

Productivity adjustment in East Germany

Why has it slowed down?

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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 mid-nineties. This paper attempts to explain stylized facts of the development based on a production function framework and an adjustment model of the firm. 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 slow-down since the mid-nineties is related to low growth rates of total factor productivity.

Keywords: Economics of transition, productivity convergence

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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 unconditional convergence had occurred. However, the 1991 level of economic activity was much below pre-unification levels. In addition, the development since then is far from being a self-sustained growth process. It still depends largely on massive subsidies from the Federal Government, the employment situation is disastrous, and real output today is hardly above pre-unification levels.² Finally, catching-up faded out in the mid-nineties, despite ongoing investment and governmental help.³ Growth rates converged, but large wage and productivity gaps persist.

This paper investigates East German productivity catching up in some detail. It presents empirical estimates of the regional disaggregated development which are based on a production function framework and an adjustment model of the firm. The main contribution is a decomposition of the sources of productivity growth. It is distinguished between price adjustment, cyclical adjustment, capital-labour substitution and total factor productivity convergence. The estimation results reveal that a large part of the enormous productivity increases in the early nineties is related to factors that were specific for those period. The slow-down of productivity growth since the mid-nineties is related to a structural total factor productivity gap.

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-labour substitution and total factor productivity convergence via technological diffusion. The output, price and employment adjustment is analyzed within a model of imperfect competition on the product market with adjustment constraints. This permits the analysis of cyclical and price effects within the theoretical model. Section 4 discusses the data and the estimation procedure. The estimates employ annual panel data for the 16 German states 1991-2002 which stem from National Accounts and the Federal Labour Office. Section 5 presents estimation results for wages, prices and labour productivity. The final section summarizes the main findings and concludes with policy implications.

¹For instance, Barrel 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).

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

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, less than 8 months after the opening of the border. In terms of the political development, this decision and its implementation was 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 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 1990.⁵ The currency conversion rate of 1:1 for flows (wages, prices, pensions etc.) implied a wage level in East Germany of about 1/3 of the West German level. 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 output and employment broke down.

Figure 1 depicts the development of some key figures 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 lay-offs 1990/1991 (about 25 percent) and the starting investment boom, there was still a large overhang of employees not required for production. From 1991 until 1993 a further reduction of employment by more than 15 percent took place, despite real output increases of nearly 18 percent in the same period. Consequently, labour productivity in 1991 was more than 10 percent below the pre-unification level 1989. Real wages, on the other hand, increased by nearly 30 percent in 1990/1991.

⁴For a detailed discussion of the political economy of German unification see Sinn and Sinn (1992).

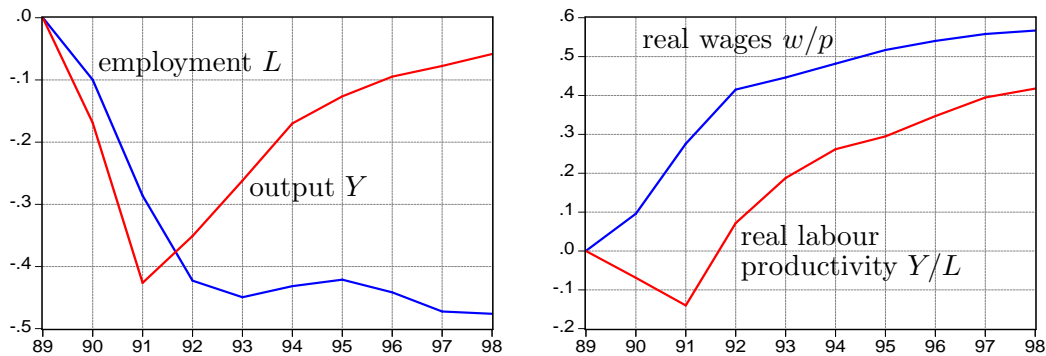
⁵For a detailed discussion see Akerlof et al. (1991), Sinn and Sinn (1992), Hughes Hallet and Ma (1993) and Welfens (1996).

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

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.

Figure 1: Macroeconomic adjustment after unification



East Germany, $index_{1989} = 0$, logarithmic values, prices of 1991.

After the breakdown a fast catching-up process began. Real output increased, employment stabilized, and since 1992 enormous increases of labour 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 since the late nineties East-West productivity gaps of about 30 percent persist.

3 Theoretical framework

The starting point of the theoretical discussion is the process of rapid wage adjustment. The central argument in the wage negotiations in the early nineties was wage convergence. The goals of union leaders and workers were in favour of uniform living conditions in both parts of Germany which should be achieved with fast wage adjustments towards western levels. 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 favour 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.

However, the breakdown of output and productivity 1990/1991 implied real unit labour costs far above West German levels. In addition, the unemployment rate rose to more than 15 percent already in 1992 which strengthened the employers' side and restricted the wage demand of unions. The empirical analysis distinguishes three determinants of long-run equilibrium wages w . The first is the adjustment with respect to West German wages w^{west} , i.e. wage convergence. The second is

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

the adjustment of wages with respect to nominal productivity $p \cdot Y/L$. p is the price level and Y/L is labour productivity, i.e. output Y per employee L . The third is the unemployment rate UR which changes the incentives and the power of unions in the wage-setting process.

$$w = w(w^{\text{west}}, p \cdot Y/L, UR). \quad (1)$$

The adjustment of the firms is analysed within a framework of monopolistic competition on the product market and uncertainty about demand.¹⁰ Wages are treated as exogenous at the firm level. In order to distinguish demand shifts, the price elasticity of demand and demand uncertainty, a log-linear demand curve for the firm's product is chosen,

$$\ln YD = \eta \cdot \ln p + \ln Z + \varepsilon, \quad E(\varepsilon) = 0, \text{Var}(\varepsilon) = \sigma_\varepsilon^2. \quad (2)$$

Demand YD depends negatively on the price p with constant elasticity $\eta < -1$, Z is a predetermined demand shift, and the demand shock ε introduces uncertainty. Supply YS is determined by a short-run limitational production function with capital K and labour L as inputs,

$$YS = \min(YC, YL) = \min(\pi_k \cdot K, \pi_l \cdot L). \quad (3)$$

YC are capacities, YL is the employment constraint, and π_l, π_k are the optimal productivities of labour and capital. In the short run output Y is determined as the minimum of demand and supply, $Y = \min(YD, YS)$. The medium-run adjustment of employment and prices takes place under uncertainty about demand. For the optimal solution two cases can be distinguished (see [figure 2](#)):

1. In case of capacity constraints employment is determined from capacities. No more workers will be hired than can be employed with the predetermined capital stock. Supply and employment result from

$$YS = YL = YC, \quad L(YC) = YC/\pi_l. \quad (4)$$

Employment is given by the maximal number of working places $L(YC)$. The optimal price depends on the relation of capacities and expected demand shifts, demand uncertainty and competition, $\ln p(YC) = [\ln YC - \ln Z - \bar{\varepsilon}(\eta, \sigma_\varepsilon)]/\eta$. In the capacity constrained case, the adjustment of employment is inhibited, and the whole adjustment with respect to expected demand shifts falls on the price.

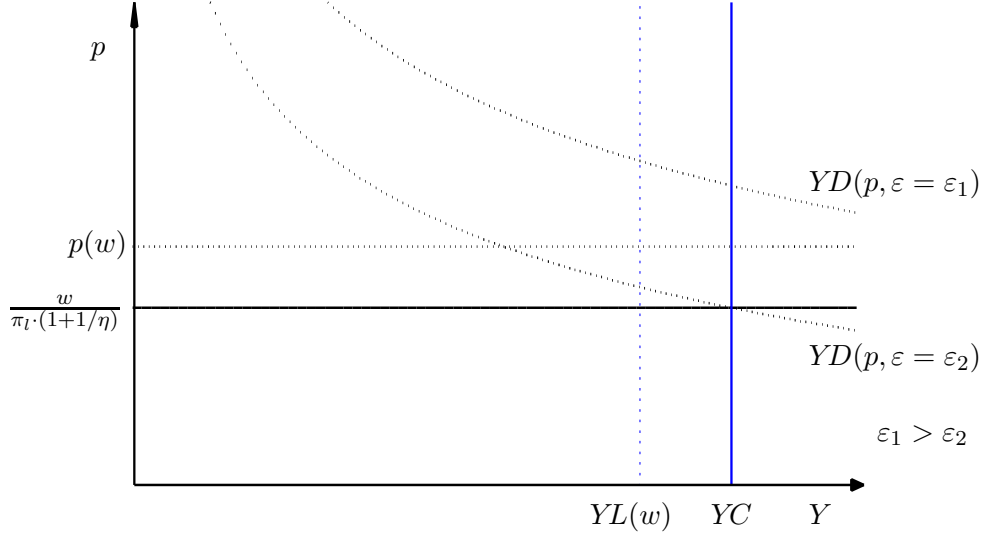
2. In case of sufficient capacities prices are determined as a mark-up over corrected unit labour costs,

$$p(w) = \frac{w}{\bar{U}^l(\eta, \sigma_\varepsilon) \cdot \pi_l \cdot (1 + 1/\eta)}. \quad (5)$$

The optimal price is determined by the price elasticity of demand, unit labour costs and the expected utilization of employment $\bar{U}^l := E(Y)/YL$. Optimal supply and

¹⁰See Barro (1972) and Blanchard and Kiyotaki (1987). For a more detailed discussion of the theoretical model see Smolny (1998).

Figure 2: Optimal prices and employment



employment result from $YL(w) = \eta \cdot \ln p(w) + \ln Z + \bar{\varepsilon}(\eta, \sigma_\varepsilon)$ and $L(w) = YL(w)/\pi_l$. In case of sufficient capacities the price is independent from expected demand shifts, and the firm adjusts quantities.

The model provides a framework for the analysis of the cyclical price and employment adjustment.¹¹ Ex ante the firm sets prices and adjusts employment under uncertainty about demand, i.e. the firm chooses one point in the $\{p, Y\}$ -diagram. Relevant for the adjustment is the capacity limit $YS = YL \leq YC$ and the minimum price $p(w)$. Ex post underutilization of employment and capacities or delivery lags can occur. The short-run demand situation can be identified from the utilization of employment $U^l = Y/YL$, the medium-run cyclical situation can be identified from the utilization of capacities $U^c = Y/YC$. Prices are determined by unit labour costs w/π_l and capacity utilization U^c . In addition, the empirical analysis takes an adjustment of East German prices with respect to West German price levels p^{west} into account.

$$p = p(w/\pi_l, U^c, p^{\text{west}}). \quad (6)$$

The long-run adjustment consists of the choice of capacities, the choice of the capital-labour ratio and total factor productivity adjustment. The long-run decision takes place under uncertainty about demand.¹² Optimal capacities depend on mark-up prices $p(w)$, expected demand shifts \bar{Z} and relative capital costs $(c/\pi_k)/(w/\pi_l)$,

$$\ln YC = \eta \cdot \ln p(w) + \ln \bar{Z} + \bar{\varepsilon}(\sigma_\varepsilon, \eta), + \bar{z} \left(\eta, \sigma_z, \frac{c/\pi_k}{w/\pi_l} \right). \quad (7)$$

¹¹Akerlof et al. (1991) discuss the development in East Germany in a similar framework.

¹²A more detailed discussion of the long-run model is contained in Smolny (2002).

c are the user costs of capital which are treated as exogenous at the firm level, and z refers to demand uncertainty at the time of the capacity decision. Expected demand shifts increase all quantities proportionally and do not affect prices or relative quantities. This implies an accelerator mechanism for the capacity adjustment. A proportional increase of wages and capital cost increases prices proportionally and reduces demand and capacities with elasticity η . Lower relative capital cost increase optimal capacities firstly through capital-labour substitution and secondly because firms choose a lower capacity utilization rate. Both effects are expected to contribute to the explanation of the enormous amount of private investment in East Germany. Immense subsidies reduced capital costs and favoured capacity increases despite of low demand and capacity utilization.¹³

The second component of the long-run decision is the choice of the capital-labour ratio k . The optimal relation between the elasticities of the factor productivities with respect to the capital-labour ratio is equal to the ratio of corrected factor shares,

$$-\frac{\frac{\partial \pi_k}{\partial k} \cdot \frac{k}{\pi_k}}{\frac{\partial \pi_l}{\partial k} \cdot \frac{k}{\pi_l}} = \frac{w \cdot \bar{U}^c(\bar{z}) \cdot \pi_k}{c \cdot \bar{U}^l(\bar{\varepsilon}) \cdot \pi_l}. \quad (8)$$

The inefficiency associated with uncertainty and a delayed adjustment exhibits the same effects as higher capital costs and favours substitution of labour against capital. For a CES production function with constant returns of scale, $Y^{-\rho} = \delta \cdot (\theta \cdot L)^{-\rho} + (1 - \delta) \cdot (\theta \cdot K)^{-\rho}$, the optimal capital-labour ratio is determined as

$$k = \frac{\pi_l}{\pi_k} = \left(\frac{\delta \cdot w \cdot \bar{U}^c}{(1 - \delta) \cdot c \cdot \bar{U}^l} \right)^\sigma. \quad (9)$$

$\rho = 1/\sigma - 1$ is the substitution parameter (σ is the elasticity of substitution), and δ is the distribution parameter. The optimal capital-labour ratio is determined by relative factor costs and utilizations. Optimal labour productivity is determined by real wages, the average utilization of employment and total factor productivity θ ,

$$\pi_l = \theta^{1-\sigma} \cdot \left(\frac{\delta \cdot w}{(1 + 1/\eta) \cdot \bar{p} \cdot \bar{U}^l} \right)^\sigma. \quad (10)$$

\bar{p} refers to average prices which are determined as a mark-up over corrected total costs.¹⁴

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

¹³See Sinn (2002) for a discussion.

¹⁴Average prices are defined as $\bar{p} := \frac{E(p \cdot Y)}{E(Y)} = \left(\frac{w}{\bar{U}^l \cdot \pi_l} + \frac{c}{\bar{U}^c \cdot \pi_k} \right) / (1 + 1/\eta)$.

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 hypotheses to understand the process of productivity convergence of the industrial countries in the post World War II period.¹⁵ 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,

$$\Delta\theta = \Delta\theta(\theta/\theta^{\text{west}}). \quad (11)$$

Combining those arguments yields three determinants of real labour productivity growth: firstly the changing utilization of labour, secondly the impact of real wages via capital-labour substitution and thirdly the effect of total factor productivity convergence via technological diffusion,

$$\Delta Y/L = \Delta Y/L(\Delta U^l, \Delta(w/p), \theta/\theta^{\text{west}}). \quad (12)$$

Eq. (12) is the base of the empirical decomposition of the sources of productivity growth in East Germany.

4 Data and empirical specification

The data source for the empirical investigation is a panel of annual National Account data for the German states 1991-2002. For the empirical estimation a panel of all 16 German states is employed. The idea of this specification is to explain the development in East Germany by using West Germany as a reference. The model is estimated using a log-linear error correction specification. Rates of change of the endogenous variables are regressed on rates of change of the explanatory variables and lagged logarithmic levels of the model; the long-run relation is obtained from solving the log-linear error correction term. For the estimation, fixed effects OLS and instrumental variable panel data estimators are employed.¹⁶ Since lagged values of the variables in the error correction term are used as instruments, the econometric model corresponds to a system estimator.

The development of nominal wages and real unit labour costs is depicted in [figure 3](#). Remarkable is the similar development of nominal wages in the East Germany states as well as the enormous wage increases since 1991. Note that wages were already about 30 percent higher in 1991 as compared with 1989, the pre-unification level.

¹⁵Coe and Helpman (1995) discuss technological diffusion in terms of R&D spillovers, and Barro and Sala-i-Martin (1997) analyse productivity convergence in terms of cost advantages of imitation as compared with innovation. See Temple (1999) and Smolny (1999, 2000) for a discussion.

¹⁶The IV estimator potentially removes the simultaneous equation bias, but the OLS estimates are more efficient.

Figure 3: Wages and competitiveness

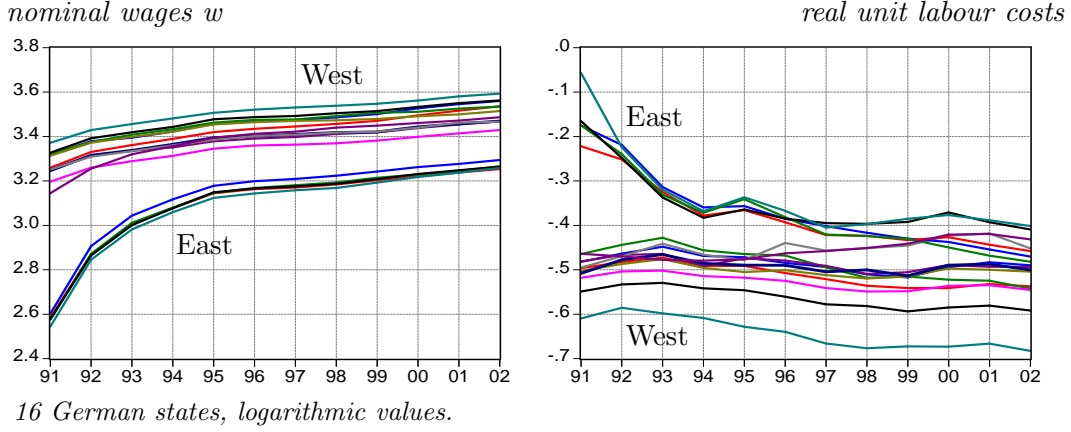
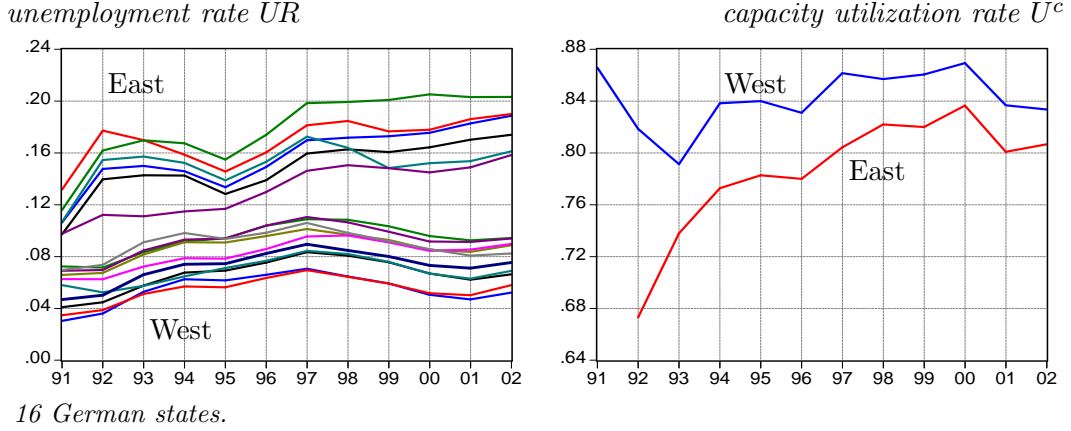


Figure 4: Unemployment and capacity utilization



Since prices and labour productivity adjusted only slowly, unit labour costs in East Germany were well above those in West Germany. The left panel in [figure 4](#) depicts unemployment rates which are about twice as high as those in West Germany. The empirical model for nominal wage changes $\Delta \ln w$ augments eq. (1) above with short-run dynamics for inflation $\Delta \ln p$, productivity growth $\Delta \ln Y/L$ and the change of the unemployment rate ΔUR . The long-run equilibrium level is determined by wage convergence w/w^{west} , real unit labour costs $(w/p)/(Y/L)$ and unemployment UR ,

$$\Delta \ln w_t \leftarrow \Delta \ln p_t, \Delta \ln(Y/L)_t, \Delta UR_t, \quad (13)$$

$$\ln(w/w^{\text{west}})_{t-1}, \ln\left(\frac{w/p}{Y/L}\right)_{t-1}, UR_{t-1}.$$

The central explanatory variables for inflation are wages and labour productivity (see eq. (6) above). The price adjustment with respect to demand is specified with the capacity utilization rate U^c (see the right-hand panel of figure 4). Especially in

the early nineties capacity utilization was far beyond West German values.¹⁷ The long-run equilibrium of the price equation is determined in terms of real unit labour costs $(w/p)/(Y/L)$, relative regional prices p/p^{west} and the capacity utilization rate U^c . Central for the development of prices in East Germany is the impact of rapidly increasing wages, slowly adjusting labour productivity and the relative impact of real unit labour costs and demand conditions.

$$\Delta \ln p_t \leftarrow \Delta \ln w_t, \Delta \ln(Y/L)_t, \Delta \ln U_t^c, \quad (14)$$

$$\ln \left(\frac{w/p}{Y/L} \right)_{t-1}, \ln(p/p^{\text{west}})_{t-1}, \ln U_{t-1}^c.$$

The development of real labour productivity and real wages is depicted in [figure 5](#). Clearly visible is the catching-up of the East German states, but also the still persisting gap. The 2002 productivity gap is about 30 percent, and the wage gap is about 1/4. [Figure 6](#) depicts the development of two indicators for the extent of labour hoarding, the share of short-time workers STW and the share of workers in active labour market programs ALMP. Since short-time workers are counted as employees, but are on part-time or are not working at all, it is clear that observed productivity is affected. The figure reveals that short-time working was an important instrument to accomodate employment reductions in the early nineties. A second indicator for labour hoarding is the share of workers in programs of active labour market policy ALMP (see the right-hand panel of [figure 6](#)). Especially in 1992, many short-time workers lost their jobs and were parked in measures of active labour market policy.

Labour productivity is specified according to [eq. \(12\)](#) above. Central for the decomposition of the sources of productivity growth is the distinction between cyclical effects, substitution effects and total factor productivity convergence. The first step consists in determining the cyclical and substitution effect by explaining labour productivity with real wages and the indicators of labour hoarding. Due to slow adjustment, observed productivity differs from the optimal one by the utilization of employment, $Y/L = \pi_l \cdot U^l$. Total factor productivity θ is determined as the residual after accounting for cyclical and substitution effects,

$$(1 - \sigma) \cdot \ln \theta = \ln Y/L - \ln U^l - \text{constant} - \sigma \cdot \ln w/p. \quad (15)$$

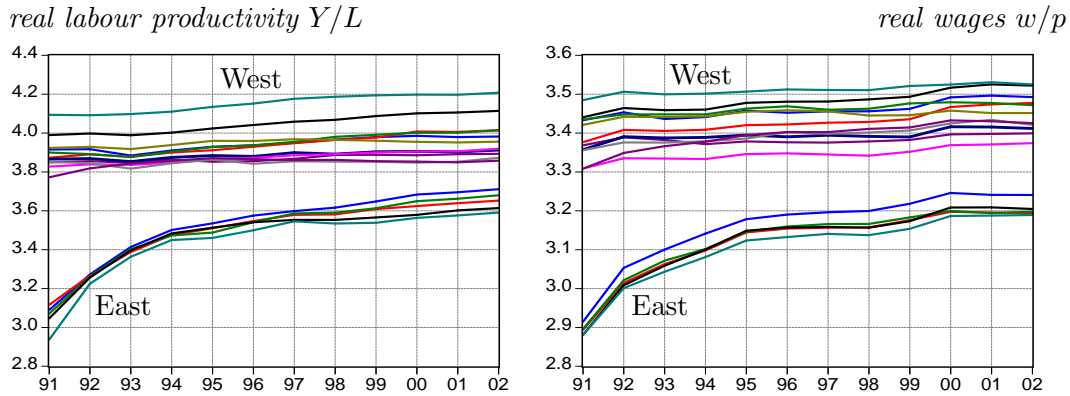
In a second step, total factor productivity catching up is modelled according to an error correction mechanism, $\Delta \ln \theta_t = \lambda \cdot \ln(\theta/\theta^{\text{west}})_{t-1}$. The extent of total factor productivity catching up is estimated by including the technological distance $\theta/\theta^{\text{west}}$ as an explanatory variable into the equation for labour productivity growth,

$$\Delta \ln(Y/L)_t \leftarrow \Delta \ln(w/p)_t, \Delta \text{STW}_t, \Delta \text{ALMP}_t, (\theta/\theta^{\text{west}})_{t-1}. \quad (16)$$

For the utilization of employment U^l the indicators of short-time working STW and active labour market policy ALMP are substituted. The aim of the empirical model

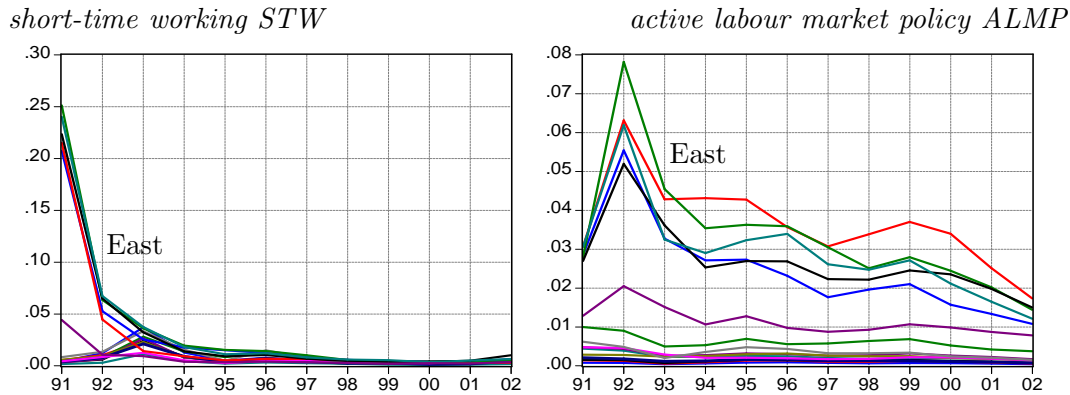
¹⁷For this variable only aggregate data for East and West Germany are available, and the East German data are available from 1992 onwards only. The lower average capacity utilization in East Germany is consistent with lower capital costs due to investment subsidies.

Figure 5: Productivity and wages



16 German states, logarithmic values, prices of 1995.

Figure 6: Labour hoarding



16 German states, shares in employment.

is to estimate the quantitative contribution of cyclical effects, substitution effects and θ -convergence for labour productivity growth accounting.

5 Estimation results

The estimates for the wage adjustment are reported in the left-hand columns of [table 1](#); they refer to eq. (13) above. The standard error of estimate SEE is below 1 percent, all coefficients exhibit the expected sign, and the included variables contribute significantly to the explanation of nominal wage growth. The short-run elasticity of wage changes with respect to inflation is 0.75 in the OLS estimates and about 0.9 in the IV estimates; both coefficients are highly significant. Labour productivity growth exhibits a significant impact on wages as well, but the short-run effect is small. Changes of the unemployment rate significantly reduce wage growth. The estimates also reveal a strong impact of wage convergence especially in the OLS

Table 1: Wage and price adjustment

<i>dependent variable:</i>	<i>wages</i> $\Delta \ln w_t$		<i>prices</i> $\Delta \ln p_t$		
	OLS	IV	OLS	IV	
$\Delta \ln p_t$	0.751 (10.1)	0.905 (10.6)	0.455 (12.7)	0.530 (13.0)	$\Delta \ln w_t$
$\Delta \ln(Y/L)_t$	0.099 (1.8)	0.304 (2.8)	-0.133 (-3.2)	-0.318 (-4.8)	$\Delta \ln(Y/L)_t$
ΔUR_t	-0.541 (-6.0)	-0.447 (-4.0)			
$\ln(w/w^{\text{west}})_{t-1}$	-0.345 (-10.2)	-0.237 (-4.8)	-0.150 (-2.8)	-0.165 (-2.7)	$\ln(p/p^{\text{west}})_{t-1}$
$\ln\left(\frac{w/p}{Y/L}\right)_{t-1}$	-0.125 (-3.8)	-0.196 (-4.4)	0.134 (5.2)	0.181 (5.7)	$\ln\left(\frac{w/p}{Y/L}\right)_{t-1}$
UR_{t-1}	-0.518 (-7.4)	-0.501 (-6.3)			
constant	-0.018 (-1.0)	-0.059 (-2.6)	0.076 (5.6)	0.100 (5.9)	constant
dummy East	-0.027 (-2.4)	0.006 (0.3)	-0.019 (-6.2)	-0.022 (-6.2)	dummy East
dummy Berlin	0.028 (5.0)	0.035 (4.8)	-0.008 (-3.0)	-0.012 (-3.7)	dummy Berlin
SEE	0.0090	0.0095	0.0078	0.0083	SEE
\overline{R}^2	0.970	0.966	0.935	0.926	\overline{R}^2

16 German states 1992-2002, cross section fixed effects, *t*-values in parentheses.

model. Wages increased faster in those states which exhibit a wage level below the average West German level, *ceteris paribus*. This contributes to the explanation of high wage inflation in the East German states especially in the early nineties. However, both real unit labour costs and the unemployment rate exhibit a dampening effect on wage growth. This contributes to the explanation of the observed convergence of wage changes in East and West Germany in the second half of the nineties.

The estimates for the price adjustment are reported in the right-hand columns of table 1; they refer to eq. (14) above. Firstly aggregate capacity utilization does not show up significantly in the estimates of the price equation. One reason might be that capacity constraints were hardly binding during the estimation period 1992-2002.¹⁸ Another reason might be that only aggregate data for West and East Germany were available which do not capture the demand conditions in each state appropriately; in addition, the data for East Germany are available from 1992 onwards only. Therefore capacity utilization was left out for the reported results. However, both nominal

¹⁸In East Germany, low relative capital cost favoured high capacities and low optimal utilization.

Table 2: Productivity adjustment

dependent variable:	<i>labour productivity growth</i> $\Delta \ln(Y/L)_t$			
	OLS	IV	OLS	IV
$\Delta \ln(w/p)_t$	0.364 (4.0)	0.385 (3.5)	0.301 (3.7)	0.310 (3.1)
ΔSTW_t	-1.354 (-16.0)	-1.414 (-13.9)	-1.292 (-17.0)	-1.361 (-14.9)
ΔALMP_t	-2.460 (-12.0)	-2.777 (-12.3)	-2.268 (-12.2)	-2.578 (-12.6)
$(1 - \sigma) \cdot \ln(\theta/\theta^w)_{t-1}$			-0.310 (-6.4)	-0.292 (-5.9)
constant	0.005 (3.4)	0.005 (3.2)	0.006 (4.8)	0.006 (4.5)
dummy East	0.009 (3.1)	0.006 (2.3)	-0.046 (-5.2)	-0.044 (-4.9)
dummy Berlin	-0.007 (-1.6)	-0.008 (-1.7)	-0.022 (-4.7)	-0.021 (-4.5)
SEE	0.0141	0.0142	0.0126	0.0127
\bar{R}^2	0.890	0.888	0.912	0.910

16 German states 1992-2002, cross section fixed effects, *t*-values in parentheses.

wages and real labour productivity contribute to the explanation of price inflation. The short-run coefficients of wage growth is about 0.5 and highly significant, and the long-run effect of real unit labour costs is well determined. This confirms that wage policy had an important impact on the price adjustment. In addition, a direct impact of price convergence is confirmed.

The estimates for productivity growth are reported in [table 2](#); the left-hand columns refers to eq. (15). Labour productivity growth is related to real wage growth and the indicators of labour hoarding; total factor productivity growth is treated as the residual after accounting for cyclical and substitution effects. The results firstly yield a significant and robust estimate of the short-run elasticity of substitution $\hat{\sigma}$ of about 1/3. Second, the estimates reveal a highly significant and large impact of the indicators of labour hoarding, i.e. short-time working STW and persons in measures of active labour market policy ALMP. The constant captures (exogenous) technological progress in the West German states. The significant coefficient of the dummy variable for East Germany indicates that average total factor productivity growth was higher as compared with West Germany.¹⁹

The error correction model requires an estimate of the technological distance. For this purpose the logarithmic level of labour productivity is regressed on real wages

¹⁹Note that total factor productivity growth $\Delta \ln \theta_t$ can be obtained by dividing the reported coefficients with $1 - \sigma$.

Table 3: Total factor productivity

$\ln(Y/L)_t = 0.551 \cdot \ln(w/p)_t - 1.326 \cdot \text{STW}_t - 2.621 \cdot \text{ALMP}_t + (1 - \sigma) \cdot \ln \theta_t$
(4.8) (-11.2) (-7.4)
$(1 - \sigma) \cdot \ln \theta_t = 2.052 + 0.003 \cdot t - 0.217 \cdot \text{dummy} + 0.006 \cdot \text{dummy} \cdot t - 0.053 \cdot \text{dummy} + \varepsilon_t$
(5.2) (5.1) (-5.7) East (3.7) East (-7.0) Berlin

SEE: 0.0199, \overline{R}^2 : 0.993

16 German states 1992-2002, cross section fixed effects, t-values in parentheses.

and the indicators of labour hoarding. The cointegrating regression includes time trends for East and West Germany as well. The results are reported in [table 3](#) and reveal a long-run elasticity of substitution above the corresponding short-run estimate. The coefficients of the indicators of labour hoarding hardly differ. The technological distance is calculated from the state-specific θ in relation to the average value for West Germany. The second-step estimates are reported in the right-hand columns of table 2; they refer to eq. (16). Introducing the technological distance as a determinant of productivity growth yields a significant rate of total factor productivity catching up λ of about 0.3. This value is well above those coming out of cross-country studies of productivity convergence for the industrial countries in the post World War II period.²⁰ However, the significant negative coefficient of the dummy variable for the East German states indicates a structural total factor productivity gap which is not closed in the adjustment process.

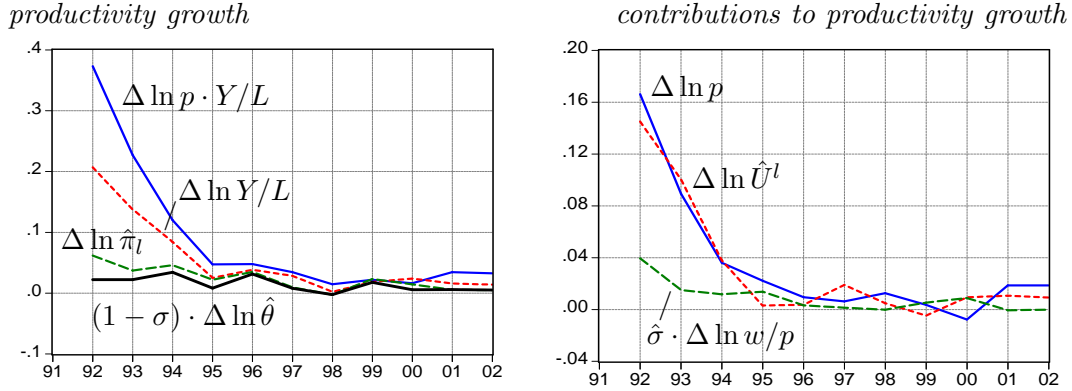
Starting from those estimates the contributions of price adjustment, cyclical adjustment, capital-labour substitution and total factor productivity convergence for East German productivity growth are calculated. The calculations are based on the coefficients of the IV estimates of the full model, i.e. the right-hand column of table 2. The time series development of the respective variables is depicted in [figure 7](#). The upper plot-line in the left-panel shows the enormous growth rates of nominal labour productivity $\Delta \ln p \cdot Y/L$ in the early nineties. The next line depicts real productivity growth $\Delta \ln Y/L$, and the right-hand panel depicts price increases $\Delta \ln p$. The figures reveal that a large part of nominal productivity growth in the early nineties is attributable to price increases.

In [figure 8](#), the corresponding logarithmic gaps are depicted. Relative nominal labour productivity increased from about 35 percent in 1991 to 71 percent in 2002, relative prices increased by about 25 percent, and real labour productivity increased from 42 to 71 percent of the West German level.²¹ Those price increases can partly be seen as relative price adjustments from distorted centrally planned prices towards

²⁰Most cross-country analyses of the catching-up of the industrial countries yield a rate of convergence of about 2 percent. See Temple (1999).

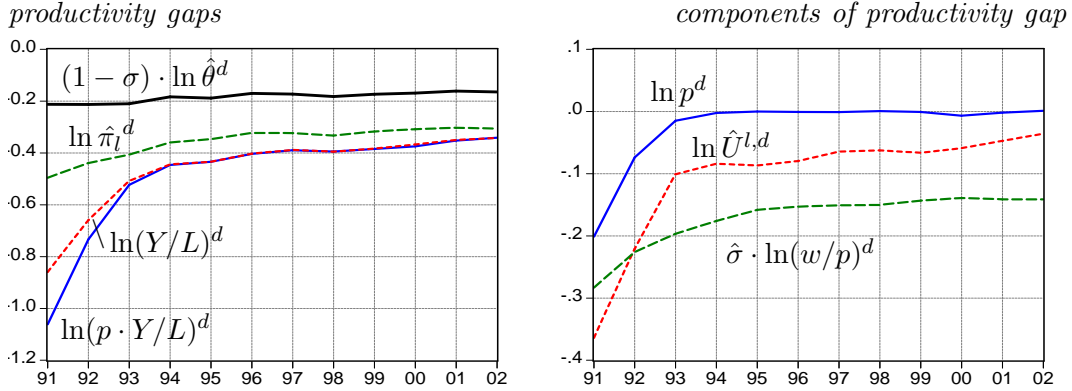
²¹East German nominal labour productivity more than doubled from about 15 000 € in 1991 to more than 40 000 € in 2002. Real labour productivity (prices of 1995) increased from 22 000 € to 38 000 €.

Figure 7: Decomposition of productivity growth



The figures refer to East German averages. Annual rates of change.

Figure 8: Decomposition of productivity gaps



Relative logarithmic levels, East vs. West Germany

supply and demand determined market prices of firms' products. Another part is caused by wage increases in due course of the process wage convergence. This process of price adjustment is a necessary side-effect of economic transformation, but it should not be interpreted as real income growth.

In addition, the 1991 productivity level does not represent the productivity of the former GDR economy, but is biased downward due to labour hoarding. After unification output broke down, employment adjusted slowly, and real labour productivity was certainly lower in 1991 as compared with the pre-unification level 1989. Consequently, a non-negligible part of real productivity growth in the early nineties can be attributed to cyclical adjustments as the return to a normal cyclical situation. The contribution of those cyclical factors is the difference between real productivity growth $\Delta \ln Y/L$ and growth of optimal labour productivity $\Delta \ln \hat{\pi}_l$; the difference is the change of the utilization of labour. $\Delta \ln \hat{U}^l$ is calculated from the coefficients and time-series values of short-time working STW and active labour market policy

ALMP. The figures reveal that the estimated contribution of those cyclical effects is about as large as the price effect. In addition, the utilization gap is not closed yet.

The remaining productivity growth can be attributed to technological adjustment. The sources of technological adjustment, in turn, can be further distinguished into capital-labour substitution and total factor productivity growth. Capital-labour substitution was strongly promoted by steeply increasing wages, slowly adjusting prices and enormous investment subsidies. Relative real wages increased from 60 in 1991 to 77 percent in 2002 of the West German level.²² The resulting productivity adjustment via capital-labour substitution caused many job losses and contributed to the deteriorating employment situation. Figure 7 reveals that the substitution effect is relevant but clearly smaller as compared with price and cyclical effects.

A final part of productivity adjustment is attributable to total factor productivity growth. Its contribution is calculated as the residual of this augmented growth accounting exercise. Before unification, East German firms had hardly access to high-technology investment goods such as modern computers. Trade restrictions and the absence of direct investments from western firms separated them from spillovers of foreign best-practise technology. In addition, the distorted incentives for firms and workers through central planning led to an inefficient allocation of resources. After unification, those restrictions should have vanished. Since summer 1990, firms had easy and highly subsidized access to modern investment goods and production technology. The transportation infrastructure was build up quickly, and East Germany received a modern communication network. Finally, the fast introduction of West German institutions should have led to an efficient allocation of resources through the market system.

The estimation results reveal that East German total factor productivity catching-up has taken place, but not at those rates expected from the large growth rates of labour productivity in the early nineties. Most of those productivity increases are related to relative price adjustment, cyclical adjustment and capital-labour substitution; only a small part can be attributed to total factor productivity convergence. Since those factors were relevant mainly in the first half of the nineties, the catching-up of the East German economy faded out in the late nineties. The contribution of total factor productivity growth was about 3 percent per year in the early nineties but hardly more than 0.5 percent afterwards. Even more important is the structural total factor productivity gap which contributes with about 15 percent to the labour productivity gap and which is not closed in the adjustment. Therefore it is expected that further productivity advances will take place at a much slower pace.

²²Nominal wages in East Germany about doubled from 13 000 € per year and employee in 1991 to 26 000 € in 2002 which implies a wage convergence with respect to West German levels from 49 to 77 percent. Real wages (prices of 1995) rose from 18 000 € to 25 000 €.

6 Conclusion

The economic development in East Germany after unification was more than disappointing. Even today, real gross domestic product is hardly above pre-unification levels, unemployment is high, and productivity adjustment has not come up with expectations. In addition, convergence towards West German levels faded out in the mid-nineties. In this paper the sources of productivity catching-up are investigated in some detail. The paper presents estimates of the wage, price and productivity adjustment which employ annual panel data for the 16 German states 1991 to 2002. The estimates are based on a theoretical model of the short- and long-run adjustment of firms and permit to distinguish relative price effects, cyclical adjustment, capital-labour substitution and total factor productivity convergence. The central empirical result is a decomposition of the sources of productivity growth in the East German economy.

Central for the understanding of the development in the early nineties is the breakdown of demand in consequence of the low competitiveness of East German firms. The most important policy decision was the choice of the currency conversion rate of 1:1 for flows in combination with the state of the East German economy 1990. On average, the implied wage level was roughly compatible with East German productivity, but for the export oriented industry sector, the currency conversion rate implied an immediate loss of competitiveness. As a result, manufacturing output dropped by about $2/3$, and GDP was about $1/3$ lower in 1991 as compared with 1989. Employment adjusted only slowly; therefore productivity decreased as well. Central for the understanding of the development afterwards was the wage adjustment. Unions succeeded in achieving nominal wage growth well above productivity growth. In consequence, prices increased, real unit labour costs were far above West German levels and demand remained low. Since wages increased fast and capital costs were highly subsidised, firms chose capital-intensive production technologies. Both, supply and demand conditions contributed to the persisting high unemployment.

Later on, high unemployment and high real unit labour costs changed the incentives and the power of unions and employers in the wage-setting process, factor utilization increased, and in the second half of the nineties the development of the East German economy more or less normalized. Nominal wage growth, inflation and labour productivity growth converged towards West German rates, but large gaps persisted. In 2002 nominal wages in East Germany are about 25 percent below West German levels, and the productivity gap is still about 30 percent. A part of the current East German labour productivity gap is due to lower real wages, but most of it are differences of total factor productivity. During the nineties, some total factor productivity catching-up had occurred. The estimated rate of convergence is well above those rates estimated for the industrial countries in the post World War II period, but a large structural total factor productivity gap persists. Therefore, productivity catching-up faded out in the late nineties.

This leaves the question for the reasons of the persistent total factor productivity gap and for policy measures to close it. One argument is that adjustment simply takes time. East Germany started from a heavily distorted centrally planned economic system, outdated technology and a repressive political system. In less than 15 years, a lot of improvements have taken place. However, since 7 years neither labour productivity nor total factor productivity catching up has taken place any more. A second argument is related to the low productivity of capital investment, caused partly by enormous investment subsidies which made nearly every investment profitable, at least for the investing firm. Subsidies strengthen substitution effects, contribute to the persisting low employment level and lead to an inefficient allocation of resources. Therefore, when thinking about policy measures, a consequent analysis of the efficiency of investment subsidies should be placed high on the research agenda. A third argument is related to the qualification of the employees. On the one hand, the formal qualification of East German employees is high. On the other hand, the missing experience with high productive capital equipment and the history of working with distorted incentives might make them less productive today. In addition, high unemployment and lower wages imply an incentive for highly qualified and mobile employees to migrate to the West. A final argument is the still insufficient infrastructure equipment. Once again, a consequent evaluation of the relative efficiency of R&D and investment subsidies, public infrastructure investment and active labour market policy is a necessary prerequisite for an informed discussion.

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