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Cyclical adjustment, capital-labor substitution and total factor productivity convergence - East Germany after unification

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Cyclical adjustment, capital-labor substitution and total factor productivity convergence – East Germany after unification

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Abstract

Despite rapid economic integration and massive help from the Federal Government East German productivity catching up faded out in the nineties. This paper presents panel-data estimates of the productivity adjustment based on a production function framework and a stylized adjustment model of the economy. The central empirical result is a decomposition of the sources of productivity growth. The estimates reveal that a large part of productivity growth in the early nineties is related to factors that were specific for those period. The fading out since the mid-nineties is attributed to the development of total factor productivity.

Keywords: Economics of transition, productivity convergence

JEL No.: O11, O47, O52, P20

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1 Introduction

In November 1989 the opening of the border between the Federal Republic of Germany and the German Democratic Republic initiated a rapid process of political and economic unification which took place in 1990. Until the late nineties the productivity development in East Germany was considered as a remarkable success. Enormous investments in infrastructure and private capital had build up productive capacities, and since 1991 large absolute and relative productivity increases took place.¹ One can therefore conclude that catching up had occurred. However, the 1991 level of economic activity was much below pre-unification levels, and the development since then is far from being a self-sustained growth process. It still depends to a large extend on subsidies from the Federal Government, and sizeable wage and productivity gaps between East and West Germany persist.² Finally, catching up faded out in the nineties, despite ongoing investment and governmental help.³

This paper investigates East German productivity catching up in some detail. It presents new estimates of the regional disaggregated development based on a production function framework and a stylized adjustment model of the economy. The central contribution of the paper is a decomposition of the sources of productivity growth in East Germany. It distinguishes price adjustment, cyclical adjustment, capital-labor substitution and total factor productivity convergence. The estimation results reveal that a large part of the enormous productivity increases that took place in the early nineties is related to factors that were specific for those period, i.e. wage and price adjustment, capital-labor substitution and cyclical adjustment. The fading out of productivity growth since the mid-nineties is attributed to the development of total factor productivity. The adjustment of total factor productivity was slow, and large structural total factor productivity gaps persist.

Section 2 gives a short overview of the macroeconomic adjustment after unification. Section 3 discusses the theoretical framework. The central ingredient of the model is an augmented production function which permits to distinguish wage effects via capital-labor substitution, cyclical adjustment via a varying utilization of labor and total factor productivity catching up via technological diffusion. Section 4 presents the empirical results. The estimates employ annual panel data for the German

¹For instance, Barrell and te Velde (2000, p. 271) conclude that "...labor productivity in East Germany has caught up faster than has happened elsewhere."

²See DIW, IfW, IAB, IWH and ZEW (2003) and BMVBS (2008).

³Klodt (2000, p. 315) summarizes "Catching-up of East German productivity to West German levels has completely faded out since the mid-1990s."

states from 1991 to 2008 which stem from National Accounts and Labor Market Statistics. The final section summarizes the main findings and concludes with some policy implications.

2 Macroeconomic adjustment after unification

Unification began with the opening of the German border November 9, 1989. The first cornerstone of the economic development in East Germany was the decision for a fast implementation of Economic, Monetary and Social Union in July 1990. In terms of the political development this decision and its implementation can be considered as a great success. In a very short time span the regulations and institutions of a market economy were introduced to a former centrally planned and ruled economy. Unification was concluded with the joining of the East German states October 3, 1990, i.e. the whole process took less than one year.⁴ After the successful political implementation of the unification treaty East and West German citizens and politicians were very optimistic about the future prospects of the East German economy.

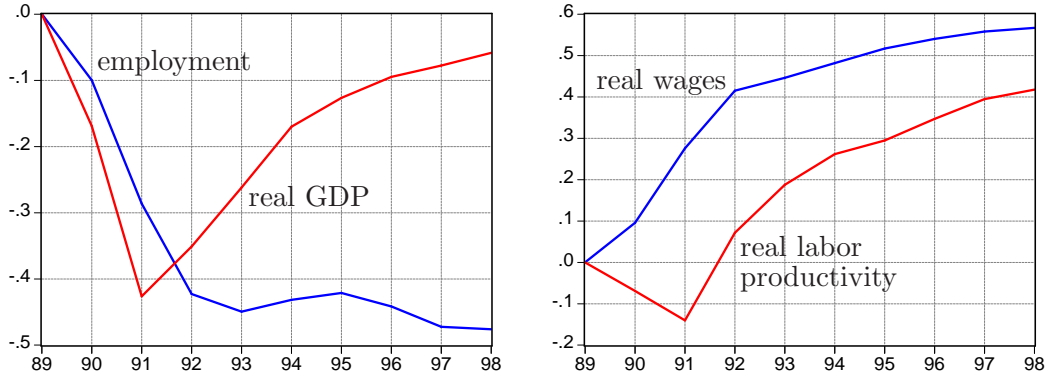
In terms of the economic development the introduction of West German currency and institutions in East Germany imposed many problems. Central was the currency conversion rate in combination with the state of the East German economy in 1990.⁵ The currency conversion rate of 1:1 for flows (wages, prices, pensions etc.) implied wage levels in East Germany of about 1/3 of West German levels. On average East German productivity was not far beyond, but for the export-oriented industry sector the currency conversion rate implied an immediate loss of competitiveness. East German consumers switched to western products, East German investors had no interest in outdated technology, former CMEA partners⁶ were not able to pay western currency, and east-west trade was low already before unification. Consequently demand and output broke down.

⁴A short time table of the unification process is depicted in table A.1 in the appendix. For a detailed discussion of the political economy of German unification see Sinn and Sinn (1992) and the articles in Lange and Shackelton (1998).

⁵For a detailed discussion see Akerlof et al. (1991), Sinn and Sinn (1992), Hughes Hallet and Ma (1993) and Lange and Pugh (1998).

⁶The CMEA (Council for Mutual Economic Assistance) was the economic association of the Eastern bloc countries.

Figure 1: Macroeconomic adjustment after unification



East Germany, logarithmic indices₁₉₈₉ = 0

Figure 1 depicts the development of some key variables 1989-1998.⁷ In 1991 output (real GDP) was about 1/3 lower as compared with 1989, and in 1992 the employment loss amounted to about 1/3, too.⁸ Employment adjusted only slowly with respect to output due to several measures of employment policy introduced specifically for the situation in East Germany after unification. Despite massive layoffs 1990/1991 (about 25 percent) and the starting investment boom, there was still a large overhang of employees not required for production. Consequently labor productivity in 1991 was more than 10 percent below the pre-unification level 1989. From 1991 until 1993 a further reduction of employment by more than 15 percent took place, despite real output increases of nearly 20 percent in the same period.

The process of wage adjustment, on the other hand, began even before Economic, Monetary and Social Union, and real wages increased by nearly 30 percent already in 1990/1991. The central argument in the wage negotiations in the early nineties was wage convergence. The goals of union leaders and workers were in favor of uniform living conditions in both parts of Germany which should be achieved with fast wage adjustments. The employers' side was less organized and, since it was dominated by West German firms, feared the competition of a low-wage region. Not surprisingly, the public opinion was also in favor of wage convergence, and the political process with a sequel of elections in the East German states supported the view of the unions.⁹ Consequently wages increased fast in the early nineties.

⁷The data stem from the National Accounts of the DIW, Berlin.

⁸See Akerlof et al. (1991) and Lipschitz and McDonald (1990) for a detailed discussion.

⁹See Akerlof et al. (1991), Franz and Steiner (2000), Burda and Hunt (2001) and Hunt (2001) for a more detailed discussion.

After the breakdown a fast catching-up process began. Real output increased, employment stabilized, and since 1992 enormous increases of labor productivity took place. However, since the mid-nineties the adjustment process slowed down. Output growth became smaller. Low competitiveness and high unemployment changed the incentives and the power of unions and firms in the wage-setting process, and wage inflation became smaller. Inflation rates which were high in the early nineties converged towards West German rates. Productivity catching up faded out as well, and in the late nineties the East-West productivity gap persists at about 30 percent.

3 Productivity adjustment in East Germany

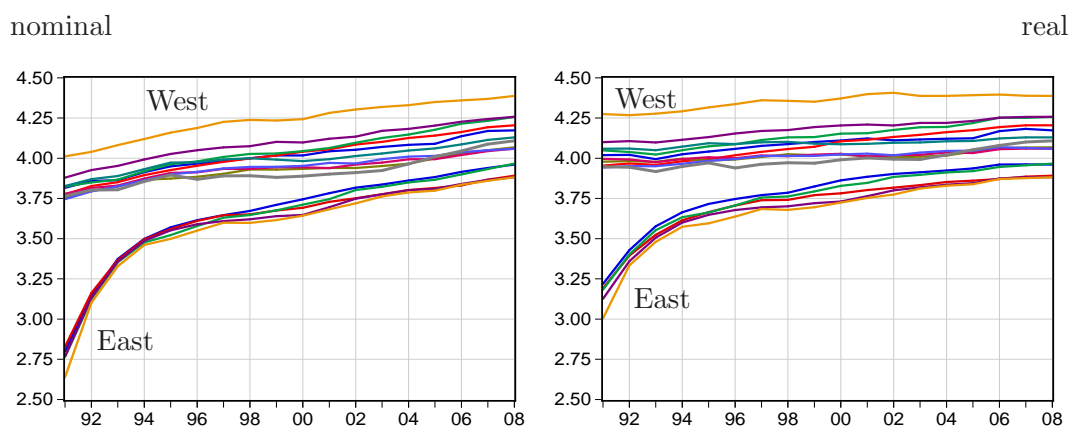
The development of labor productivity for the years from 1991 to 2008 is depicted in figure 2.¹⁰ The upper left-hand figure shows the strong increase of nominal productivity in the East German states (the 5 lower lines in the figure) in the first half of the nineties. Nominal productivity about doubled from 1991 to 1994. Since the mid-nineties productivity growth in East Germany slowed down, and in the more recent years growth rates hardly differed between East and West Germany. Correspondingly the relative productivity of the East German states (the lower left hand figure) increased fast in the early nineties. Since the mid-nineties the adjustment process slowed down, and in the more recent years the productivity gap amounts to about 20 to 25 percent.

The development of real labor productivity gives a similar impression of a fast adjustment in the early nineties and a fading out of the catching-up process later on. However, the figures reveal that the real labor productivity gap was smaller as compared with the nominal productivity gap, i.e. a significant part of the nominal productivity adjustment in the nineties was based on price increases. Those price increases can firstly be understood as the adjustment of prices from pre-unification (policy-based) levels to competitive market prices. Secondly, wage increases above real productivity growth in the early nineties induced inflation via mark-up cost-based pricing. Nevertheless real labor productivity increased enormously as well from about 40 percent of the average West German level in 1991 to about 75 percent in the more recent years.

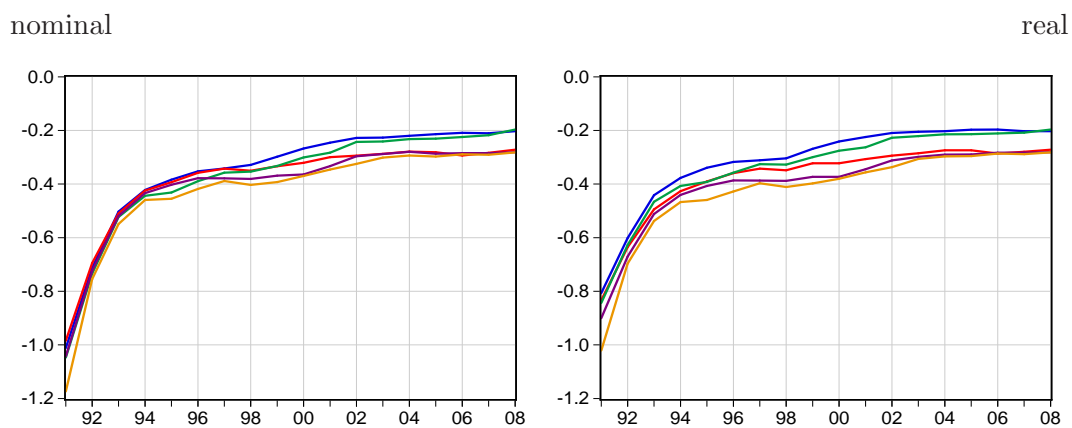
¹⁰The data stem from the National Accounts of the States (Federal Statistical Office). Those data are available from 1991 onwards only. Detailed data sources and definitions are given in table A.2 in the appendix.

Figure 2: Productivity adjustment

labor productivity, 15 German states (excluding Berlin)



relative labor productivity, 5 East German states



Source: National Accounts of the States

Logarithmic values, real values are based on 2008 prices (chain indices)

Our theoretical discussion distinguishes three channels of real productivity catching up in East Germany after unification. Firstly, the large wage increases in the early nineties should have encouraged capital-labor substitution; therefore labor productivity should have increased as well. Secondly, after the breakdown of demand in 1990/1991 idle resources were available; the reduction of employment should have increased the utilization of labor. Thirdly, the opening of the border should have initiated a rapid process of total factor productivity catching up, speeded up by investment subsidies and consequently large investment rates.

The theoretical framework consists of a production function and a stylized adjustment model of the economy. The starting point is a standard neoclassical CES production function with capital K and labor L as inputs,

$$YP = \theta \cdot [\delta \cdot L^{-\rho} + (1 - \delta) \cdot K^{-\rho}]^{-1/\rho}. \quad (1)$$

YP is potential output, $\rho = 1/\sigma - 1$ with σ being the elasticity of substitution, δ is the distribution parameter, and θ is total factor productivity. Optimizing firms choose a production technique in accordance with the remuneration of the production factors. In case of imperfect competition on the product market prices p are set as a mark up on total factor costs. Accordingly the potential (full employment) productivity of labor is determined as

$$\log \pi_l = \sigma \cdot \log w/p + (1 - \sigma) \cdot \log \theta - \sigma \cdot \log \delta. \quad (2)$$

$\pi_l = YP/L$ and w is the wage rate.

However, the unification process in East Germany was accompanied by a sharp breakdown of demand. In addition, several measures of employment protection delayed the adjustment of employment.¹¹ Consequently measured labor productivity was below potential productivity, i.e.

$$\log Y/L = \log \pi_l + \log U_l. \quad (3)$$

Y/L is real output per employee, and $U_l \leq 1$ is the utilization of labor. Inserting eq. (2) into eq. (3) yields

$$\log Y/L = \sigma \cdot \log w/p + (1 - \sigma) \cdot \log \theta + \log U_l + \text{constant} \quad (4)$$

which will serve as the starting point of the empirical analysis.

¹¹After unification short-time working increased sharply. Later on the Federal Labor Agency introduced several measures of active labor market policy especially for the situation in East Germany after unification.

A final component of East German productivity adjustment is total factor productivity growth. In the early nineties many economists expected a fast convergence of East German productivity towards West German levels. Before 1990 East German firms employed less efficient technologies, since they had hardly access to imported high technology capital goods. Unification and the associated subsidies from the Federal Government initiated a large inflow of direct investment from mostly West German firms. Since West German firms had access to best practice technology from all over the world and exhibited high productivity levels, a large increase of total factor productivity in East Germany could be expected.

This argumentation corresponds to the model of technological diffusion which is the primary hypothesis to understand the process of productivity convergence of the industrial countries in the post World War II period.¹² Technological diffusion implies that total factor productivity growth depends positively on the productivity distance with respect to the leader country, in this case West Germany,

$$\Delta \log \theta = \lambda \cdot \log(\theta/\theta^w) + \text{residual.} \quad (5)$$

Combining those arguments yields three determinants of real labor productivity growth: firstly the impact of real wages via capital-labor substitution, secondly the changing utilization of labor in case of demand shocks and thirdly the catching up of total factor productivity via technological diffusion,

$$\Delta \log Y/L = \sigma \cdot \Delta \log w/p + (1 - \sigma) \cdot \lambda \cdot \log(\theta/\theta^w) + \Delta \log U_t + \text{residual.} \quad (6)$$

Eq. (6) is the base for the empirical analysis of the sources of productivity growth in East Germany after unification.

4 Empirical analysis

The data source for the empirical investigation of the determinants of productivity adjustment in East Germany after unification is a panel of annual National Accounts data for the German states from 1991 to 2008.¹³ The starting point of the

¹²Coe and Helpman (1995) discuss technological diffusion in terms of R&D spillovers, and Barro and Sala-i-Martin (1997) analyze productivity convergence in terms of cost advantages of imitation as compared with innovation. The importance of social and political factors for catching up is discussed by Abramovitz (1986). See Temple (1999) for a general discussion and Smolny (1999, 2000) for empirical applications for West Germany.

¹³Detailed data sources and definitions are provided in table A.2 in the appendix. The data are depicted in figure A.1 and A.2 in the appendix.

empirical analysis is the estimation of the first order condition based on the CES production function. Labor productivity Y/L is determined by real wages w/p , the estimated coefficient is the elasticity of substitution σ . The demand effects on the utilization of labor U_l are taken into account with two indicators based on short-time working (STW) and the extend of active labor market policy programs (ALMP). The development of total factor productivity θ is firstly approximated with linear and quadratic time trends; differences between the states are captured with dummy variables for the 5 East German states. The final estimates of the productivity adjustment incorporate the total factor productivity gap with respect to West Germany.

Table 1 reports the results for two sets of estimates. The augmented production function is firstly estimated with absolute values of the data. The second set of estimates is based on relative values, i.e. differences between state-specific values and West German averages. The advantage of this proceeding is that it excludes the common (West German) trend from the data. This should capture the specifics of the productivity adjustment in East Germany after unification more clearly. The first two columns refer to the logarithmic level equation, i.e. are specified according to eq. (4). Columns (3) and (4) refer to rates of change, i.e. correspond to eq. (4) in differences. The right-hand columns depict the results of the adjustment model corresponding to eq. (6).

The results for the level equations firstly reveal significant effects of real wages on labor productivity, the estimated elasticities of substitution appear plausible. The estimates show secondly highly significant effects of the indicators for the utilization of labor, i.e. a large share of short-time workers and the extend of active labor market policy programs are associated with a lower productivity of labor. The estimates finally yield meaningful estimates for the rate of total factor productivity growth. The estimated coefficients for the absolute data imply a trend rate of technological progress in East Germany of about 4 percent per year in 1991 and about 1 percent for the more recent years.¹⁴ The estimates with the relative data imply a trend rate of 4 percent in 1991 as well; for the years since 2006 the calculated rate becomes negative.

¹⁴The trend rate of technological progress is calculated as $\Delta \log \hat{\theta} = (\hat{\gamma}_1 + 2 \cdot \hat{\gamma}_2 \cdot t)/(1 - \hat{\sigma})$, $\hat{\gamma}_1$ and $\hat{\gamma}_2$ are the estimated coefficients of the linear and quadratic time trend, and $\hat{\sigma}$ is the estimated elasticity of substitution.

Table 1: Estimates of the production function

endogenous variable: real labor productivity Y/L

	levels		differences		adjustment	
	absolute	relative	absolute	relative	absolute	relative
	(1)	(2)	(3)	(4)	(5)	(6)
real wages w/p	0.36 (0.14)	0.42 (0.12)	0.42 (0.17)	0.62 (0.17)	0.17 (0.15)	0.24 (0.15)
ALMP	-2.43 (0.32)	-2.23 (0.32)	-2.19 (0.26)	-1.89 (0.25)	-1.76 (0.22)	-1.63 (0.20)
STW	-1.50 (0.14)	-1.39 (0.12)	-1.31 (0.15)	-1.13 (0.14)	-1.25 (0.13)	-1.18 (0.11)
lagged tfp gap					-0.26 (0.04)	-0.28 (0.04)
constant	2.482 (0.440)	0.288 (0.043)	0.030 (0.007)	0.023 (0.007)	-0.069 (0.017)	-0.084 (0.017)
trend	0.025 (0.004)	0.022 (0.003)	-0.001 (0.001)	-0.001 (0.001)	0.001 (0.001)	0.002 (0.001)
trend ²	-0.0006 (0.0002)	-0.0008 (0.0001)				
state dummies	with	with	without	without	with	with
\overline{R}^2	0.992	0.988	0.927	0.930	0.950	0.954
SEE	0.018	0.018	0.016	0.017	0.014	0.014

Standard errors in parentheses. Annual data for the East German states 1991-2008.

Relative values are calculated as (log.) differences from West German averages.

Real labor productivity is the logarithm of real GDP per employee.

Real wages is the logarithm of gross labor income per worker.

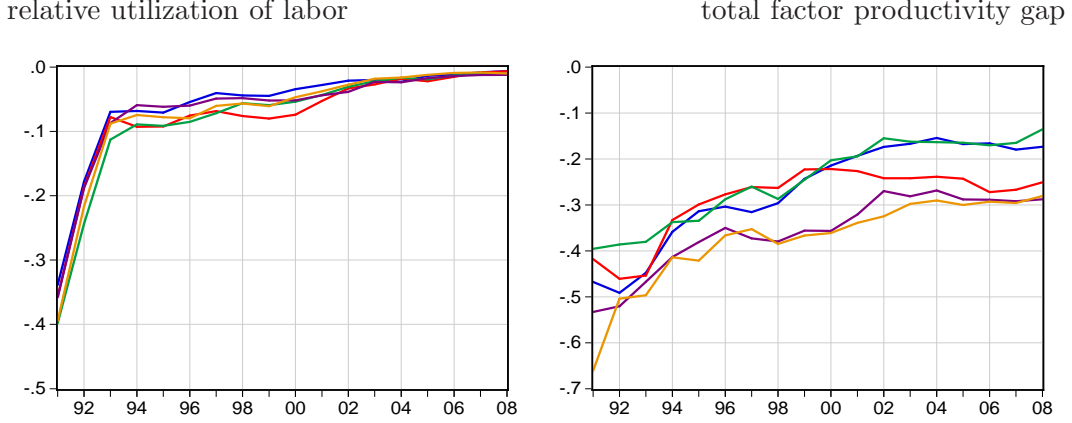
Real values are calculated with price index (2008) = 1.

ALMP: Share of workers in active labor market policy programs.

STW: Share of short-time workers in total employment.

The total factor productivity (tfp) gap is calculated from column (2).

Figure 3: Total factor productivity and cyclical adjustment



5 East German states relative to average of West Germany, logarithmic values

Figure 3 depicts the implied results for the utilization of labor and the total factor productivity gap of the 5 East German states. The data for the figures are calculated from the coefficients in column (2), i.e. they refer to the level equation with the relative data. The utilization of labor is calculated as $\log U_l = \hat{\beta}_1 \cdot \text{ALMP} + \hat{\beta}_2 \cdot \text{STW}$. The left-hand figure shows the low utilization of labor in 1991/1992. Utilization increased quickly, and in the more recent years the cyclical gap nearly vanishes. The right-hand figure depicts the total factor productivity gap. It is calculated as the residual after taking the substitution effect and utilization into account, i.e. $\log \hat{\theta} = (\log Y/L - \hat{\sigma} \cdot \log w/p - \hat{U}_l)/(1 - \hat{\sigma})$.¹⁵ The estimates indicate a sizeable reduction of the gap during the nineties. In the more recent years the gap persists at about 15 to 30 percent with marked differences between the states.

The results for labor productivity growth based on first differences are depicted in columns (3) and (4) of table 1. The advantage of the estimation in terms of rates of change is that it extracts possible stochastic trends from the data; working with differences also permits to exclude the state-specific fixed effects. However, one should hold in mind that the estimation in terms of rates of change tends to capture short-run effects only. The results more or less confirm those of the level equation. The estimates of the elasticity of substitution, the indicators of the utilization of employment and the trend rate of technological progress all remain within the confidence bands of the corresponding coefficients of the level equations.

¹⁵Correspondingly, total factor productivity can be calculated as the sum of trend and state-specific effects and residual, i.e. $\log \hat{\theta} = (\hat{\gamma}_0 + \hat{\gamma}_1 \cdot t + \hat{\gamma}_2 \cdot t^2 + \text{state dummies} + \hat{\varepsilon})/(1 - \hat{\sigma})$.

Table 2: Adjustment speed and equilibrium gap

	nominal productivity	prices	real productivity	real wages	utilization of labor	tfp gap
adjustment coefficient	-0.413 (0.012)	-0.560 (0.016)	-0.371 (0.013)	-0.444 (0.014)	-0.496 (0.019)	-0.176 (0.033)
equilibrium gap	-0.286 (0.007)	-0.005 (0.001)	-0.277 (0.007)	-0.255 (0.003)	-0.032 (0.004)	-0.222 (0.024)
\overline{R}^2	0.931	0.938	0.907	0.924	0.885	0.236
SEE	0.023	0.006	0.019	0.009	0.015	0.027

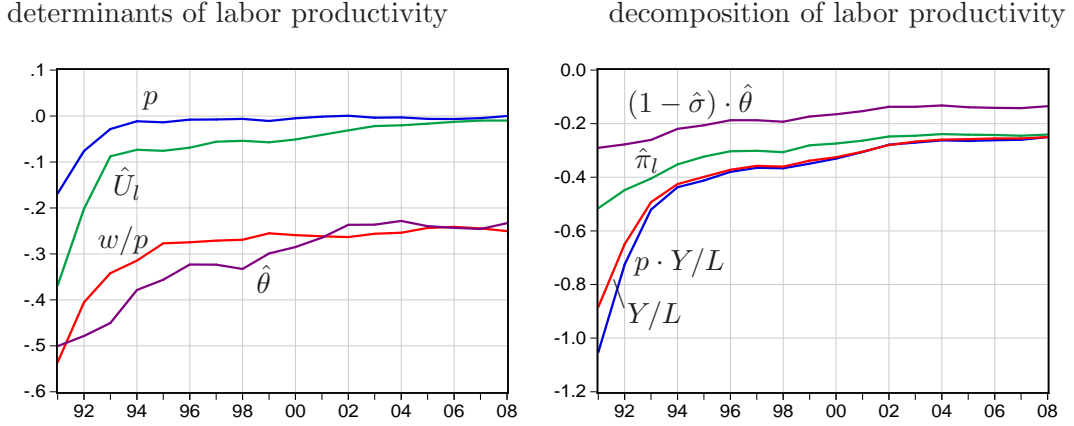
Standard errors in parentheses. Annual data for the East German states 1991-2008. Relative values, 5 East German states relative to average of West Germany. State dummies included (not reported), coefficients of state dummies add up to 1.

The results in the right-hand columns of table 1 refer to the total factor productivity adjustment model according to eq. (6). The results for real wages point towards an uncertainty associated with the estimation of substitution effects. The models in differences yield a slightly larger elasticity of substitution, the estimates of the adjustment model yield a slightly smaller coefficient as compared with the level equations. In addition, the estimated cyclical effects of utilization are slightly smaller for labor productivity growth. Finally, the one year lagged total factor productivity gap exhibits a highly significant effect on labor productivity growth. The estimated coefficients indicate a noticeable adjustment of total factor productivity. However, the large negative constant and the significant state-specific effects point towards a structural gap between the East and West German states.¹⁶

The final estimates in table 2 explore the dynamic adjustment of the different measures of productivity and its components directly. They are based on univariate adjustment models. The estimated equations are $\Delta \log x_t / \overline{x}_t^w = \lambda \cdot (\log x_{t-1} / \overline{x}_{t-1}^w - \text{constant} - \text{state dummies})$ for $x \in \{p \cdot Y/L, p, Y/L, w/p, \hat{U}_l, \hat{\theta}\}$. λ is the adjustment coefficient and the constant can be interpreted as the average equilibrium gap of the East German states. The results reveal a fast adjustment of prices and the utilization of labor and a slower adjustment of total factor productivity. The adjustment

¹⁶The state dummies are defined as differences with respects to the reference state, i.e. the coefficients add up to 1. Therefore the reported constants can be interpreted as the average for the East German states.

Figure 4: Decomposition of labor productivity



Average East Germany relative to average of West Germany, logarithmic values

coefficients for real wages and nominal and real labor productivity are in between. The corresponding equilibrium gaps for prices and utilization are small, the equilibrium gaps for real wages and the different measures of productivity are between 20 and 30 percent.

Figure 4 gives a visual impression of those results. It depicts the development of the determinants of labor productivity and provides a decomposition of the productivity adjustment. The figures show the fast adjustment and the vanishing of gaps for prices and the utilization of labor. The nominal, real and cyclical adjusted labor productivity gaps nearly coincide in the most recent years. The adjustment of real wages and especially total factor productivity was slower. The corresponding equilibrium gaps are about 25 percent, thereby yielding nearly equal contributions to the about 25 percent labor productivity gap.

Summarizing those results, East Germany experienced a fast recovery from the unification shock in 1990. The strong increase of productivity in the early nineties stems from fast increases of factor utilization and prices. The results also reveal significant contributions from wage-induced capital-labor substitution and total factor productivity catching up. In the more recent years the catching-up process faded out. The results indicate a more or less complete adjustment of prices and utilization towards West German levels. For wages and productivity an equilibrium situation with corresponding structural gaps of about 25 percent is achieved as well.

5 Conclusion

The productivity development in East Germany shows both success and failure. In 1990 the opening of the border hit the East German economy like a shock. The opening to competition combined with the currency conversion rate and the desolate state of the East German economy led to a breakdown of demand and rendered large parts of the capital stock obsolete. Soon afterwards a fast recovery with large rates of output and productivity growth began. In the late nineties the catching-up process faded out, and in the recent years productivity gaps of about 20 to 30 percent persist.

The paper presents new estimates of the determinants of productivity catching up based on a production function framework and a stylized adjustment model of the economy. The results identify four sources of productivity catching up. Firstly, a sizeable contribution to the large rates of nominal productivity growth in the early years after unification stems from price increases. Secondly, the expiration of labor market programs and the adjustment of employment during the nineties led to an increase of unemployment but spurred productivity growth. Thirdly, a corresponding effect on productivity and labor market situation resulted from wage-induced capital-labor substitution. A final contribution to the development of labor productivity during the nineties stems from total factor productivity catching-up.

The empirical analysis shows that the fading out of the catching-up process since the mid-nineties resulted from the expiration of those effects that spurred productivity growth in the early nineties, i.e. price adjustment, cyclical adjustment of utilization and wage-induced capital-labor substitution. In addition, total factor productivity catching up faded out as well at a level markedly below those of West Germany. Relevant for the persisting productivity gap in the more recent years are corresponding real wage and total factor productivity gaps.

In terms of policy conclusions one should not hope for wage increases. The real wage gap basically corresponds to the productivity gap, East German unemployment is high and competitiveness is low.¹⁷ Therefore a remedy which could help both in terms of labor market situation and productivity differences could stem only from a resurgence of total factor productivity catching-up. From theoretical arguments one would expect a continuation of an adjustment process. The prerequisites for catching up were quickly established via policy decisions at an early stage of the unification process, and for the Federal Government economic convergence is an important

¹⁷See Smolny (2009) for a more detailed discussion of wage adjustment, competitiveness and unemployment in East Germany after unification.

objective. In terms of the empirical development the East German productivity catching up shows no sign of recovery since 2002. So one is tempted to ask what distinguishes the East German states?

A convenient answer might be that the unfavorable starting position provides an explanation for the productivity gap. However, the starting position can explain temporary disequilibria, but not a structural gap which was established in the nineties with hardly any adjustment afterwards. A more elaborated line of argument is related to the inheritance of the unification process. The political decisions at the beginning of the unification process – adoption of the West German social security system, massive investment subsidies – had left the East German economy with distorted incentives which might have impeded the continuation of the catching up.¹⁸ Those policy measures have helped at the early stage of the unification process, but may have contributed to the persistence of gaps later on.

A final set of arguments refers to the locational disadvantages of East Germany.¹⁹ Firstly, the specific allocation of transfers resulted in a sectoral structure with above average weights of low productivity sectors such as construction and social services and below average weights of high productivity sectors such as industry and financial services. Secondly, the accumulation of human capital is impeded by the bad employment situation on the East German labor market. and qualified workers migrating to West Germany, where wages are higher and employment opportunities are more favorable. Finally, why should (West German) firms open a dependence in East Germany? Given the location at the eastern border of western Europe and still less developed infrastructure, it is still easier to supply East Germany from the West as the other way round. Until today the empirical relevance of those arguments is hardly understood, and the puzzle of the fading out of East German productivity catching up is not yet solved.

¹⁸See Sinn (2002) and Snower and Merkl (2006) for a discussion.

¹⁹See Burda (2006), Redding and Sturm (2009) and Buch and Toubal (2009) for a discussion.

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Appendix

Table A.1: Time table of the unification process

May 1989	Removal of border controls in Hungary
August 1989	Mass migration of GDR-citizens via Hungary
September 1989	“Monday demonstrations” in Leipzig
November 9, 1989	<i>Opening of the German border</i>
January 12, 1990	Privat ownership of production facilities and joint ventures with foreigners permitted
May 5, 1990	Begin of 2+4 negotiations
May 18, 1990	Signing of the treaty about formation of an Economic, Monetary and Social Union
July 1, 1990	The treaty came into force
August 31, 1990	Signing of the Unification Treaty
September 12, 1990	Closing of the 2+4 Treaty
October 3, 1990	<i>German unification</i>
October 14, 1990	Elections of East German state parliarments
December 2, 1990	Elections of the Federal Government

Table A.2: Data sources and definitions

Figure 1:

The data stem from National Accounts, 1989 to 1998, West and East Germany (Federal Statistical Office, the data for 1989 and 1990 are estimates of DIW). West and East Germany include West and East Berlin.

Output is real GDP (prices of 1991). Employment is total employment. The wage rate is total labor costs per employee. Prices refer to the GDP deflator (base 1991). Labor productivity is real GDP per worker.

Figure 2 and empirical analysis:

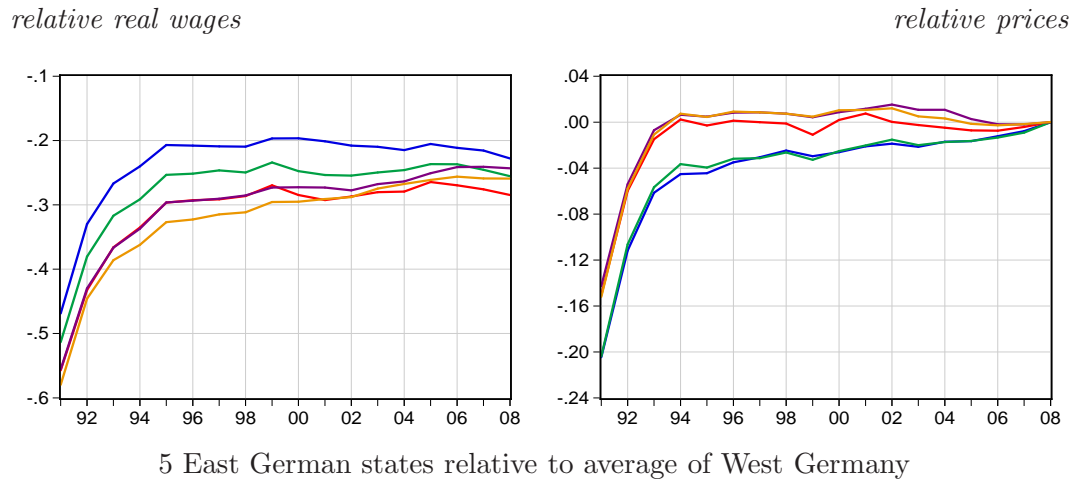
The data stem from the National Accounts of the States (Volkswirtschaftliche Gesamtrechnung der Länder) and from the Federal Labor Agency.

The East German states are Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt and Thüringen. The reference West Germany refers to the aggregate values for the 10 West German states. Berlin is excluded.

Labor productivity Y/L is real GDP (chain index) per employee. Real values are normalized at prices of 2008. The wage rate w is gross wage costs per employee. Prices p refer to the GDP deflator (chain index) normalized for 2008.

Short-time working STW refers to the share of short-time workers in total employment. Active labor market policy $ALMP$ refers to the share of workers in labor market programs in total employment.

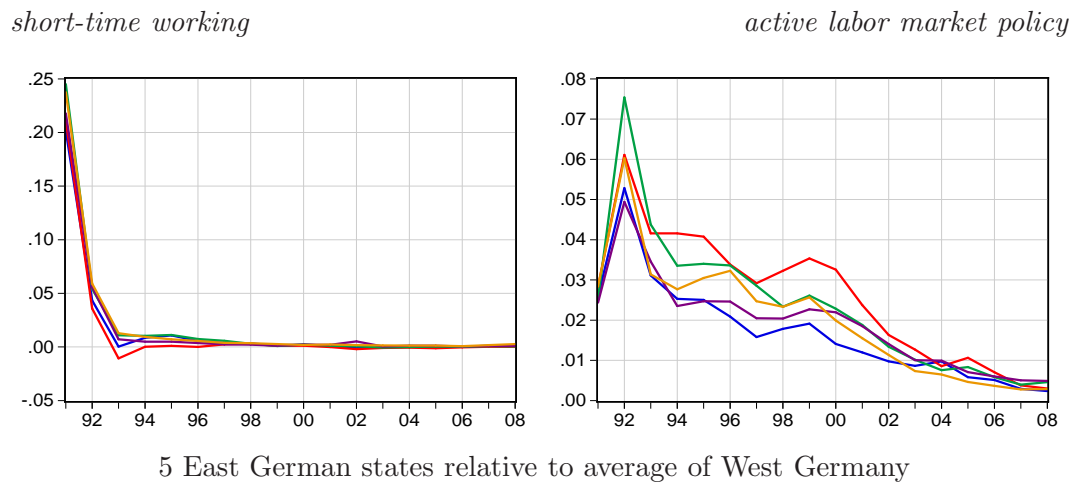
Figure A.1: Wages and prices



Logarithmic values, price base 2008

Source: National Accounts of the States, Federal Statistical Office

Figure A.2: Cyclical adjustment



Shares in total employment

Source: Federal Labor Agency