				
$\ln \frac{I_{t-1}}{Y_{t-1}}$	-0.27***	-0.27***	-0.26***	-0.20***	-0.25***	-0.18**
	(0.07)	(0.08)	(0.06)	(0.05)	(0.06)	(0.06)
$ratiostartup_{t-1}$	0.18**	0.21**	0.27***	0.25**	0.28***	0.26**
	(0.07)	(0.08)	(0.08)	(0.09)	(0.08)	(0.09)
$fractionest < 50_{t-1}$	-4.51***	-4.06***	-2.89*	-1.69	-2.27	-0.66
	(1.18)	(1.20)	(1.37)	(1.00)	(1.60)	(1.33)
$fractionest > 250_{t-1}$	-0.01	-0.10	-0.15	-0.21	-0.25*	-0.27*
	(0.14)	(0.20)	(0.11)	(0.14)	(0.14)	(0.14)
$\ln \frac{est_{t-1}}{km^2}$	0.15***	0.15**	0.06	0.06	0.03	0.01
	(0.04)	(0.05)	(0.06)	(0.04)	(0.07)	(0.05)
$\ln \frac{population_{t-1}}{km^2}$	0.02	-0.25**	0.21**	-0.21**	0.32**	-0.10
	(0.09)	(0.10)	(0.10)	(0.08)	(0.12)	(0.10)
$\ln fractionurban_{t-1}$	0.24	0.30*	0.07	0.16	0.06	0.16
	(0.14)	(0.16)	(0.10)	(0.09)	(0.10)	(0.09)
$\frac{managers_{t-1}}{employees_{t-1}}$		4.52***		6.47***		6.75***
		(1.33)		(0.66)		(0.85)
$\frac{professionals_{t-1}}{employees_{t-1}}$		-0.00		-0.60		-1.38
		(0.45)		(0.73)		(0.93)
$\frac{semi\ professionals_{t-1}}{employees_{t-1}}$		-0.01		0.51		0.75*
		(0.22)		(0.40)		(0.41)
$\frac{technicians_{t-1}}{employees_{t-1}}$		-0.51		0.05		0.04
		(0.61)		(0.59)		(0.61)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}}$					-1.48	-1.93
					(1.22)	(1.28)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}} * \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$					4.97	4.54
					(4.21)	(4.44)
Constant	4.01***	4.83***	1.67	2.43**	0.66	0.96
	(1.20)	(1.21)	(1.46)	(0.97)	(1.88)	(1.53)
R^2	0.62	0.64	0.75	0.77	0.76	0.78
Time dummies	NO	NO	YES	YES	YES	YES
No. of observations	234	234	234	234	234	234

Notes: Regression estimates are weighted by state GDP share in 1993. *Bundesland* fixed effects included in all regressions. *, **, and *** denote significance at 90%, 95% and 99% confidence levels respectively, on the basis of robust standard errors clustered by state.

Table 8: **Determinants of TFP Growth in German *Bundesländer*, IV Regressions**

Dependent Variable: a_{it}^{ST}	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$	0.22***	0.34***	0.31***	0.39***	0.04	0.15	0.15
	(0.08)	(0.09)	(0.07)	(0.08)	(0.11)	(0.12)	(0.12)
a_{Ft}^{ST}	1.10***	1.10***					
	(0.12)	(0.12)					
$\ln \frac{I_{t-1}}{Y_{t-1}}$	-0.24***	-0.25***	-0.28***	-0.21***	-0.27***	-0.19***	-0.23***
	(0.07)	(0.08)	(0.06)	(0.07)	(0.06)	(0.08)	(0.08)
$ratiostartup_{t-1}$	0.03	0.15*	0.12	0.13	0.17*	0.18**	0.17*
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
$fractionest < 50_{t-1}$	-1.63	-1.84	-2.07	-1.31	-0.59	0.36	0.02
	(1.88)	(2.40)	(1.97)	(2.03)	(1.61)	(1.62)	(1.53)
$fractionest > 250_{t-1}$	-0.20	-0.21	-0.23	-0.35*	-0.51**	-0.68***	-0.69***
	(0.19)	(0.20)	(0.16)	(0.19)	(0.22)	(0.23)	(0.23)
$\ln \frac{est_{t-1}}{km^2}$	0.07	0.12*	0.09	0.11	0.02	-0.01	0.00
	(0.05)	(0.06)	(0.07)	(0.09)	(0.06)	(0.07)	(0.07)
$\ln \frac{population_{t-1}}{km^2}$	0.10	-0.19	0.16	-0.31*	0.46***	0.02	0.06
	(0.11)	(0.12)	(0.14)	(0.16)	(0.15)	(0.18)	(0.17)
$\ln fractionurban_{t-1}$	0.18	0.16	0.15	0.23**	0.14	0.24***	0.25***
	(0.11)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)
$\frac{managers_{t-1}}{employees_{t-1}}$		4.82***		6.85***		7.62***	7.36***
		(1.60)		(1.56)		(1.56)	(1.61)
$\frac{professionals_{t-1}}{employees_{t-1}}$		-0.54		-0.21		-0.67	-0.67
		(0.59)		(0.83)		(0.99)	(0.98)
$\frac{semi\ professionals_{t-1}}{employees_{t-1}}$		0.52		0.81*		1.25**	1.27**
		(0.38)		(0.46)		(0.54)	(0.54)
$\frac{technicians_{t-1}}{employees_{t-1}}$		0.09		0.44		0.06	-0.15
		(0.92)		(0.89)		(0.97)	(0.98)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}}$					-3.54**	-4.26**	-4.15**
					(1.64)	(1.70)	(1.73)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}} * \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$					13.67**	14.25**	14.08**
					(5.43)	(5.97)	(5.97)
Constant	0.97	2.43	1.11	2.48	-1.64	-0.58	-0.42
	(2.04)	(2.33)	(2.30)	(2.26)	(1.87)	(1.83)	(1.78)
R^2	0.65	0.69	0.77	0.79	0.77	0.78	0.78
Time dummies	NO	NO	YES	YES	YES	YES	YES
Sargan (p value)	0.93	0.61	0.54	0.32	0.17	0.05	0.05
N. of observations	208	208	208	208	208	208	208

Notes: Regression estimates are weighted by state GDP share in 1993. *Bundesland* fixed effects included in all regressions. *, **, and *** denote significance at 90%, 95% and 99% confidence levels respectively, on the basis of robust standard errors . Instruments: $\ln \frac{A_{Ft-2}^{ST}}{A_{it-2}^{ST}}$ and $\ln \frac{A_{Ft-3}^{ST}}{A_{it-3}^{ST}}$ in all columns, $\ln \frac{R\&D_{t-2}}{Y_{t-2}}$ and $\ln \frac{A_{Ft-2}^{ST}}{A_{it-2}^{ST}} * \ln \frac{R\&D_{t-2}}{Y_{t-2}}$ in columns (5), (6) and (7), $\ln \frac{I_{t-1}}{POP_{t-1}}$ in column (7).

Table 9: **Determinants of TFP Growth in German *Bundesländer*, ECM Regressions**

Dependent Variable: Δa_{it}^{ST}	(1)	(2)	(3)	(4)
a_{it-1}^{ST}	-3.11***	-3.29***	-3.15***	-3.36***
	(0.28)	(0.27)	(0.18)	(0.18)
a_{Ft-1}^{ST}	3.05***	3.41***	3.12***	3.52***
	(0.35)	(0.40)	(0.31)	(0.36)
$\ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$	0.23**	0.37**	0.04	0.10
	(0.10)	(0.14)	(0.11)	(0.12)
$\ln \frac{est_{t-1}}{km^2}$	-0.16***	-0.21**	-0.17***	-0.20*
	(0.05)	(0.07)	(0.05)	(0.09)
$\ln \frac{I_{t-1}}{Y_{t-1}}$	-0.23**	-0.33***	-0.21**	-0.28***
	(0.09)	(0.06)	(0.10)	(0.06)
$\frac{managers_{t-1}}{employees_{t-1}}$		4.20**		4.85**
		(1.44)		(1.65)
$\frac{professionals_{t-1}}{employees_{t-1}}$		4.18***		5.13***
		(0.96)		(1.50)
$\frac{semi\ professionals_{t-1}}{employees_{t-1}}$		-0.08		0.13
		(0.66)		(0.58)
$\frac{technicians_{t-1}}{employees_{t-1}}$		-0.68		-0.05
		(1.11)		(1.71)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}}$			-2.09*	-3.50*
			(1.13)	(1.80)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}} * \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$			8.33*	13.38*
			(4.63)	(6.16)
Δa_{Ft-1}^{ST}	-0.17*	-0.10	-0.20**	-0.13
	(0.08)	(0.09)	(0.09)	(0.11)
$\Delta ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$	-2.51***	-2.65***	-2.41***	-2.46***
	(0.35)	(0.36)	(0.23)	(0.27)
$\Delta ln \frac{est_{t-1}}{km^2}$	0.07	0.16	0.10	0.17
	(0.12)	(0.16)	(0.14)	(0.21)
$\Delta \ln \frac{I_{t-1}}{Y_{t-1}}$	0.03	0.11	0.02	0.10
	(0.09)	(0.08)	(0.10)	(0.09)
$\Delta \frac{managers_{t-1}}{employees_{t-1}}$		2.47		1.25
		(2.71)		(3.61)
$\Delta \frac{professional_{t-1}}{employees_{t-1}}$		-1.75*		-2.41**
		(0.85)		(1.05)
$\Delta \frac{semiprofessional_{t-1}}{employees_{t-1}}$		0.89		1.10
		(0.76)		(0.66)
$\Delta \frac{technician_{t-1}}{employees_{t-1}}$		0.56		0.12
		(2.18)		(2.24)
$\Delta \ln \frac{R\&D_{t-1}}{Y_{t-1}}$			1.83	2.72
			(4.63)	(4.82)
$\Delta \ln \frac{R\&D_{t-1}}{Y_{t-1}} * \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$			-6.37	-11.66
			(9.84)	(9.72)
Constant	-8.22***	-6.27**	-8.88***	-6.90**
	(1.91)	(2.19)	(2.24)	(2.46)
R^2	0.73	0.74	0.73	0.75
N. of observations	208	208	208	208

Notes: Regression estimates are weighted by state GDP share in 1993. *Bundesland* fixed effects included in all regressions. *, **, and *** denote significance at 90%, 95% and 99% confidence levels respectively, on the basis of robust standard errors clustered by state. The following regressors are not reported: $ratiostartup_{t-1}$, $fractionest < 50_{t-1}$, $fractionest > 250_{t-1}$, $\ln \frac{est_{t-1}}{km^2}$, $\ln \frac{population_{t-1}}{km^2}$, and $\ln fractionurban_{t-1}$ and respective first difference.

Table 10: **Determinants of TFP Growth in western and eastern *Bundesländer***

Dependent Variable: a_{it}^{ST}						
	OLS (a_{it}^{ST})		**IV** (a_{it}^{ST})		**ECM** (Δa_{it}^{ST})	
	WEST	**EAST**	**WEST**	**EAST**	**WEST**	**EAST**
$\ln \frac{A_{Ft}^{ST}}{A_{it-1}^{ST}}$	0.09	0.34	-0.04	0.03	0.19	-0.13
	(0.15)	(0.20)	(0.15)	(0.15)	(0.23)	(0.28)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}}$	-2.45	-4.21	-5.35**	-11.09***	-4.73**	3.43
	(1.79)	(3.50)	(2.23)	(3.11)	(1.94)	(5.14)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}} * \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$	10.11	4.47	24.83***	21.59***	19.67**	1.78
	(6.13)	(8.71)	(8.78)	(7.13)	(8.08)	(10.30)
$\ln \frac{I_{t-1}}{Y_{t-1}}$	-0.20*	-0.38***	-0.20***	-0.09	-0.63	0.06
	(0.10)	(0.52)	(0.13)	(0.23)	(0.05)	(0.20)
$\frac{managers_{t-1}}{employees_{t-1}}$	5.58**	3.84	6.11***	3.57	3.36	17.43
	(1.91)	(3.64)	(2.15)	(3.17)	(2.75)	(9.76)
N. of observations	144	90	128	90	128	80

Notes: Regression estimates are weighted by state GDP share in 1993. Bundesland fixed effects included in all regressions. *, **, and *** denote significance at 90%, 95% and 99% confidence levels respectively, on the basis of robust standard errors .

Appendix

Income and product account data used in this study are available for all 16 *Bundesländer* beginning in 1992: 11 Western Länder (Bavaria, Baden-Württemberg, Bremen, Hamburg, Hesse, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saarland, Schleswig-Holstein) and the 6 "new" Eastern states (Berlin, Brandenburg, Mecklenburg-West Pomerania, Saxony-Anhalt, Saxony, and Thuringia). Berlin/Brandenburg is the union of East and West Berlin, because the western half of Berlin, while under the protection and economic aegis of Western Germany until 1989, never enjoyed full status as a *Bundesland*. We employ the income and product accounts and capital stock estimates at the level of the federal states published by the Working Group for State Income and Product Accounts (*Arbeitsgemeinschaft Volkswirtschaftliche Gesamtrechnung der Länder*).[25] Descriptive statistics are presented in Table A1.

[25] The data can be downloaded at the website `http://www.vgrdl.de/Arbeitskreis_VGR/ergebnisse.asp`. Capital stocks for the new states in the period 1991-1993 were computed by backcasting the perpetual inventory method from the 1994 estimates.

Table A.1. **Growth accounting variables: Descriptive statistics**

	Y	K	I	L
East Germany	**328.6**	**1077.0**	**82.2**	**7449.5**
	(21.9)	**(197.4)**	**(17.8)**	**(168.1)**
Berlin	87.9	258.8	14.3	1612.4
	(3.8)	(17.9)	(2.231)	(48.8)
Brandenburg	45.4	157.0	133.6	1055.2
	(45.5)	(38.9)	(3.1)	(26.3)
Mecklenburg-Western Pomerania	30.4	115.4	9.2	743.9
	(2.2)	(24.9)	(2.4)	(20.0)
Saxony	80.3	256.7	21.7	1952.8
	(7.2)	(54.3)	(5.0)	(37.2)
Saxony-Anhalt	44.3	150.3	12.144	1050.7
	(3.1)	(31.1)	(3.8)	(52.4)
Thuringia	40.4	138.5	11.6	1034.5
	(3.7)	(31.4)	(2.6)	(22.3)
West Germany	**1846.2**	**5404.9**	**317.4**	**31.6**
	(147.8)	**(390.7)**	**(35.0)**	**(1148.4)**
Baden-Württenberg	316.0	944.4	54.0	5408.8
	(28.1)	(67.5)	(6.6)	(215.2)
Bavaria	362.0	1227.4	74.1	6345.6
	(42.3)	(119.8)	(9.2)	(250.4)
Bremen	23.9	54.2	3.1	394.0
	(1.5)	(1.8)	(0.4)	(8.9)
Hamburg	82.8	158.8	14.7	1053.8
	(6.6)	(27.5)	(5.6)	(42.1)
Hesse	200.0	508.4	30.3	3043.9
	(13.9)	(32.3)	(4.2)	(80.8)
Lower Saxony	187.5	599.3	34.1	3511.7
	(13.0)	(40.1)	(3.0)	(136.9)
North Rhine-Westphalia	485.9	126.2	72.8	8333.2
	(32.0)	(67.5)	(6.9)	(300.7)
Rhineland-Palatinate	96.2	339.6	18.0	1778.1
	(6.1)	(20.4)	(1.3)	(82.5)
Saarland	26.4	88.8	4.5	494.9
	(2.2)	(3.9)	(0.5)	(16.9)
Schleswig-Holstein	65.7	221.8	12.1	1243.4
	(3.8)	(13.2)	(1.2)	(30.7)
Germany (in milions)	**21.7**	**6.48**	**39.9**	**39.1**
	(1.68)	**(5.80)**	**(2.4)**	**(1.08)**

Table A.2. **Regression covariates: Descriptive statistics**

	mean	std. error	min	max	N. of obs.
$\ln \frac{A_i^{ST}}{A_F^{ST}}$	2.80	0.15	2.56	3.06	234
$\frac{I}{Y}$	0.21	0.08	0.13	0.51	234
$ratio\ startup$	0.07	0.03	0.04	0.18	234
$ratio\ firm\ 50$	0.97	0.01	0.95	0.98	234
$ratio\ firm\ 250$	0.08	0.17	0.00	0.58	234
$\frac{firm}{km^2}$	3.54	1.74	0.87	8.83	234
$\frac{population}{km^2}$	241.03	117.55	70.15	530.04	234
$\frac{population100}{population}$	0.27	0.15	0.11	0.62	234
$\frac{managers}{employees}$	0.03	0.00	0.02	0.04	234
$\frac{professionals}{employees}$	0.02	0.00	0.01	0.03	234
$\frac{semi\ professionals}{employees}$	0.07	0.01	0.05	0.10	234
$\frac{technicians}{employees}$	0.04	0.01	0.03	0.06	234
$\frac{R\&D}{Y}$	0.02	0.01	0.01	0.05	208

Table A.3. **Determinants of TFP Growth in German *Bundesländer*, OLS Regressions**

Dependent Variable: a_{it}^{DS}						
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$	0.19***	0.27***	0.22***	0.28***	0.12	0.19
	(0.05)	(0.06)	(0.06)	(0.05)	(0.13)	(0.11)
a_{Ft}^{ST}	1.05***	1.05***				
	(0.13)	(0.13)				
$\ln \frac{I_{t-1}}{Y_{t-1}}$	-0.29***	-0.31***	-0.28***	-0.24***	-0.27***	-0.22***
	(0.08)	(0.08)	(0.06)	(0.05)	(0.06)	(0.06)
$ratiostartup_{t-1}$	0.19**	0.20**	0.32***	0.26**	0.33***	0.27**
	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.09)
$fractionest < 50_{t-1}$	-5.41***	-5.06***	-3.81**	-2.72**	-3.21*	-1.76
	(1.23)	(1.20)	(1.35)	(0.93)	(1.56)	(1.27)
$fractionest > 250_{t-1}$	0.01	-0.11	-0.14	-0.21	-0.24*	-0.27*
	(0.14)	(0.19)	(0.11)	(0.13)	(0.13)	(0.13)
$\ln \frac{est_{t-1}}{km^2}$	0.17***	0.15**	0.08	0.06	0.05	0.02
	(0.04)	(0.05)	(0.06)	(0.04)	(0.07)	(0.05)
$\ln \frac{population_{t-1}}{km^2}$	-0.01	-0.25**	0.19*	-0.19**	0.29**	-0.08
	(0.08)	(0.10)	(0.10)	(0.08)	(0.11)	(0.09)
$\ln fractionurban_{t-1}$	0.22	0.32*	0.04	0.15	0.03	0.15
	(0.14)	(0.17)	(0.10)	(0.10)	(0.10)	(0.10)
$\frac{managers_{t-1}}{employees_{t-1}}$		4.54***		6.20***		6.45***
		(1.48)		(0.69)		(0.91)
$\frac{professionals_{t-1}}{employees_{t-1}}$		0.06		-0.62		-1.32
		(0.46)		(0.60)		(0.89)
$\frac{semi\ professionals_{t-1}}{employees_{t-1}}$		0.05		0.58		0.81*
		(0.25)		(0.42)		(0.43)
$\frac{technicians_{t-1}}{employees_{t-1}}$		-1.04		-0.50		-0.51
		(0.64)		(0.53)		(0.59)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}}$					-1.45	-1.86
					(1.19)	(1.24)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}} * \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$					4.77	4.75
					(4.14)	(4.40)
Constant	4.98***	5.83***	2.68*	3.36***	1.69	1.96
	(1.27)	(1.22)	(1.45)	(0.90)	(1.82)	(1.45)
R^2	0.66	0.68	0.77	0.79	0.77	0.79
Time dummies	NO	NO	YES	YES	YES	YES
No. of observations	234	234	234	234	234	234

Notes: Regression estimates are weighted by state GDP share in 1993. *Bundesland* fixed effects included in all regressions. *, **, and *** denote significance at 90%, 95% and 99% confidence levels respectively, on the basis of robust standard errors clustered by state.

Table A.4. **Determinants of TFP Growth in German *Bundesländer*, IV Regressions**

Dependent Variable: a_{it}^{DS}	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$	0.19**	0.31***	0.28***	0.36***	0.05	0.15	0.16
	(0.08)	(0.09)	(0.07)	(0.07)	(0.11)	(0.12)	(0.11)
a_{Ft}^{ST}	1.03***	1.04***					
	(0.10)	(0.10)					
$\ln \frac{I_{t-1}}{Y_{t-1}}$	-0.27***	-0.29***	-0.31***	-0.27***	-0.30***	-0.26***	-0.31***
	(0.07)	(0.08)	(0.06)	(0.07)	(0.06)	(0.07)	(0.08)
$ratiostartup_{t-1}$	0.03	0.13	0.15*	0.14	0.20**	0.18**	0.17**
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)
$fractionest < 50_{t-1}$	-2.42	-2.85	-3.10	-2.62	-1.81	-1.16	-1.60
	(1.81)	(2.29)	(1.98)	(2.04)	(1.64)	(1.66)	(1.55)
$fractionest > 250_{t-1}$	-0.19	-0.21	-0.21	-0.30	-0.45**	-0.59***	-0.60***
	(0.18)	(0.19)	(0.16)	(0.19)	(0.21)	(0.22)	(0.22)
$\ln \frac{est_{t-1}}{km^2}$	0.10*	0.13**	0.12*	0.11	0.06	0.01	0.02
	(0.05)	(0.06)	(0.07)	(0.08)	(0.06)	(0.07)	(0.07)
$\ln \frac{population_{t-1}}{km^2}$	0.08	-0.19	0.12	-0.28*	0.38***	0.01	0.06
	(0.10)	(0.12)	(0.14)	(0.16)	(0.15)	(0.18)	(0.17)
$\ln fractionurban_{t-1}$	0.15	0.16	0.12	0.21**	0.11	0.22**	0.24**
	(0.11)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)
$\frac{managers_{t-1}}{employees_{t-1}}$		4.74***		6.38***		7.05***	6.69***
		(1.56)		(1.57)		(1.56)	(1.59)
$\frac{professionals_{t-1}}{employees_{t-1}}$		-0.49		-0.48		-0.88	-0.89
		(0.56)		(0.82)		(0.98)	(0.97)
$\frac{semi\ professionals_{t-1}}{employees_{t-1}}$		0.57		0.95**		1.33**	1.35**
		(0.36)		(0.46)		(0.54)	(0.54)
$\frac{technicians_{t-1}}{employees_{t-1}}$		-0.43		-0.29		-0.63	-0.90
		(0.90)		(0.88)		(0.95)	(0.96)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}}$					-3.08**	-3.72**	-3.57**
					(1.57)	(1.65)	(1.67)
$\ln \frac{R\&D_{t-1}}{Y_{t-1}} * \ln \frac{A_{Ft-1}^{ST}}{A_{it-1}^{ST}}$					11.91**	12.50**	12.26**
					(5.20)	(5.72)	(5.72)
Constant	1.86	3.44	2.30	3.62	-0.09	0.96	1.16
	(1.98)	(2.24)	(2.30)	(2.26)	(1.90)	(1.84)	(1.79)
R^2	0.70	0.73	0.79	0.80	0.78	0.80	0.80
Sargan (p value)	0.77	0.44	0.25	0.08	0.21	0.07	0.06
N. of observations	208	208	208	208	208	208	208

Notes: Regression estimates are weighted by state GDP share in 1993. *Bundesland* fixed effects included in all regressions. *, **, and *** denote significance at 90%, 95% and 99% confidence levels respectively, on the basis of robust standard errors . Instruments: $\ln \frac{A_{Ft-2}^{ST}}{A_{it-2}^{ST}}$ and $\ln \frac{A_{Ft-3}^{ST}}{A_{it-3}^{ST}}$ in all columns, $\ln \frac{R\&D_{t-2}}{Y_{t-2}}$ and $\ln \frac{A_{Ft-2}^{ST}}{A_{it-2}^{ST}} * \ln \frac{R\&D_{t-2}}{Y_{t-2}}$ in columns (5), (6) and (7), $\ln \frac{I_{t-1}}{POP_{t-1}}$ in column (7).