"EASTERN GERMANY:CAN'T WE BE MORE OPTIMISTIC?"
by

M.BURDA*
and
M. FUNKE**

93/63/EPS

* Associate Professor, at INSEAD, Boulevard de Constance, Fontainebleau 77305 Cedex, France and Humboldt University.

** Free University, Berlin and London Business School, UK.

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Eastern Germany: Can't We Be More Optimistic?

Michael Burda

Humboldt University and INSEAD

Michael Funke

Free University of Berlin and London Business School

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Abstract

This paper argues that the application of the "2% rule," which predicts convergence in three decades or more, is overly pessimistic in the case of eastern Germany. First, it ignores discrete improvements in initial conditions related to the transition, which have been significant to date. Because labor productivity in manufacturing exhibits wide sectoral dispersion, structural change is likely to further increase aggregate productivity. Second, convergence is also driven by physical and human capital mobility, which in contrast to labor mobility appears to be high in eastern Germany. Finally, an unusually high rate of physical investment in eastern Germany will accelerate convergence.

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1. Introduction

Nearly three years after monetary union, eastern Germany continues to struggle with the economic, political and social burdens of its now-famous shock-therapeutic switch from central planning to capitalism. Rather than an industrial powerhouse, the economy of the ex-German Democratic Republic was revealed to be inefficient, underspecialized, and underdeveloped in its management of economic resources. The most telling and widely cited comparison which has emerged since unification is that of relative aggregate labor productivity in both parts of Germany on a GDP basis shown in Table 1, which reveals a gap of roughly 60% in 1992. Naturally, relative productivity developments are likely to be affected by a number of cyclical factors (see Gordon (1979)). In the appendix we describe a crude cyclical correction of relative East-West productivity in total manufacturing, where these effects are particularly strong. Our estimate of "cyclically corrected" eastern German manufacturing productivity in 1991 (the most recent data available) is 40.3%, compared with a measured ratio of 25.6%. While correcting for cyclical effects improves the East German outlook, labor productivity lags significantly behind the West.

Table 1. Labor Productivity in Eastern and Western Germany

	1990	1991	1992
GDP/employed (West), DM	83,670	84,384	84,871
GDP/employed (East), DM	31,750	27,837	34,063
Rel. Productivity (entire economy, %)	37.9	32.9	40.1

Source: Volkswirtschaftliche Gesamtrechnung der Bundesrepublik Deutschland; DIW Wochenbericht, Nos 47/92 and 7/93.

The central question that arises in the debate surrounding the economic cost of German unification is: how long will it take before the eastern regions as a whole can carry their weight without having to depend on subsidies from the West? Put differently, what is the expected time for convergence for the East to western productivity and living standards?[1] The public mood concerning the economic fate of East Germany has been characterized by a series of dramatic about-faces. Initially, discussion of unification was dominated by a misplaced emphasis of monetary issues. In contrast, initial discussion of the real economy before the state treaties was marked by an almost euphoric optimism. An extreme example can be found in Professor Willgerodt's report to the government in March 1990:

"Once reform is decisively embraced, the crisis will turn out to be less extreme -- just as in Western Germany after 1948 -- as it currently seems. The capital stock of the GDR is too often underestimated, with the impression of run-down factories, a devastated environment, buildings ready for the demolition ball, etc. Yet in certain respects the situation

[1]The word "convergence" is subject to wide interpretation. For the purposes of this paper, convergence is said to occur when the average level of labor productivity in the East has reached at least 80% of average western levels.

is similar to that which historically follows wars: the destruction is more impressive than the possibilities for reconstruction. Both following the Napoleonic wars and the two world wars has it turned out that the capital stock was rebuilt in market economies much faster than was often assumed." (p.68-69, authors' translation)

The collapse of industrial activity in the ex-GDR, the steep increase in open and hidden unemployment and a more realistic picture of the investment necessary changed this optimistic view. A number of academic contributions -- primarily from outside Germany .--- began to stress the backward state of the eastern region's economy and the large investment levels necessary to raise standards of living in the East to those of the West.[2] In the meantime, a decided re-evaluation of previous predictions and the prospects for a second "Wirtschaftswunder" has occurred. This new pessimism was brought to a head with the prediction of Barro and Sala-i-Martin (1991) that convergence of East Germany to West German standards of living will take much longer:

"An extrapolation of the US experience to the eastern regions of unified Germany implies that per-capita growth in the East would be initially 1.5 to 2 percentage points per year higher than in the West. This growth advantage... means that it will take about 15 years to eliminate one-quarter of the [per capita income] gap, and about 70 years to eliminate three-quarters of it. If so, the East would eventually catch up to the West, but in a couple of generations rather than a couple of years or a a couple of decades."[3]

The objective of this paper is to evaluate critically the reasons for the new pessimism that has dominated recent public discussion of the economic reintegration of East Germany. Our guarded conclusion is that there are good reasons to be more optimistic about the economic future of Eastern Germany than the current discussion admits. Section 2 reviews the key theoretical predictions on convergence from the economic growth literature, which predicts that economies converge to theoretical steady states --- which may be conditional on a number of country-specific factors --- at a rate of about 2% per annum. Section 3 discusses some of the important reasons that the 2% convergence rule -- which was estimated from cross sections of nations or regions --- may yield only limited insights into the development of East Germany. Some, but not all of these qualifications concern the special situation of the ex-GDR as a previously inefficient planned economy with large potential for rapid productivity improvements. The second part of section 3 examines the effect of both physical and human capital mobility in the neoclassical framework assumed and the effect that it may have on convergence. It turns out that high values of either human or physical capital mobility will accelerate convergence markedly. We argue that historically estimated values of the convergence parameter may only yield limited insight into the future development of Eastern Germany.

Section 4 expands the attention paid to investment to a more controversial aspect which lies outside the standard growth model: the growth effects of investment. Based on the work of DeLong and Summers (1991, 1992), we argue that the massive investment rates observed in Eastern Germany -- recently as high as 45% of GDP for total investment and 25% of GDP for business equipment investment -- cannot be without extraordinary effects on

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[2]See Gagnon and Alexander (1990), Burda (1990), McDonald, and Thumann (1990), Siebert (1990), Begg et al. (1990), Scott (1991), Barth (1992) and Hughes-Hallett and Ma (1993). Akerlof et al. (1991) were among the first in documenting the extent of the real overvalution implied by monetary union. Sinn and Sinn (1991) emphasized the effects of rapid wage increases in the East. Siebert (1991) among others warned against excessive use of the 1948 economic reform analogy in studying the East German case due to the extreme investment necessary.

[3]Robert Barro, "Eastern Germany's Long Haul," *Wall Street Journal* May 3 1991, p. A10.

productivity and living standards. Section 5 concludes with implications for the Treuhandanstalt's policies of "restructuring through privatization," which can be justified as accepting radical restructuring today against the future benefits of more rapid convergence to West German and European levels of productivity.

2. The Theory of Economic Convergence: A Synopsis

Although widely used in the context of regional economic integration, the "2% rule" of convergence has its origins in the theory of closed economy growth in the tradition of Solow (1956) and Swan (1956). Internal capital formation is the driving force behind convergence to a steady state standard of living determined by technology and tastes; factor mobility is ignored. Following Mankiw et al. (1992), we assume a simple Cobb-Douglas constant returns to scale production function:

$$Y=K^{\alpha}H^{\beta}(AL)^{1-\alpha-\beta} \tag{1}$$

where Y is real output, L is employment (man-hours), H is human capital, and K is physical capital. A stands for labor-augmenting technical progress. In intensive form the function can be written as a function of values "per effective capita", where N denotes the number of inhabitants:

$$y=k^{\alpha}h^{\beta}p^{1-\alpha-\beta} \tag{2}$$

and where y=Y/AN, k=K/AN, h=H/AN; p can be thought of as the participation rate, which may be as much a function of demographics as the incentive to sell labor services in the market. Clearly, p is bounded from above by unity so it cannot be considered a permanent source of growth but might contribute for some finite time period. We first assume that there is full employment so p=1,the production function in (2) is

$$y=k^{\alpha}h^{\beta}. \tag{3}$$

Population is assumed to grow at rate n, capital depreciates at rate δ, and technical progress occurs at exogenous rate g, so $A_t=A_0e^{gt}$, where A_0 is some assumed initial condition. In what follows, we shall assume that A is common to both East and West.[4]

2.1. Local Convergence in the Closed Economy

In a closed economy, per capita economic growth has two sources: growth in total factor productivity A, and accumulation, or savings, which affects the stocks of physical and human capital. Following Mankiw et al. (1992), physical and human accumulation are assumed to be a constant fraction of income respectively, s_K,s_H: so physical and human capital obey the differential equations

$$\dot{H}= s_HY - \delta H$$

[4]This assumption removes a degree of freedom associated with regional integration which depends on the "state of the art". In the case of Germany, it is unlikely that this represents an important source of convergence except for the initial jump, which we consider in detail in Section 3.

$$\dot{K} = s_K Y - \delta K$$

so physical and human are assumed to depreciate at the same rate δ (for simplicity).[5] In per effective capita terms we can write

$$\dot{h} = (s_H y/h - g - n - \delta)h$$

(4)

$$\dot{k} = (s_K y/k - g - n - \delta)k$$

From (3), output per effective worker y will grow at rate given by

$$\dot{y}/y = \alpha(\dot{k}/k) + \beta\dot{h}/h$$

$$= \alpha(s_K y/k - g - n - \delta) + \beta(s_H y/h - g - n - \delta)$$

(5)

$$= -(g + n + \delta)\{\alpha[1 - s_K(y/k)/(g + n + \delta)] + \beta[1 - s_H(y/h)/(g + n + \delta)]\}$$

Apply the logarithmic approximation to the two expressions in brackets to obtain

(6)

$$\dot{y}/y = (g + n + \delta)\{\alpha[\ln s_K + \ln(y/k) - \ln(g + n + \delta)] + \beta[\ln s_H + \ln(y/h) - \ln(g + n + \delta)]\}$$

The steady state level of output per effective worker y* implied by (6) is:

(7)

$$y^* = [s_H^{\alpha} s_K^{\beta}/(g + n + \delta)^{(\alpha+\beta)}]^{1/(1-\alpha-\beta)}$$

which we assume to be the level of productivity per capita in the western part of Germany. It is possible to approximate (6) around the steady state y* at which growth is zero by

$$\dot{y}/y = (g + n + \delta)\{\alpha[(\ln y - \ln y^*) - (\ln k - \ln k^*)] + \beta[(\ln y - \ln y^*) - (\ln h - \ln h^*)]\}$$

or since $\ln y^* = \alpha \ln k^* + \beta \ln h^*$,

(8)

$$\dot{y}/y = \lambda(\ln y^* - \ln y).$$

where $\lambda = (g + n + \delta)(1 - \alpha - \beta)$.

[5]The constant savings (or in a closed economy, investment) rate assumption with a single asset can be justified if utility is logarithmic and production is Cobb-Douglas (Sala-i-Martin 1991). With two assets (human capital and physical capital) the assumption is somewhat dubious; savings and investment decisions should depend on rates of return of both factors (marginal products in production) and possibly other factors. In addition, the marketability of human capital will affect these conclusions.

It is from (8) that the famous "iron law of convergence" originates. Barro and Sala-i-Martin (1991,1992) estimate a robust rate of convergence of roughly 2% per annum, ie λ =0.02, among regions of the United States, Japan, and within European countries. In a neoclassical model which ignores human capital, such a slow rate of convergence is hard to justify.[6] Mankiw, Romer and Weil (1992) have shown convincingly, however, that this rate of convergence is consistent with a parametrization of the production function $\alpha=\beta=1/3$ and conventional values for depreciation, population growth, and the evolution of technology over time.

2.2. Implications for Time to Convergence

Equation (8) allows us to draw conclusions about the time T required to reach some degree of convergence $x_T = y_T/y^*$, measured as a fraction of western productivity levels. The solution to the differential equation (8) with initial condition y(0) is given by

$$\ln(y(t)) = (1-e^{-\lambda t})\ln(y^*) + e^{-\lambda t}\ln(y(0)) \tag{9}$$

or

$$y(t) = y(0)e^{\ln(y^*/y(0))(1-e^{-\lambda t})}$$

So at t=0, it is possible to solve for T, given an initial per capita income gap $x_0=y_0/y^*$:

$$T = -\lambda^{-1}\ln[\ln(x_T)/\ln(x_0)] \tag{10}$$

Table 2 displays times to convergence implied by (10), assuming a value of $x_0=0.3$, or that the initial per capita productivity of East Germany was 30% of corresponding Western levels. This conservative value -- compared with data from Table 1 -- was widely assumed as the starting position of Eastern German after unification. As can be seen from the table, the times to convergence implied by (10) are fairly pessimistic, even more so than those cited by Dornbusch and Wolf (1992) who effectively assume a constant rate of convergence and approximate $\ln(x_T)/\ln(x_0)$ with x_T/x_0.[7] Both sets of results confirm the "Barro-pessismism" cited in the introduction to the paper. For the commonly assumed value of λ=0.02, convergence to 80% of western German per capita output levels will require 84 years, or half a century by the Dornbusch-Wolf formula.

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[6] In the current model, this would correspond to $\beta=0$ and $\lambda=(g + n +\delta)(1-\alpha)$ implying much faster growth than is consistent with international experience (see Barro and Sala-i-Martin (1992)).

[7] Letting Y and Y* be per capita GDP in East and West, Dornbusch and Wolf (1992, p.246-7) assume

$$v_t \equiv \dot{Y}/Y - \dot{Y}^*/Y^* = \lambda\ln(Y^*/Y)_{t-1}$$

which implies a declining growth differential over time. Yet in calculating the time to convergence they set $v_t=v$ constant so that

$$x_T = x_0\, e^{vT}$$

where $x=y^E/y^W$. As the two tables show, this approximation is not terribly accurate for convergence gaps normally considered. This is because as convergence occurs, the growth rate differential declines asymptotically to zero, implying that 100% convergence only occurs in infinite time.

Table 2. Implied Time to Convergence (in years), Assuming x_0=0.3

Exact formula: $T = -\lambda^{-1}\ln[\ln(x_T)/\ln(x_0)]$

		x_T:		
	0.8	0.9	0.95	
λ:	0.01	168.6	243.6	315.6
	0.02	84.3	121.8	157.8
	0.04	42.1	60.9	78.9
	0.06	28.1	40.6	52.6
	0.08	21.1	30.4	39.4
	0.10	16.9	24.4	31.6

Dornbusch and Wolf (1992): $T = v^{-1}\ln(x_T/x_0)$

		x_T:		
	0.8	0.9	0.95	
v:	0.01	98.1	109.9	115.3
	0.02	49.0	54.9	57.6
	0.04	24.5	27.5	28.8
	0.06	16.3	18.3	19.2
	0.08	12.3	13.7	14.4
	0.10	9.8	11.0	11.5

3. Challenging the 2% Rule

The 2% rule governing the convergence of productivity per capita can be challenged on several grounds. In the first instance, this rule is unconditional in the sense that it presumes no further knowlege about the particular country under consideration, even in analyses which control for a variety of country attributes. In the empirical analysis of Barro and Sala-i-Martin (1991, 1992) and Mankiw et al. (1992) these factors enter in the disturbance term, but it is clear that conditioning on more knowledge about the time period or region can improve prediction. For example, Barro's (1991) cross-country regression analyses include a dummy variable for the "communist countries." Indeed, it seems logical that the Lucas critique would apply with special force to reforming planned (ex-socialist) economies which are in the process of reorganizing their systems of resource allocation and property rights.

A second possibility is to challenge the Solowian neoclassical growth model with constant returns to scale. Recently a series of endogenous growth models with constant or increasing returns to scale have been proposed which generate any number of results.[8] Concretely, differences in savings rates across countries can lead to permanent differences in growth rates and therefore little tendency for economies to converge. In the case of East Germany, however, these effects may be of little consequence if capital is highly mobile between the two regions. Increasing returns to scale may imply faster growth for *both* regions if there are increasing returns to scale (see for example Baldwin (1989)).

The strategy taken in the following section is to accept the underlying paradigm of the neoclassical (Solowian) growth model, which has had remarkable success in explaining cross country variation in growth over time (see Mankiw et al. (1992)). The key message of this section is that even in the context of the standard model of growth, there are important reasons to be more optimistic about the future growth path of eastern Germany.

[8]See Romer (1986), Lucas (1988), Barro (1991) and Rebelo (1991), for example.

3.1. Moving to the Frontier: The Effect of Discrete Changes in y on Time to Convergence

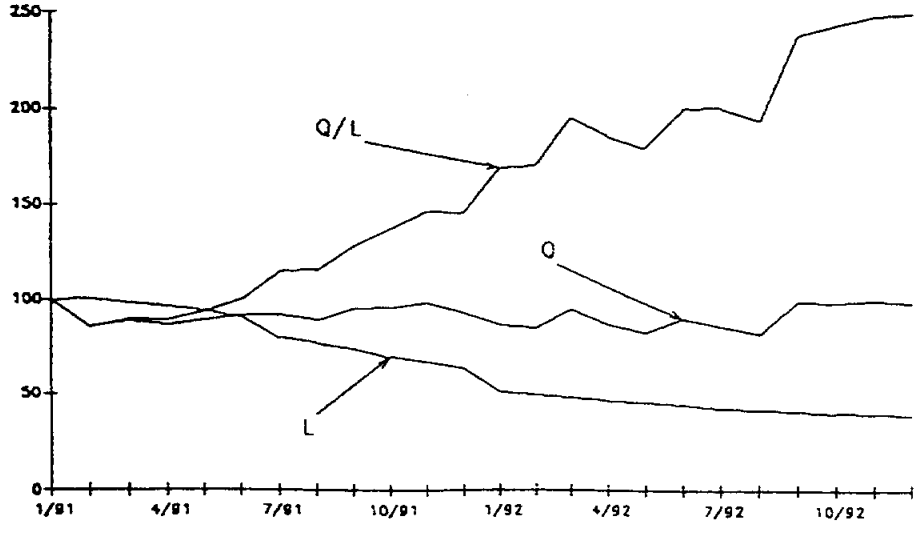
The speed of convergence in the neoclassical growth model is driven by initial conditions. In theory, these initial conditions are assumed to be the outcome of an efficient market economy. Yet, the transition to a market economy is associated with jump increases in efficiency as the economy moves to the production possibilities frontier. This change has nothing to do with the theory of convergence and should be considered separately; it is related to the reduction of labor hoarding, adoption of Western methods of production and distribution, the elimination of waste, and so forth. (In terms of the model of Section 2, the eastern states are acquiring western levels of A). Such jumps -- which will show up as unusually high measured rates of growth over discrete time intervals -- will change the base and significantly affect the anticipated time to convergence. To see this differentiate formula (10)

$$\partial T/\partial x_0 = [\lambda x_0 \ln(x_0)]^{-1}$$

which is always negative, since $x_0 < 1$. Assuming $\lambda=0.02$, $x_0=0.3$, we have $\partial T/\partial x_0=$ -138.4, which is quite large in absolute terms ($\partial T/\partial x_0$ declines quite rapidly in x_0, and therefore is only valid for very small changes). For example, a discrete increase of x_0 from 0.3 to 0.45 reduces the time necessary to reach 80% of western productivity level from 84.3 years to 63.7 years. (Dornbusch-Wolf: 49 to 28.8 years).

Preliminary evidence from the eastern states show spectacular gains in labor productivity since early 1991. Figure 1 substantiates this claim at the level of aggregate manufacturing.

Figure 1. The Evolution of Eastern German in Manufacturing Output, Employment and Labor Productivity



Note: Q=monthly index of net production (constant prices); L=total employees (including self-employed); 1991:1=100.

The behavior of aggregate productivity belies a considerable degree of heterogeneity at the sectoral level. This is made clear by the first column of Table 3, which documents a remarkable variation in the relative productivity levels across manufacturing sectors of eastern Germany. The table shows that in 1991, the last year for which level comparisons are available, labor productivity ranged from 8% of western levels (petroleum refining) to nearly 80% (printing and publishing). Many firms in low productivity industries will not survive the fierce competition with Western Germany and the rest of the world and will be closed. Their exit will arithmetically raise average economy-wide productivity and free up labor and capital to move to more productive sectors. This is an essential component of structural change in normal economies, and should be expected in eastern Germany in the years to come.

Table 3.
Relative Productivity in Eastern German Manufacturing Sectors , 1991

Industry	Rel. Productivity (%)
Total manufacturing	25.6
Intermediate Goods	21.6
Oil Refining	8.3
Quarrying	29.4
Iron and Steel	19.1
Foundries	21.5
Chemicals	22.5
Other Intermediate Goods	19.2
Capital Goods	23.3
Structural Metal	51.0
Mechanical Engineer.	27.5
Road Vehicles	23.0
Electrical Engineering	17.0
Optical Instruments	10.2
Office Machinery	6.6
Other Capital Goods	20.2
Consumer Goods	21.6
Wood Products	16.9
Printing/Publishing	79.5
Textiles	25.6
Other Consumer Goods	13.0
Food, Beverages, Tobacco	50.7

Note: Labor productivity is defined as gross value added (at 1980 prices) divided by the number of employees.
Source: Görzig (1992).

A key implication of this significant sectoral heterogeneity is that structural change is likely to raise aggregate productivity, for at least two reasons. First, high-performing sectors are likely to expand in the medium run and will attract additional labor from declining sectors. Table 4, which presents preliminary data on sectoral gross value added, shows productivity in 1992 rising by more than 150% in instrument engineering, road vehicles, office machinery, leather products, clothing and textiles, while actually *declining* in chemicals and shipbuilding. The unweighted correlation of relative productivity in 1991 and growth in 1992 for the sectors in Tables 3 and 4 was 0.608. Second, poorly performing sectors are likely to shrink or exit

completely, leading to another positive selection effect on aggregate productivity. In addition, it is likely that within-sector heterogeneity will lead to a similar effect within individual sectors, although we have no direct evidence in support of this claim.

Table 4. Growth in Labor Productivity in the East, 1991-1992 (%)

Industry	1991:1-1991:12	1991:12-1992:12
All Manufacturing	45.9	71.2
Intermediate Goods	54.8	47.2
Oil Refining	81.9	33.2
Quarrying	91.2	102.4
Iron and Steel	-14.6	131.9
Nonferrous metals	29.2	130.9
Foundries	-13.1	34.4
Chemicals	75.0	-13.3
Sawmills, timber	-11.9	14.5
Pulp and paper products	63.5	27.6
Rubber products	-2.6	85.7
Capital Goods	43.1	73.3
Structural Metal	92.3	48.4
Mechanical Engineering	41.2	24.6
Road Vehicles	-0.7	177.2
Shipbuilding	52.0	-35.7
Electrical Engineering	46.5	122.3
Instrument Engineering	-47.8	176.6
Finished metal products	13.5	127.0
Office Machinery	-34.7	215.0
Consumer Goods	58.7	97.2
Musical instruments, toys	198.7	68.5
Fine ceramics	34.6	31.3
Glass products	27.7	18.4
Wood Products	5.7	70.6
Paper products	48.9	60.6
Printing and publishing	61.0	41.2
Plastic products	100.0	53.6
Leather products	-45.2	344.5
Textiles	-16.5	189.1
Clothing	-24.1	160.3
Food, Beverages, Tobacco	8.4	86.1

Note: Calculated from data reported in Appendix 2.

Table 5 represents a crude attempt to capture the sectoral "exit effect" on aggregate labor productivity in manufacturing. First, we first estimate 1992 East-West productivity ratios employing sectoral data presented in Table 2 plus the evolution of sectoral productivity indices in 1992.[9] Next, we assume three alternative cutoff levels for relative productivity: 40%, 50%

[9]Relative productivity ratios for 1992 were estimated using annual growth rates constructed from average annual employment and net production indices for the list of industries in the East analyzed by Görzig (1992). We also ignore productivity growth in the West, which was flat in 1992 overall.

and 60%. We then calculate aggregate manufacturing productivity under three assumptions concerning shutdown (in terms of employment): 50% exit, 75% exit, and 100% (complete shutdown) of the respective sectors with relative productivity below the assumed cutoff level. We reweight productivity by the implied new sectoral employment shares and assume that surviving firms attain the hurdle level of relative productivity. The results show that the selection effect could raise aggregate productivity to 60-70% of western levels. At the same time, this type of structural change will be costly; for example, assuming a 50% hurdle rate and a 75% exit rate, manufacturing employment will drop from 864,000 to 423,000. These crude employment estimates should be considered as a *lower bound*, to the extent that no account is taken either of expansion of employment and output in high-productivity sectors or of high-productivity firms within low-productivity sectors; output growth in these sectors will further improve the aggregate outcome. Given the evidence from advanced industrialized nations, the latter type of heterogeneity should also be significant.[10]

Table 5. Aggregate East-West Manufacturing Productivity Gap Implied by Sectoral Exit (%)

	Assumed Hurdle Productivity Relative to West (1992)		
	40%	50%	60%
Assumed exit rate 50%	57.6	62.6	68.5
Assumed exit rate 75%	63.5	66.9	71.8
Assumed exit rate 100%	76.7	76.7	79.5

To summarize, Tables 4 and 5 imply first, that significant reductions in the productivity gap have already occurred, and second, future jumps should not be ruled out in the near future. These discrete productivity gains should not be confused with the convergence process described in the previous section; rather they concern the initial conditions of the convergence process. This effect can be quite significant: in Table 6 we display the effect of changes in initial aggregate productivity on the time to convergence under both formulae. Given the aggregate evidence in Table 4 and 5, we assume starting values of x_0=0.6 and 0.7. For the standard value of λ, 0.02, a jump of productivity from 30% to 60% reduces the time to reach 80% of Western living standards by 50.9% or 42.9 years. Irrespective of the exact productivity jump assumed, the time to convergence is quite sensitive to changes in the initial conditions, and these jumps have already occurred. On this basis alone, convergence within a generation is more likely to be the case.

[10]According to Appendix 2, 14 of 29 East German industrial sectors showed an absolute increase in gross output over the year 1992. For evidence on within-sector heterogeneity, see Davis and Haltiwanger (1991) for the US and Boeri (1993) for Germany.

Table 6. Implied Time to Convergence (in Years)

1) Assuming Initial 60% Productivity Relative to West

Exact formula: $T = -\lambda^{-1}\ln[\ln(x_T/\ln(x_0)]$

		x_T: 0.8	0.9	0.95
λ	0.01	82.8	157.9	229.8
	0.02	41.4	78.9	114.9
	0.04	20.7	39.5	57.5
	0.06	13.8	26.3	38.3
	0.08	10.4	19.7	28.7
	0.10	8.3	15.8	23.0

Dornbusch and Wolf: $T = v^{-1}\ln(x_T/x_0)$

		x_T: 0.8	0.9	0.95
v	0.01	28.8	40.5	46.0
	0.02	14.4	20.3	23.0
	0.04	7.2	10.1	11.5
	0.06	4.8	6.8	7.7
	0.08	3.6	5.1	5.7
	0.10	2.9	4.1	4.6

2) Assuming Initial 70% Productivity Relative to West

Exact formula: $T = -\lambda^{-1}\ln[\ln(x_T)/\ln(x_0)]$

		x_T: 0.8	0.9	0.95
λ	0.01	46.9	121.9	193.9
	0.02	23.5	61.0	97.0
	0.04	11.7	30.5	48.5
	0.06	7.8	20.3	32.3
	0.08	5.9	15.2	24.2
	0.10	4.7	12.2	19.4

Dornbusch and Wolf: $T = v^{-1}\ln(x_T/x_0)$

		x_T: 0.8	0.9	0.95
v	0.01	13.4	25.1	30.5
	0.02	6.7	12.6	15.3
	0.04	3.3	6.3	7.6
	0.06	2.2	4.2	5.1
	0.08	1.7	3.1	3.8
	0.10	1.3	2.5	3.1

3.2. Modifications under capital and labor mobility

It is important to stress that the predictions of Section 2 were derived from a closed economy, neoclassical growth model in which the sole source of convergence is internal capital formation. Growth deriving from factors brought into the country or region, either via foreign direct investment or migration, were ruled out. Factor mobility may affect the evolution of the stocks of productive factors and thereby production and productivity in the economy. Migration of labor, human capital and physical capital from regions from low factor incomes to those where returns are higher will tend to equalize per capita income more rapidly than if these factors were immobile.

The factor that has received most attention is labor: in three year period spanning 1989:IV-1992:IV, 576,000 eastern Germans migrated to the West. In addition, 351,000 commuters have taken up work in western Germany (Deutsches Institut für Wirtschaftsforschung and the Institut für Weltwirtschaft (1993)). Whether or not this labor mobility will represent a driving force towards convergence remains to be seen, however. Barro and Sala-i-Martin (1992) do not find significant responses of migration to income differentials in either the US or Japan. For these two countries, they estimate that a 10% difference in income leads to a 0.27% increase in migration per year. Indeed in late 1992, East-West migration dropped to approximately 2500 per week.

Capital mobility -- both physical and human -- is another matter. Human capital can move from West to East in the form of migration of skilled labor from West to East or reverse migration of workers who have "tooled up" by commuting to the West for longer periods of time.[11] Physical capital, in principle, is also mobile. The new German states have adopted the same legal system of property rights as the West; at the same time there is significant uncertainty concerning the ownership of land and existing productive assets.

How important, in theory, is mobility of physical and human capital for convergence? From (4) we have *domestic sources of capital accumulation*

$$\begin{aligned} \dot{k} &= (s_K y/k - g - n - \delta)k \\ \dot{h} &= (s_H y/h - g - n - \delta)h \end{aligned} \tag{4}$$

Suppose that *foreign sources* of capital k^{Es} and h^{Es} are governed by[12]

$$\begin{aligned} \dot{k}^{Es} &= \psi \ln(r^E / r^W)k^E \\ \dot{h}^{Es} &= \xi \ln(q^E/q^W)h^E \end{aligned}$$

where ψ amd ξ are elasticities of supply and r and q are the rentals to the two respective factors. We assume that both East and West share the same production technology. If factors are paid their marginal product, now per effective capita physical and human capital in the East will evolve according to

[11] Of course, indigenous accumulation (via savings) of residents is already incorporated in the basic model and is discussed in Section 2.

[12] For a similar model of capital mobility in a regional context, see Blanchard (1991).

$$\dot{k}/k = s_K y/k - g - n - \delta + \psi[(1-\alpha)\ln(k^W/k^E) + \beta \ln(h^E/h^W)]$$

(11)

$$\dot{h}/h = s_H y/h - g - n - \delta + \xi\,[(1-\beta)\ln(h^W/h^E) + \alpha \ln(k^E/k^W)]$$

These two expressions can be rearranged and substituted into the time derivative of equation (3) to get an expression analogous to (8):

(12) $$\dot{y}/y = \lambda'(\ln y^* - \ln y) + \alpha\xi \ln(k^E/k^W) + \beta\psi \ln(h^E/h^W)$$

where $\lambda'=(g + n +\delta + \xi +\psi)(1-\alpha-\beta) + \alpha\xi+\beta\psi$.

Comparison of equation (12) with equation (8) reveals two important differences. First, the convergence parameter, now denoted as λ', is increased by the short run elasticities of external supply of physical (ψ) and human capital (ξ). Second, all other factors equal, convergence is *reduced* by to the extent that initial capital intensities are lower in the East. (ie $k^E<k^W$ and $h^E<h^W$). Intuitively, the complementarity of the two factors is behind this brake on convergence. If, for example, there is little physical capital in the East, the marginal product of human capital will be lower and this factor will tend to leave the East, reducing the productivity of physical capital in the East, etc. Consequently, while the first effect unequivocally increases convergence speed, the second effect decreases it. The extent of second effect depends on the relative strength of the two external supply elasticities. Consider a special case in which both types of capital equally mobile, that is $\psi=\xi=\psi^*$. Now it can be shown that

(12′) $$\dot{y}/y = \lambda''(\ln y^* - \ln y)$$

where $\lambda''=(g + n +\delta + \psi^*)(1-\alpha-\beta)$. The speed of convergence is increased unambiguously.

In order to illustrate the magnitude of these effects, assume ψ and ξ both equal to 0.1, measured in units of percent response per year to a one percent change in the yield differential. This is a conservative estimate; the specification of the model implies that long run supply elasticities of both types of capital are infinite. Assuming parameter values in Mankiw, et al. (1992), the rate of convergence is increased from 2% per annum to 5.3%, or more than 2.5 times the original value![13]

How can this result be reconciled with Barro and Sala-i-Martin's results for regional convergence in the United States and Japan? There are two good reasons to believe that capital mobility in German in the 1990s is higher than that of the United States a century earlier. First, interstate capital mobility was likely to have been hindered by legal and communication considerations in the late 19th early 20th century (when income gaps were largest). Second, it is difficult to assert that the world capital market was perfect in the 19th century, in the absence of modern communications and data processing. Large-scale borrowing

[13] Mankiw et al. (1992) assume $\delta+g=0.05$ and $\alpha=\beta=1/3$; if $n=0.01$ then $\lambda=.02$.

by poor states was bound to have feedback effects on the rate of return in capital-sending states; the US was a borrower nation until after World War I, so Feldstein-Horioka considerations were probably operative. In contrast, Western Germany can finance unification under modern conditions as well as draw on its significant foreign assets in order to finance this investment boom.[14] As regards human capital mobility, East-West commuters continue to work in West Germany, but while living in the East. This will raise eastern endowment of human capital without the raising the corresponding saving rate.

3.3. A Qualification: per capita income versus per capita output

A limitation of the arguments in favor of a more rapid convergence of eastern Germany is they implicitly equate per worker productivity and per capita income. This is equivalent to assuming full employment and no change in transfer policies. These assumptions may not hold for eastern Germany, and this fact would affect the force of some of the conclusions above. To the extent that structural change is more likely to associated with voluntary or involuntary unemployment or the withdrawal of individuals from the labor force, labor productivity increases alone (GDP per worker) will not necessarily be associated with increases in per capita income.[15] This will be especially true if young people migrate to the West, leaving older workers and retirees in the East, increasing the transfer burden of the West (an important component of the "Mezzogiorno problem"). On the other hand, the demographics of eastern Germany -- due to the outmigration of young people and declining fertility -- may result in lower population growth than in the West, which by equation (7) should raise the (conditional) steady state output and transitional growth.

4. Investment and Growth in Eastern Germany

The German government and the Council of Economic Advisers (Sachverständigenrat) have emphasized the role of investment in the East for improving medium term prospects for productivity and growth. Various tax measures have been introduced favoring investment spending there (see Funke and Willenbockel (1992)). Indeed the empirical evidence suggests that such policies may be economically sensible. Barro (1991) and Levine and Renelt (1992) among others have emphasized the robust empirical link between investment spending and average growth in cross-sections of economies. This empirical link, however, is difficult to rationalize in the context of the Solow model. As is well known, classical growth theory does not admit a link between investment and long term growth; investment influences only steady state capital intensity and thereby long-run living standards. In theory, increased investment is only capable of affecting growth in a transition to a higher steady state. In this section we depart from the Solow model (with its modifications) and discuss potential effects of high investment *independent* of classical growth-theoretic considerations.

Figure 2 shows the relative evolution of the gross investment share in GDP for both the East and West. While the western German gross investment share in 1990-1992 fluctuated around an average value of 20%, eastern German investment was twice as high over the same period. A crude guess regarding the impact of such investment rates on per capita growth is

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[14] In December 1992, Germany's net external position was DM 487.9 billions (Deutsche Bundesbank (1993))

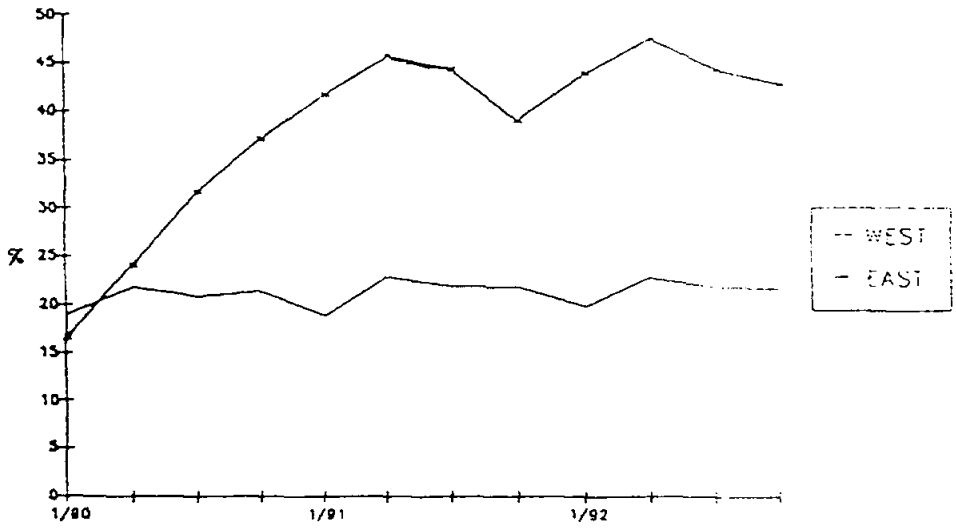
[15] Recall from (2) that

$$y=k^{\alpha}h^{\beta}p^{1-\alpha-\beta}$$

so a decrease in p decreases per capita income with elasticity $1-\alpha-\beta$.

possible, based on recent results reported in Levine and Renelt (1992, p.947). They find that a one percentage point increase in the overall investment share is associated with a 0.17 increase in per capita growth rates in a sample of 101 countries over the period 1960-89. If sustained, higher investment in eastern Germany should be associated with roughly 3.5% higher growth relative to the West over the medium to long term. This is considerable larger than the differential implied by the 2% convergence rule of roughly 1% per annum.

Figure 2. East and West German Investment Share (%)



Note: The investment share is defined as total gross investment divided by GDP. Source: Volkswirtschaftliche Gesamtrechnung der Bundesrepublik Deutschland; DIW *Wochenbericht*, Nos 47/92 and 7/93.

4.1. Investment in Business Equipment and Growth

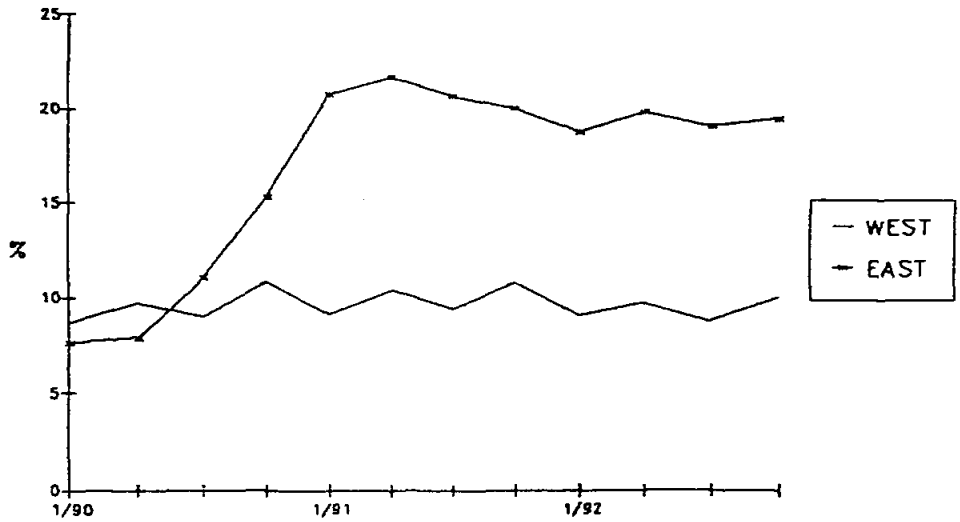
DeLong and Summers (1991, 1992) have argued for a more differentiated treatment of the investment-growth nexus. They adduce evidence that the high correlation of investment and growth is primarily due to the component business machinery in the former. Contrary to the "investment pessimism" of the Solowian growth model, they find that market economies with high rates of equipment investment tend to have higher long run rates of growth of output per head. In their view, the general level of technical expertise of the workforce depends on the availability of capital from which to learn and gain experience. Equipment investment is a catalyst for learning-by-doing and upgrading skills and its effect on growth should be greater, ceteris paribus, than say residential construction. Controlling for schooling, initial productivity relative to the US, labor force growth, investment in nonequipment capital and continental effects, they estimate that an extra point in the equipment investment share of GDP raises long-run growth by 0.3 percentage points compared with a mere 0.02 percentage points for other investment.[16] When compared with Levine and Renelt's (1992) estimate for overall investment

[16]DeLong and Summers (1991) find that equipment investment can explain about three-quarters of the variation in growth of high productivity countries and about two-fifth when developing countries are included in the cross-section data set. But does this correlation necessarily mean causation, ie that more investment

share of 0.17 cited above, the evidence suggests that business equipment has a higher growth dividend than other investment spending.

Figure 3 compares the equipment investment performance of East and West, as a fraction of GDP. Not only is eastern German business equipment spending astonishingly high compared with the West (more than 10 percentage points), but is also high in absolute terms in international comparison. For example, the investment share in eastern Germany is higher than in any country in the DeLong/Summers data set, including Japan, Singapore and Hong Kong. (Delong and Summers (1992), p. 171). On the basis of DeLong and Summers' (1992) estimates, East Germany will enjoy a 3% higher long run increase in growth, assuming its investment performance is maintained over the period. This predicted effect is roughly consistent with that implied by Levine and Renelt's (1992) results.

Figure 3. East and West German Equipment Investment Share (%)



Note: The investment share is defined as total gross business equipment investment divided by GDP. Source: Volkswirtschaftliche Gesamtrechnung der Bundesrepublik Deutschland; DIW *Wochenbericht*, Nos 47/92 and 7/93.

4.2. Infrastructure Investment and Growth

A third link between investment and long term growth that has received attention in both the theory and policy literature concerns the role of public infrastructure. Infrastructure

means more growth? DeLong and Summers argue that, were causality in the other direction, relative prices for investment goods would be higher due to higher demand; it turns out that fast-growing economies actually tend to have lower relative prices for capital equipment (which may be responsible for the investment rate in the first instance).

refers to the cumulative investment spending of central, regional and local government agencies and public enterprises (postal service, telecommications, hospitals, and railways). The standard view is that such spending has external effects on the productivity of private economic activity; for example, firms with access to a good telecommunications system are capable of operating more efficiently. In endogenous growth models, public investment is a policy measure which can spur both private capital formation as well as total factor productivity.

While controversial, there is mounting evidence that government investment in infrastructure can have an effect on aggregate growth. Put differently, the social return on infrastructure investment seems to exceed its private return.[17] Clarida (1993) has recently estimated an elasticity of total factor productivity (the Solow residual) with respect to public capital in West Germany of 0.48.[18] Infrastructure spending in eastern Germany is currently 30 (36) billion DM for 1991 (1992); in per capita terms this is 50% higher than in the West.[19] Assuming an eastern German public capital stock of 10% of the West and a 3% depreciation rate, this would imply a real net growth rate of public capital stock of roughly 10% for 1991. If sustained over the medium to longer term, this infrastructure investment policy translates into an increase of about 5% growth over that in the West. While this is unlikely to be sustained, it illustrates the qualitative significance for growth of the investment boom in eastern Germany.

5. Conclusion

The discussion of medium to long term prospects for the economy of the ex-GDR has been characterized by extreme pessimism. The current thinking is that it will take several generations to close the gap in productivity and livings standards between eastern and western Germany. Recent development in labor productivity and investment in eastern Germany, however, give good reason to be more optimistic. This optimism stems from several sources. First, "Barro-pessimism" implied by the 2% convergence rule is based on initial conditions for the East which have already proved too low. In 1992 alone, aggregate manufacturing productivity jumped by more than 70%, with many two-digit sectors experiencing much higher rates of improvement. Heterogeneity among sectors of economic activity will contribute greatly to this process: noncompetitive sectors will contract and unprofitable firms exit, while high productivity sectors and enterprises will expand. Second, the mobility of physical and human capital -- which for obvious reasons will be much higher between the two parts of German than between countries -- will accelerate the convergence process. Finally, the weight of several empirical studies imply that the unusually strong investment performance following unification is likely to be associated with eastern German per capita growth well above that in the West.

Our optimism has important policy implications. First, the analysis in Section 3 showed that the time to convergence to western productivity levels is negatively related to initial conditions, and therefore to initial efficiency gains. While these initial efficiency gains have received little attention in the discussion of eastern German development, it is well recognized that they are associated with significant reductions of employment. In other words, a tradeoff exists between employment reductions today and short-term discomfort associated with

[17] See Aschauer (1989), Barro (1989), Clarida (1993), Ford and Poret (1991), Coe and Moghadam (1993), and Lynde and Richmond (1993), for example.

[18] The elasticity is therefore even higher than those reported by Aschauer (1989). Clarida (1993) also shows that productivity is Granger-caused by public capital.

[19] Source: Sachverständigenrat (1992), p. 93-94.

unemployment, versus slower convergence to the West with longer term ramifications.[20] In the short term (taking output as given), the former course will imply fewer jobs, but over the medium to longer term, eastern Germany will ultimately gain in competitiveness, increasing both its share of world output as well as total employment. The second implication concerns the current and future policies of the Treuhandanstalt, the agency responsible for privatizing eastern German industry. Until now, official policy has favored a "big bang" approach, meaning rapid privatization and leaving most restructuring to the private sector. The continuation of this strategy has become increasingly controversial and politically difficult; adverse selection has reduced the Treuhand portfolio to extremely unprofitable firms with disproportionate regional significance.[21] This paper vindicates the initial aggressive Treuhand strategy of emphasizing efficiency over defensive measures, which ultimately must be "bought" with a more prolonged transition period. In this respect it would seem advisable, as Siebert (1991) recommended, to protect people rather than obsolete production structures.

References

Akerof, G., A. Rose, J. Yellen, and H. Hessenius (1991), "East Germany in from the Cold: the Economic Aftermath of Currency Union," *Brookings Papers on Economic Activity* 1:1991, 1-106.

Aschauer, D. (1989) "Is Public Expenditure Productive?" *Journal of Monetary Economics* 20, 177-200.

Baldwin, R. "The Growth Effects of 1992" *Economic Policy* 9, 247-281.

Barro, R. (1989), "A Cross-Country Study of Growth, Savings, and Government," NBER WP #2855.

_____(1991), "Economic Growth in a Cross-Section of Countries," *Quarterly Journal of Economics* 106, 407-444.

Barro, R. and X. Sala-i-Martin (1991), "Convergence across States and Regions," *Brookings Papers on Economic Activity* 1: 1991, 107-158

_____, (1992a), "Convergence," *Journal of Political Economy* 100, 223-251.

_____, (1992b) "Regional Growth and Migration: A Japan-US Comparison, *Journal of the Japanese and International Economies* 6: 312-346.

Barth, A. (1992) "Investionsbedarf bis zum Jahr 2000 -- Eine Modellrechnung," *IAB-Werkstattbericht* Nr.12, Nürnberg.

Begg, D., J.-P. Danthine, F. Giavazzi, and C. Wyplosz (1990), "The East, the Deutschmark, and EMU," in *Monitoring European Integration: The Impact of Eastern Europe*, Centre for Policy Research, London.

[20]These intertemporal considerations illustrate that the transition process in eastern Germany contains potential intergenerational conflicts. Young people have the most to lose from a slower transition process, whereas older generations are hardest hit by restructuring, unemployment and the associated loss of human capital.

[21]The potash mines in Bischofferode and Deutsche Waggonbau are two well-known examples.

Blanchard O. "Comment" on Barro and Sala-i-Martin (1991) *Brookings Papers on Economic Activity* 1:1991, 159-174.

Boeri, T. (1993) "Why are Establishments so Heterogeneous?" mimeo, OECD.

Burda, M. (1990) "The Consequences of German Economic and Monetary Union," CEPR Discussion Paper no. 449, May.

Clarida, R. H. (1993) "International Capital Mobility, Public Investment, and Economic Growth: A Neoclassical Framework with an Empirical Test," paper presented at the 16th International Seminar on Macroeconomics, Kiel.

Coe, D. and R. Moghadam (1993) "Capital and Trade as Engines of Growth in France: An Application of Johansen's Cointegration Methodology," IMF, mimeo.

Davis, S. and J. Haltwanger (1993) "Gross Job Creation, Gross Job Destruction and Job Reallocation," *Quarterly Journal of Economics* 107, 819-863.

DeLong, J.B. and L. H. Summers (1991), "Equipment Investment and Growth," *Quarterly Journal of Economics* 106, 445-502.

_____ (1992), "Equipment Investment and Growth: How Strong is the Nexus?" *Brookings Papers on Economic Activity*, 2:1992, 157-199.

Deutsche Bundesbank (1993) *Statistisches Beiheft zum Monatsbericht: Zahlungsbilanzstatistiken* June.

Deutsches Institut für Wirtschaftsforschung and the Institut für Weltwirtschaft (1993), "Gesamtwirtschaftliche und unternehmerische Anpassungsprozesse in Ostdeutschland," *DIW Wochenbericht* 60, No. 13/93, 131-158.

Dornbusch, R. and H. Wolf (1992) "Economic Transition in Eastern Germany," *Brookings Papers on Economic Activity*, 1:1992, 235-272.

Ford R. and P. Poret (1991) "Infrastructure and Private Sector Productivitry" *OECD Economic Studies*. No 17, 63-90.

Funke, M. and D. Willenbockel (1992) "Steuerliche Investitionsförderung in den neuen Bundesländern -- Maßnahmen und Auswirkungen," *Finanzarchiv* 49, 457-480.

Godfrey, L.G. (1978) "Testing Against General Autoregressive and Moving Average Error Models when the Regressors Include Lagged Dependent Variables", *Econometrica*, 46, 1293-1302.

Gordon, R. (1979), "The End-of -Expansion Phenomenon in Short-run Productivity Behavior," *Brookings Papers on Economic Activity* 2:1979, 447-461.

Görzig, B. (1992) *Produktion und Produktionsfaktoren für Ostdeutschland - Kennziffern 1980-1991*, Berlin.

Hughes-Hallett and Y. Ma (1993), "East Germany, West Germany, and their Mezzogiorno Problem: A Parable for European Economic Integration," *Economic Journal* 103, 416-28.

Jarque, C.M. and A.K. Bera (1980) "Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals", *Economic Letters*, 6, 255-259.

Kiviet, J.F. (1986) "On the Rigour of some Misspecification Tests for Modelling Dynamic Relationships", *Review of Economic Studies*, 53, 241-261.

Levine, R. and D. Renelt (1992), "A Sensiitivity Analysis of Cross-Country Growth Regressions," *American Economic Review* 82, 942-963.

Lynde, C. and J. Richmond (1993), "Public Capital and Total Factor Productivity," *International Economic Review* 34, 401-414.

Mankiw N.G. D. Romer and D.Weil (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics* 107, 407-437.

Rebelo, S. (1991) "Long-run Policy Analysis and Long-run Growth," *Journal of Political Economy* 99, 500-521.

Ramsey, J.B. (1969) "Tests for Specification Errors in Classical Linear Least Squares Regression Analysis", *Journal of the Royal Statistical Society B*, 31, 350-371.

Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (1992) *Für Wachstumsorientierung – Gegen lähmenden Verteilungsstreit* Jahresgutachten 1992/93, Wiesbaden.

Sala-i-Martin, X.(1990), "Lecture Notes on Economic Growth, I and II" NBER WPs Nos: 3563 and 3564, December.

Scott, A. (1991) "Investment Needs in a Unified Germany" *International Economic Outlook* 1, 30-35.

Siebert, H. (1991) "German Unification: The Economics of Transition," *Economic Policy* 13, 287-340.

Sinn, G. and H.-W. Sinn (1991), *Kaltstart* Tübingen, JCB Mohr.

Sinn, S. (1990) *Net External Asset Positions of 145 Countries* Kieler Studien no. 234. Tübingen, JCB Mohr.

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

Swan, T. "Economic Growth and Capital Accumulation," *Economic Record* 32, 334-361.

Willgeroth, H. (1990) "Vorteile der wirtschaftlichen Einheit Deutschlands," Universität Köln, mimeo, March.

Appendix 1. An Estimate of Cyclically-adjusted Productivity in East German Manufacturing in 1991

This appendix presents a crude cyclical correction of the relative productivity levels in Table 2 reported by Görzig (1992). To the extent that productivity is procyclical, the measured East-West productivity ratio in 1991 will be biased downwards. Our idea is simply to estimate a "cyclical adjustment" using manufacturing time series data from East and West from 1981-1991 as well as capture the "overhead effect" of 1991 in the East. Using ordinary least squares we estimated the following equation for the sample period 1981 - 1991:[22]

$$(A1)\quad (y^E/y^W)_t = \underset{(4.9)}{28.16} + \underset{(2.7)}{0.35}(y^E/y^W)_{t-1} + \underset{(15.1)}{0.25}\Delta\%(Q^E/Q^W)_t - \underset{(1.8)}{2.17}\,DUMMY91$$

$$F(2,8) = \underset{(0.00)}{514.12},\ DW_h = \underset{(0.20)}{1.29},\ F_{LM}(1,7) = \underset{(0.42)}{0.72},\ F_R(1,7) = \underset{(0.16)}{0.04},$$

$$F_H(1,9) = \underset{(0.12)}{2.92},\ \chi^2_{JB}(2) = \underset{(0.88)}{0.26}$$

where $(y^E/y^W)_t$ denotes East Germany's labour productivity in manufacturing in percent of West Germany and $(Q^E/Q^W)_t$ denotes East Germany's gross value added in manufacturing in percent of West Germany. $F(\cdot,\cdot)$ is the conventional F-test for testing the joint significance of the explanatory variables, DW_h is Durbin's h-statistic, $F_{LM}(\cdot,\cdot)$ is Godfrey's (1978) Lagrange multiplier test of first-order residual serial correlation, $F_R(\cdot,\cdot)$ is Ramsey's (1969) RESET test for functional form misspecification, $F_H(\cdot,\cdot)$ is a test of the homoscedasticity assumption based on the regression of squared residuals on squared fitted values, and $\chi^2_{JB}(\cdot)$ is the test proposed by Jarque and Bera's (1980) for testing the normality assumption. All diagnostic tests are comfortably passed. Our estimate of relative productivity for 1991, including the effect of the dummy variable for that year, is 40.25%. The actual ratio for 1991 from Table 2 is 25.6%.

Appendix 2: Underlying Output, Employment and Productivity Data for Eastern German Manufacturing Industries (1991:1=100)

Industry	Variable	1991:12	1992:12
Total Manufacturing	Q	93.3	98.3
	L	63.9	39.4
	Q/L	145.9	249.8
Intermediate Goods	Q	93.5	87.7
	L	60.4	38.5
	Q/L	154.8	227.8
Oil refining	Q	114.1	111.0
	L	62.8	45.8
	Q/L	181.9	242.3
Quarrying	Q	121.9	194.9
	L	63.7	50.4
	Q/L	191.2	387.1
Iron and Steel	Q	56.9	63.2
	L	66.6	31.9

22 *t*-values (probability values) are given below the coefficients (diagnostic tests). The probability values are computed on the assumption that the underlying model is correctly specified. The diagnostic tests are given in the F-form because Kiviet (1986) has shown that in small samples the F version is generally preferable to the LM version. The annual data were taken from Görzig (1992).

	Q/L	85.4	198.0
Nonferrous Metals	Q	65.4	76.0
	L	50.6	25.4
	Q/L	129.2	298.3
Foundries	Q	51.7	39.8
	L	59.5	34.1
	Q/L	86.9	116.8
Chemicals	Q	105.9	62.2
	L	60.6	41.0
	Q/L	175.0	151.7
Sawmills, timber	Q	49.4	34.8
processing	L	56.0	34.5
	Q/L	88.1	100.9
Pulp and paper.	Q	86.8	68.4
processing	L	53.1	32.8
	Q/L	163.5	208.7
Rubber products	Q	52.9	52.3
	L	54.2	28.9
	Q/L	97.4	180.9
Capital goods	Q	93.2	100.3
industries	L	65.2	40.5
	Q/L	143.1	248.0
Structural Steel	Q	182.1	247.0
	L	94.7	86.6
	Q/L	192.3	285.3
Mech. engineering	Q	87.2	66.1
	L	61.8	37.6
	Q/L	141.2	175.9
Road vehicles	Q	61.5	108.1
	L	62.0	39.3
	Q/L	99.3	275.3
Shipbuilding	Q	96.0	46.3
	L	63.2	47.4
	Q/L	152.0	97.8
Electrical	Q	88.9	104.7
engineering	L	60.7	32.1
	Q/L	146.5	325.7
Instrument engineering	Q	36.4	45.0
	L	69.7	31.2
	Q/L	52.2	144.4
Finished metal prods.	Q	94.0	97.6
	L	82.8	37.9
	Q/L	113.5	257.6
Office machinery	Q	40.0	31.5
	L	61.3	15.3
	Q/L	65.3	205.7
Consumer goods	Q	86.9	103.6
	L	61.1	33.1
	Q/L	158.7	313.0
Musical instr., toys	Q	163.9	137.9
	L	54.8	27.4
	Q/L	298.9	503.6
Fine ceramics	Q	85.3	78.6
	L	63.3	44.5
	Q/L	134.6	176.8
Glass products	Q	79.3	60.4
	L	62.1	39.9
	Q/L	127.7	151.2
Wood processing	Q	74.4	84.5
	L	70.4	46.9
	Q/L	105.7	180.3
Paper products	Q	82.4	87.6

	L	55.4	36.6
	Q/L	148.9	239.2
Printing, publishing	Q	164.1	173.0
	L	100.9	76.0
	Q/L	161.0	227.4
Plastic products	Q	119.2	184.2
	L	59.5	60.0
	Q/L	200.0	307.1
Leather products	Q	44.7	45.5
	L	81.7	18.7
	Q/L	54.8	243.6
Textiles	Q	64.2	48.0
	L	76.9	19.9
	Q/L	83.5	241.4
Clothing	Q	65.7	48.1
	L	86.5	24.4
	Q/L	75.9	197.6
Food, beverages, tobacco	Q	89.8	102.0
	L	72.8	50.6
	Q/L	108.4	201.7
Food, beverages	Q	96.4	111.3
	L	88.1	50.6
	Q/L	109.5	219.9
Tobacco	Q	68.1	58.9
	L	67.2	48.8
	Q/L	101.3	120.6

Note: Q=monthly index of net production (constant prices); L=total employment (including self-employed).
Source: Statistisches Bundesamt, Fachserie 4.11 and 4.21.