Kieler Arbeitspapiere • Kiel Working Papers

1306

What kind of shock was it?

Regional Integration and Structural Change in Germany after Unification

Michael C. Burda

January 2007

This paper is part of the Kiel Working Paper Collection No. 1

"What Went Wrong in East Germany and What Can Be Done?"

http://www.ifw-kiel.de/prog2/p2ra1.htm#publications

Institut für Weltwirtschaft an der Universität Kiel
Kiel Institute for the World Economy

Kiel Institute

Kiel Institute for World Economics
Duesternbrooker Weg 120
24105 Kiel (Germany)

Kiel Working Paper No. 1306

What kind of shock was it?

Regional Integration and Structural Change in Germany after Unification

by

Michael C. Burda

January 2007

Michael C. Burda. (Humboldt-Universität zu Berlin, CEPR, CESifo, IZA) *

What kind of shock was it?
Regional Integration and Structural Change in Germany after Unification

Abstract

Eastern Germany's recovery from the "unification shock" has been characterized by deep structural change – with apparent repercussions for the West as well – and an integration process involving both capital deepening (extensive and intensive investment) and labor thinning (net out-migration). I propose a constant-returns neoclassical model of economic integration which can account for these facts. Adjustment costs determine dynamics and steady state regional distribution of production factors. The model also explains persistent wage and capital rate-of-return differentials along the equilibrium path. Under competitive conditions, observed factor price differentials contain information on those adjustment costs.

Keywords: German reunification, regional integration, costs of adjustment, capital mobility, migration

JEL: F2, J61, P23

* A shorter version of this paper was presented at the Annual Meetings of the American Economic Association, Boston, January 8, 2006, and at the Verein für Socialpolitik September 2006. This research was supported by the DFG Collaborative Research Center 649 (SFB 649, Deutsche Forschungsgemeinschaft). I thank Maike Burda and Kurt Helmes for very useful discussions and Dirk Bethmann, Sebastian Braun, Katrin Rusch, Battista Severgnini, and Didem Atakan for helpful research assistance.

1. Introduction

Fifteen years after reunification, the resurrection of the Eastern German economy is hard to overlook. Despite a negative image cultivated by the media, the region has clearly recovered from the devastating "unification shock" of the early 1990s and is well on its way to finding a place in international patterns of trade and specialization. Since 1995, industrial production in the East – excluding construction – has expanded by more than 80%, and by 38% since 2000, a period during which the Western German measure grew cumulatively by only 11%. In terms of value added, total real GDP in Eastern Germany grew by roughly 3.5% annually since 1991, and more than 8% annually in manufacturing industry alone. In the past fifteen years, more than half of the per-capita GDP gap between East and West has been closed, in less than half the time predicted by Robert Barro (1991). For the first time since 1991, an Eastern German state (Thuringia: 13.9%) can boast a lower unemployment rate than a Western one (Bremen: 14%), If the persistence of time series is any guide, some regions of south Eastern Germany are well-poised to displace some counterparts in the West.

It would be false, however, to claim that regional integration has been painless. As Table 1 shows, convergence on a wide array of indicators has been impressive, but most difficult in the labor market. Since 2000, annual net migration from East to West has averaged about 70,000 or 0.5% of the population per annum, and was especially concentrated among youth (see Harald Uhlig 2006). At the same time, new physical capital has moved east – on average 80-90 billion Euros annually, or about 20% of regional GDP. The reallocation of production factors is arguably the most impressive aspect of the German unification episode: in the years 1991-2002, EUR 1.2 trillion of new investment (1995 prices) was undertaken on behalf of about 15 million residents in the East, making this episode one of the most intensive periods of net capital formation in modern economic history, on a per capita basis. Despite this windfall of economic development, the workforce of Eastern Germany shrank by roughly 1.2 million over the period from 1991 to 2004, or by about 15%, while employment in the West rose by 4.1%.

This pattern of adjustment with factor accumulation in opposite directions is difficult to account for using a simple neoclassical growth framework. To evaluate the aggregate causes and effects of these factor movements, I propose a simple model of economic integration which can account for finite rates of factor movement and convergence, as well as provide a quantification of the costs associated with the integration process. The model is also capable of delivering an estimate of the steady-state size of the Eastern German economy.

<Table 1 here>

It is difficult to imagine such massive movements of factors occurring in the absence of structural change. Indeed, if the aggregate production function is seen as the aggregate output of many sectors, all producing optimally, rather than literally as the output of a single good, structural change and factor mobility are part and parcel of the same process. These changes have remained relatively undocumented over the past fifteen years, so a second task I take up is to show in broad brushstrokes the structural change which can been observed in East Germany. At the same time, East-West migration flows coincide with significant structural change in the West, leading one to suspect that migration may be less structurally neutral than the standard model predicts.

This paper is organized as follows. In Section 2 I document the integration shock and concomitant structural change which has occurred in both parts of Germany since 1990. In Section 3, I propose and discuss a neoclassical model of integration as a benchmark for the factor mobility that would occur under ideal conditions, i.e. under conditions of perfect competition in labor and product markets. Section 4 describes the steady state and dynamic properties of this model and describes an informal calibration of the model, including the implications for the steady state size of the Eastern German economy. Section 5 concludes.

2. East Germany's Integration Shock

2.1. Mechanisms of Integration

Early on, Horst Siebert (1992) presciently characterized the episode as a massive "integration shock," and there is little doubt that unification caught economic agents in the region by surprise. To make my discussion more precise, however, I will use Eichengreen's (1990) definition of economic integration: the achievement of the efficient production pattern by two or more geographic regions made possible by their union. Several mechanisms could be associated with an integration shock. First, internal accumulation of production factors raises output per capita in the poorer region at no expense to the richer one. Second, labor will tend to move from the capital-poor to capital-rich region. Third, capital mobility, either in the form of foreign direct investment will benefit the capital-poor region, financed either by international capital markets or at the expense of the capital-rich one. Fourth, Heckscher-Ohlin trade between incompletely specialized regions can lead to equalization of factor prices. Finally, the backward region can adopt technologies from the leading region, leading to convergence of total factor productivity. In the analysis which follows, I will suppress differences in technologies across regions, as well as the very long-term process of capital accumulation which can bring about integration (Barro and Sala-i-Martin 1990, 1995). I will also ignore the role that factor-proportions trade can play in inducing integration by assuming a single good produced in both regions. My analysis will focus on the movement of factors as well as movements along a stable production technology as prime drivers of integration of Eastern and Western Germany.

2.2. Factor Mobility

As evident from Figures 1 and 2, the intensity of factor reallocation between the two regions was not only high, but also far from constant over the period. In the first two years after unification, more than a million people changed residence on a net basis. Through the early 1990s, this rate declined to a trickle, then rose again after 1995, when growth in the region declined and unemployment rates rose. Similarly, capital investment was highest in the early 1990s, then declining after the mid-decade. In addition, an unusually large fraction (2/3) of the cumulated investment flow in Eastern Germany was dedicated to residential and business structures, compared with about 1/3 in business fixed equipment. The large run-up in investment spending on structures is frequently seen not only as the outcome of distorted investment incentives, but also as having longer run consequences for the structure of output and factor demands (Sinn 1992). Thus, after a very strong start in the 1990s, investment rates in the East have declined significantly and now are hardly different from those in the West (see Table 2).

<Figures 1 and 2 here>

The real recapitalization of the Eastern German economy is a prime determinant of the rapid rise in per employee productivity documented above in Table 1. In some sectors, it may even be the case that capital-labor ratios have overshot western levels. For example, the official estimate of eastern aggregate capital-labor ratio in manufacturing was virtually at par with the West in 2002 at 99%; this conceals variation ranging from 66% in textiles/clothing and 81% in metallurgy to significantly higher values of 125% in chemicals and 122% in automobile production. Many extreme cases can be found in intermediate materials (average 123% of the West, basic chemicals 143%) and mining and quarrying (184%!).[1] In the next section, I discuss the implications of this development for structural change in Germany.

<Table 2 here>

2.3. Structural Change

The past evolution of eastern Germany, in which factors of production move intensively in opposite directions, is difficult to explain as a reaction to disturbances in technology, preferences, or demand. Moreover, the heterogeneous evolution of sectors in the East documented in the last sections suggests that such massive movements of factors are likely to be accompanied by structural change. If the aggregate production function is seen as the aggregate output of many, many sectors, all producing optimally, rather than literally as the output of a single good, structural change and factor mobility are likely to represent the same underlying economic process. This is the process of adaptation of a region long cut off from economic incentives to the forces of international specialization and trade.

The recovery of economic activity since the early 1990s in the new states has by no means been uniform. This is hardly surprising given the early and remarkably prescient analysis by Akerlof, et al. (1990) immediately following unification; on the basis of internal statistics maintained by the central planners of the German Democratic Republic, only about 20% of industry was internationally competitive at a 1:1 Ostmark-DM exchange rate. The extent of this structural change can be seen in the two panels of Figure 3, which document the relative evolution of industrial production indexes in the periods 1995:1-2001:1 as well as the more relevant German slump period 2001:1-2006:1.

[1] These estimates as well as a detailed description of sectoral convergence are described in Kim (2006).

Note not only is the strikingly uneven recovery of East German industry, but also the extent to which a re-orientation of production appears to be occurring towards the Eastern regions. It is noteworthy that this shift is consistent with at least a partial restoration of the preeminent position held by central Germany in the industrial economy until World War II.

<Figure 3 here>

Naturally, East Germany still accounts for a smaller fraction of total output than its population share, and growth rates will be magnified by the small base at the outset. Yet in manufacturing, the eastern German states excluding Berlin now account for 9% of total German value-added in that sector, up from 7.6% in 2000 and 5.6% in 1995. In striking contrast, the East German value added share in broadly-defined services has hardly risen since 1995 from 11.2% to 11.7%; in construction it fell from 27.8% in 1995 to 16.9% in 2005, and remains considerably oversized compared to its West German counterpart.

Given the extent of the transformation of the Eastern German economy, it is inevitable that this structural change would spill over to the West. Indeed, concomitant with the expansion of manufacturing in the new states is a visible change in economic structures in the old states. The two panels of Figure 4, reproduced from Bachmann and Burda (2006), provide evidence for this claim. The first panel shows how the employment shares in the West began changing significantly after 1900, the year of German unification. Since 1990, the West German economy has lost roughly a fifth of its socially insured employment in industry, while significantly increasing the number of jobs in services, especially business-related services (Bachmann/Burda 2006).

<Figure 4 here>

The second panel shows the evolution of Lillien indexes of disparity in employment growth as described by Lillien (1982). These numbers, which are similar in behavior to weighted standard deviations of employment growth rates, show a marked increase in entropy of sectoral employment. This conjecture appears even more valid when the changes are measured over longer periods, that is, when short term fluctuations are filtered out by measuring employment growth over longer intervals. Note that the increase in the indexes is centered around 1990, the year of German unification.

The preponderance of evidence suggests that the integration shock has had a marked medium term effect on both factor allocations and the division of labor in unified Germany. In the next section, I propose a neoclassical model of regional integration which can help understand and evaluate this episode.

3. A Formal Model of Factor Mobility and Regional Integration

3.1. Model Ingredients

Two regions, East (E) and West (W) produce output Y in time t employing the same neoclassical constant returns production function $Y_t=F(K_t,G_t,L_t)$. Factor inputs consist of two types of capital – equipment (K) employed in production as well as structures (G) used both to shelter enterprises and households. I assume $F_K>0$, $F_G>0$, $F_L>0$, $F_{KK}<0$, $F_{GG}<0$, $F_{LL}<0$, and $\det(\nabla^2 F)=0$. In this paper I also assume that $F_{ij}>0\ \forall i\neq j$. Both types of capital are internationally mobile and depreciate at rates δ_K and δ_G respectively, with $\delta_K>\delta_G$. The world rate of interest is exogenously given at r. While capital services can be imported freely from abroad, labor mobility is only possible between the two regions, and total labor supply is normalized to 1. The population of the East is denoted by L^E, so under full employment assumptions L^W=1-L^E. The model is deterministic, and secular economic growth is ignored.[2]

Let $f(k,g) \equiv F(K,G,L)/L$ be the intensive form of F with per capita inputs $k \equiv K/L$ and $g \equiv G/L$. With identical technologies in both regions, static efficiency is achieved in the positive orthant of regional (East-West) factor endowments along a ray determined by (k^*,g^*), the solution to $f_k(k,g) = \overline{R}_K \equiv r + \delta_K$ and $f_g(k,g) = \overline{R}_G \equiv r + \delta_G$. This can be thought of as the grand diagonal of a three-dimensional Edgeworth polyhedron with dimensions 1, k^*, g^*. All points along that diagonal are efficient in the sense that the marginal product of either type of capital equals the world interest rate plus its respective economic depreciation; since r is exogenous and given by the rest of the world, $\overline{R}_K$ and $\overline{R}_G$ can be thought of as world user costs of capital for the respective types. The common real wage can be read off the factor price frontier and represents the residual output after capital is paid its gross marginal product in competitive labor markets.

The multiplicity of these efficient allocations in the steady state implies that the output maximizing trajectory for the economy will be determined by factor adjustment costs. The initial conditions of the economy will imply that the East is off this diagonal at t=0, while the West is on the diagonal.[3] I will assume that capital adjustment costs for both types of capital are external and convex in the net change of the capital stock (i.e. not in the gross level of investment expenditures). Similarly, for migration – the movement of labor between regions – I assume convex costs of which are borne fully by migrants (there are no externalities). Quadratic forms are chosen for tractability.[4]

---

[2] For simplicity, I assume full employment throughout. This is clearly at variance with the facts but adding labor supply or search will add little to the aspects which I focus on in this paper.
[3] Strictly speaking this is not an Edgeworth box in the traditional sense, since the endowments of the factors which can be accumulated are not fixed – they can be brought in from "abroad." The supply of labor to the two regions is fixed, however.
[4] For more details on adjustment costs, see Abel (2001), Abel and Blanchard (1983), or Lucas (1967).

3.2. Social optimum

Because this economy meets the conditions for the first and second welfare theorems to apply, the optimal allocation chosen by a hypothetical social planner can be supported as a decentralized market equilibrium. This optimal allocation selects migration and investment policies in both regions to maximize the present discounted value of national output (net of migration and capital adjustment costs).[5] More formally, I seek functions of time t$\in[0,\infty)$ – governing investment rates in equipment (I_t^W and I_t^E) and in structures (J_t^W and J_t^E) in the West and East respectively, as well as net migration from West to East (X_t) which maximize

$$(1)\quad \int_0^\infty e^{-rt}\left[F(K^W,G^W,L^W)-I^W-J^W+F(K^E,G^E,L^E)-I^E-J^E-\frac{\psi_I}{2}\left(I^E-\delta_K K\right)^2-\frac{\psi_J}{2}\left(J^E-\delta_G G\right)^2-\frac{\phi}{2}X^2\right]dt\,,$$

subject to initial conditions, which are the allocations of both capital types and labor in East and West at t=0. Gross and net migration flows are therefore equal; negative values of X imply net migration from West to East. The positive parameters ψ_I, ψ_J and ϕ capture the intensity of adjustment costs. Labor and capital stocks obey the following equations of motion:

$$(2)\qquad \dot{K}_t^i = I_t^i - \delta K_t^i \qquad \text{for } i=E,W$$

$$(3)\qquad \dot{G}_t^i = J_t^i - \delta G_t^i \qquad \text{for } i=E,W$$

$$(4)\qquad \dot{L}_t^E = -\dot{L}_t^W = X_t\ .$$

---

[5] Here output is equated with utility. Setting up problem in terms of utility maximization would require an arbitrary weighting of eastern and western citizens' utility. As long as production and consumption decisions are separable and the world interest rate is given, there is no loss of generality by focusing on the production side.

By assuming that adjustment of western capital stocks is costless, I am able to simplify the model considerably and shift emphasis to relative adjustment costs in the East. These are determined by relative legal regulations, conflicting property rights, bureaucracy-related transactions costs related to both private and public infrastructure.

3.3. Planner's optimum as market equilibrium

Define q^E, ρ^E and μ as the shadow values of a marginal unit of capital equipment, structures, or a worker in place in the East, respectively, for the policy that maximizes (1).[6] To simplify notation, superscripts are used to denote regions when arguments of functions are suppressed; time subscripts are suppressed whenever obvious. Necessary conditions characterizing the optimum are, for all $t \geq 0$:

(5) $$I^E = \left(q^E - 1\right)/\psi_I + \delta_K K^E$$

(6) $$J^E = \left(\rho^E - 1\right)/\psi_J + \delta_G G^E$$

(7) $$X = \mu / \phi$$

(8) $$q^W = 1$$

(9) $$F_K^W = \overline{R}_K \equiv r + \delta_K$$

(10) $$F_G^W \equiv \overline{R}_G = r + \delta_G$$

(11) $$\dot{q}^E + F_K^E + \delta_K \psi_I \dot{K}^E = \left(r + \delta_K\right) q^E$$

(12) $$\dot{\rho}^E + F_G^E + \delta_G \psi_J \dot{G}^E = \left(r + \delta_G\right) \rho^E$$

(13) $$\dot{\mu} + (F_L^E - F_L^W) = r\mu ,$$

---

[6] Technically, they are the co-state variables in the dynamic optimization problem, and have analogs to Lagrange multipliers in static maximization analysis.

plus the equations of motion (2), (3), and (4). Equations (5), (6) and (7) relate optimal investment rates in the East and migration *to the East* as positive and linear functions of their respective shadow prices, which are sufficient statistics for determining both activities. The greater the associated adjustment costs, the lower the respective investment rates, *ceteris paribus*. Equations (8) and (9) represents optimal behavior in the absence of adjustment costs; in the West, the static efficiency condition obtains continuously with constant capital-labor ratio k^* and structures-labor ratio g^* defined above. Migrants from the East are equipped upon arrival in the West with the same level of capital used by other western residents, and earn the western wage denoted by $\overline{w} = F_L^W$.

The three state variables in the model K^E, G^E and L^E are predetermined at any point in time, evolving according to the differential equations (2), (3) and (4). The co-state variables q, ρ, and μ stand for the respective shadow values of equipment capital, structures and labor in the East, given the economy is on the optimal adjustment path defined above. The dynamics of those shadow prices are governed by equations (11), (12) and (13), which are arbitrage conditions equating total holding returns on each "asset" to its respective opportunity cost. Integrating arbitrage conditions (11), (12), and (13) forward from initial conditions and imposing transversality conditions leads to closed form expressions for each of the shadow prices.[7] As is common in perfect foresight models, shadow prices are present values of the entire path of future returns of the respective "assets," discounted using the world interest rate. In the case of investment in the East, the shadow values q^E and ρ^E reflect the present discounted value of present and future marginal products of one unit of capital installed in the East. The shadow

[7] The transversality conditions prevent co-state variables governed by optimality conditions (11), (12) and (13) from assuming explosive paths (i.e. rising faster than rates $r+\delta_K$, $r+\delta_G$ and r, respectively, forever).

value of a worker in the East, μ, represents the present value of the difference in future marginal products of labor between the East and West. Given that $k^W > k^E$ and $g^W > g^E$ at the outset, μ will be negative throughout. The model thus implies a persistent wage gap between East and West which disappears asymptotically as capital accumulates in the East and labor migrates to the West.

4. Steady State and dynamics

4.1. Steady state

The steady state of the model is given by constancy of the state variables K^E, G^E, and L^E; this implies $q^E = \rho^E = 1 \Leftrightarrow F_K^E = \overline{R}^K, F_G^E = \overline{R}^G$, while $\dot{\mu} = 0 \Leftrightarrow F_L^E = F_L^W = \overline{w}$. Thus in the steady state, both regions' allocations are on the grand diagonal of the Edgeworth box described above. Denoting steady-state values of the endogenous variables by bars, the linearized model around that steady state can be written as:

$$(14)\quad \begin{bmatrix} \dot{q}^E \\ \dot{\rho}^E \\ \dot{\mu} \\ \dot{K}^E \\ \dot{G}^E \\ \dot{L}^E \end{bmatrix} = M \begin{bmatrix} q^E - \overline{q}^E \\ \rho - \overline{\rho}^E \\ \mu - \overline{\mu} \\ K^E - \overline{K}^E \\ G^E - \overline{G}^E \\ L^E - \overline{L}^E \end{bmatrix}, \quad \text{with } M \equiv \begin{bmatrix} r & 0 & 0 & -F_{KK}^E & -F_{KG}^E & -F_{KL}^E \\ 0 & r & 0 & -F_{GK}^E & -F_{GG}^E & -F_{GL}^E \\ 0 & 0 & r & -F_{LK}^E & -F_{LG}^E & -F_{LL}^E \\ \psi_I^{-1} & 0 & 0 & 0 & 0 & 0 \\ 0 & \psi_J^{-1} & 0 & 0 & 0 & 0 \\ 0 & 0 & \phi^{-1} & 0 & 0 & 0 \end{bmatrix}$$

The dynamic properties of the system are encoded in the eigenvalues of the matrix *M*, $\{\lambda_1,\ldots,\lambda_6\}$. First, note that $\det(M) = \prod_i \lambda_i = 0$ so at least one of them equals zero. Since $tr(M) = \sum_i \lambda_i = 3r$, at least one of the six roots is positive, so at least one variable is not predetermined, i.e. must be forward-looking. In fact, since in theory three of the system's variables are in fact jumping, forward-looking variables, exactly three roots should exceed zero. The roots have the following analytic form:

$$\text{(15)}\qquad \{\lambda_1,\ldots,\lambda_6\}=\left\{\begin{array}{l} 0, r, \frac{1}{2}\left[r+\sqrt{r^2+2\left(A-\sqrt{A^2-4B}\right)}\right], \frac{1}{2}\left[r+\sqrt{r^2+2\left(A+\sqrt{A^2-4B}\right)}\right], \\ \frac{1}{2}\left[r-\sqrt{r^2+2\left(A+\sqrt{A^2-4B}\right)}\right], \frac{1}{2}\left[r-\sqrt{r^2+2\left(A-\sqrt{A^2-4B}\right)}\right] \end{array}\right\},$$

where

$$A=-\left(\psi_I^{-1}F_{KK}^E+\psi_J^{-1}F_{GG}^E+\phi^{-1}F_{LL}^E\right)>0$$

and

$$B=\psi_J^{-1}\phi^{-1}\left(F_{GG}^E F_{LL}^E-\left(F_{GL}^E\right)^2\right)+\psi_I^{-1}\psi_J^{-1}\left(F_{KK}^E F_{GG}^E-\left(F_{KG}^E\right)^2\right)+\psi_I^{-1}\phi^{-1}\left(F_{KK}^E F_{LL}^E-\left(F_{KL}^E\right)^2\right)>0.$$

As long as the inner discriminant (A^2-4B) is nonnegative, the model has meaningful solutions. In that case, is easy to see that all eigenvalues of M are real-valued; three $(\lambda_2,\lambda_3,\lambda_4)$ are greater than zero, while two (λ_5,λ_6) are strictly less than zero. This corresponds to a typical perfect foresight model with saddle-path stability, in which three co-state (“jumping”) variables are forward-looking.

The zero root implies hysteresis (path dependence), or that initial conditions of Eastern factor supplies K^E, G^E, and L^E, as well as the constellation of adjustment costs, determine the steady state. In a stochastic version of this model with explicit treatment of uncertainty, temporary disturbances to initial factor allocations, such as migration or privatization policies, would have permanent effects on the region’s steady-state size.

4.2. The Central Role of Adjustment Costs

The previous section established that adjustment costs are a key determinant of the resting point of the economy, since the path taken by the eastern capital and labor stocks depends on the correctly anticipated, future paths of both, but also on the costs of adjustment. By inspection, the two stable (negative) roots are increasing in each of the adjustment cost parameters ψ_I, ψ_J, and φ, approaching zero from below. In the long run, the adjustment speed or persistence is determined by the negative eigenvalue of M with the smallest absolute value, which is increasing in adjustment costs. In addition, adjustment costs enter multiplicatively and amplify each other in determining the size of the stable eigenvalues. Local concavity of the production function, in contrast, works in the opposite direction, accelerating adjustment.

4.3. Implications for Factor Prices and Adjustment Costs

Adjustment costs also have implications for the behavior of observed wages and the rate of return on capital in the integration process. Since factor supplies cannot move instantaneously, the capital-labor ratios in the East k^E and g^E will remain below West levels for some time; during this period wages will be lower and return on capital will be higher. These factor price differentials are transient and consistent with finite factors flows over time. The model also predicts that they will be persistent, disappearing only in the long run. Under competitive factor remuneration in the West ($F_K = r+\delta_K = \bar{R}_K$, $F_G = r+\delta_G = \bar{R}_G$,, $F_L = \bar{w}$), (11), (12) and (13) can be rewritten as

(16) $$R_K^E = \bar{R}_K + \delta_K\left(\frac{q^E - 1}{q^E}\right) + \frac{\dot{q}^E}{q^E}$$

(17) $$R_G^E = \bar{R}_G + \delta_G\left(\frac{\rho^E - 1}{\rho^E}\right) + \frac{\dot{\rho}^E}{\rho^E}$$

(18) $$w^E = \bar{w} + r\mu - \dot{\mu}\,.$$

Since μ<0 and $\dot{\mu} > 0$, wage differentials are consistent with a persistent wage gap across regions over time ($w^E < \overline{w}$). Similarly, $q^E > 1$, $\dot{q}^E < 0$ and $\rho^E > 1$, $\dot{\rho}^E < 0$ along the adjustment path, so $R_K^E > \overline{R}_K$ and $R_K^E > \overline{R}_K$. These theoretical results can thus reconcile finite rates of factor movements with persistently low wages and high rates of return in eastern Germany.

With some mildly heroic assumptions, the model can also be used for back-of-the-envelope calculations of adjustment costs as well as shadow values associated with the three state variables consistent with recent historical experience. More concretely, it is possible to perform a rough calibration of the model for an assumed convergence path consistent with Eastern Germany in the years following unification; using assumed values for other, less controversial parameters, one can back out the adjustment costs implied by that episode.

As an example, assume that the shadow value of migration at t=0 is given by (13) integrated forward plus an appropriate transversality condition. Further assume that the wage equals marginal product in both regions, and that convergence occurs at constant average rate λ over time.[8] The historical record of Eastern Germany in the 1990s yields values of r=0.03 and λ=0.07 (the latter is roughly the observed rate of subsequent wage convergence). Measuring the eastern wage in units of the western equivalent, $w^E{}_{1991}$= 0.50. It follows that μ= -5, i.e., in 1991, i.e., the value of moving a worker from the East to the West in 1991 was roughly 500% of the annual western wage. In the command optimum as well as a competitive decentralized equilibrium, this is the marginal cost of migration. According to the Germany Federal Statistical Office, net migration to Eastern

---

[8]With initial and terminal conditions w_0 and $\bar{w}$, this approximation implies $w_s^E = w_0^E e^{-\lambda s} + \overline{w}(1 - e^{-\lambda s})$, or $w_s^E - \overline{w} = \left(w_0^E - \overline{w}\right)e^{-\lambda s}$ for s≥0 In fact, the model's true adjustment speed will vary depending on the distance from the steady state, since both stable eigenvalues jointly determine the model's persistence.

Germany was roughly -165,000 in 1991.[9] Now use the migration function (7) plus the observed net East-West migration in that year to back out the value of ϕ consistent with that migration flow, 5/165000, or 0.00303% of the annual western wage per person-squared. Put in perspective, by 2004, w^E=0.75, so the wage gap had declined to 25%, implying a shadow value of the marginal migrant of 2.5, or 250% of the western wage. With the 1991 estimate I have chosen for ϕ, the model predicts migration to equal 2.5/(0.0000303)=82,500, compared with the average of 72,000 over the period 2000-2004 (in fact, net migration had declined to 49,000 by 2005).

With additional assumptions, the model could be used to impute a shadow value to installed equipment and structures in eastern Germany, as well as to back out estimates of the investment adjustment cost parameters ψ_I and ψ_J. Unfortunately, independent information on the marginal return to capital in the East is unavailable. In addition, extreme heterogeneity of capital goods and projects renders the average return to capital a poor indicator of the marginal return, which is the decisive measure. Finally, tax treatment of investment was highly distorted over the period (Sinn 1992). Future work will incorporate tracking the rate of return on capital in the East more closely over time.

5. Conclusion

The title of this paper presents eastern Germany as a puzzle. The region was clearly hit by a shock, but hardly by a conventional productivity shock seen in real business cycle models which move total factor productivity, capital and labor together. In the German unification episode, as is the case with other integration episodes observed in Central and

[9] Source: Statistisches Bundesamt, „Abwanderung von Ost- nach Westdeutschland schwächt sich weiter ab“, Pressemitteilung vom 28. September 2005.

Eastern Europe, production factors move in opposite directions, even as output is rising. At the outset of post-unification period, Eastern Germany had been isolated from world trade and was burdened with an outdated capital stock and uncompetitive output structure (Akerlof et al., 1991). The observed path of adjustment has generally involved moving labor away from the East while bringing capital into the region at the same time. This is precisely what has been observed over the past fifteen years. This paper has taken this observation as a starting point, characterizing real regional integration as a mobility race between factors of production, which is decided by costs of moving them, even if these costs are irrelevant for the long run.

It is important to stress that there is no role for policy under conditions considered in this paper. If externalities were to arise from migration and are not reflected in market incentives, an investment subsidy in the East could be rationalized – as could a bribe for workers to stay in the East. This would have to be worked out formally, since it is not a direct implication of the current model. Steady-state production has constant returns to scale, and agglomeration effects are excluded *a priori*.

Central to my analysis are adjustment costs of moving factors across regions. While much attention has been paid to agglomeration effects, adjustment costs associated with moving factors of production across space have been neglected in the formal study of economic integration.[10] If these costs are relevant at all, they must be so for the massive redeployment of labor and capital associated with the reconstruction of Germany. Unlike the economic integration of US, Canada and Mexico or the EU, German reunification also involves significant redeployment of labor, as well as capital mobility and international trade. Barriers related to language, institutions, and culture in

---

[10] See Peter Neary (2001).

unified Germany are negligible; convergence of behavior in the past 15 years has been so significant that one can really speak of a common representative agent.[11]

This paper has abstracted from a number of important dimensions of the German reunification episode. The assumption of perfectly competitive product and labor markets is clearly violated. Despite the convergence of labor supply behavior implied by Table 1, the fact that unemployment is higher in the East suggests that labor markets are not functioning properly – not enough jobs have been created at current wages, wages are not set at market-clearing levels, or labor and product market rigidities prevent adjustment.[12] In addition, adjustment costs of moving factors within regions across sectors are bound to be significant, and probably increased by labor market policies such as unemployment insurance and job protection. A model with search and unemployment is likely to introduce a second brake on the integration process as declining industries fail to free up sufficient labor and capital for growing sectors.[13] Despite these abstractions, the model gives an opportunity to study German integration through the lens of a particular vision of economic integration which stresses migration and capital flows in determining the efficient speed of the process. It also gives clear justification for finite rates of migration and investment observed in practice, despite substantial differentials in observed factor prices during the adjustment process.

[11] Recent research by Burda and Hunt (2001), Fuchs-Schuendeln (2004), and Dohmen et al. (2005) suggest convergence in the behavior of eastern and western Germans over time.
[12] See for example Merkel and Snower (2006) and Fuch-Schündeln (2006).
[13] Rogerson (2005) has applied this type of analysis to the phenomenon of structural change. .

References

Abel, Andrew (2001) "On the Invariance of the Rate of Return to Convex Adjustment Costs" *Review of Economic Dynamics* 5: 586-601

_______ and Olivier Blanchard (1983) "An Intertemporal Model of Savings and Investment" *Econometrica* 51: 672-692.

Akerlof, George, Janet Yellen, Andrew Rose and Helen Hessenius (1991) "East Germany In From the Cold: The Economic Aftermath of Currency Union," *Brookings Papers on Economic Activity*, 1991:1.

Bachmann, Robert and Michael C. Burda (2006) "Sectoral Transformation, Turbulence, and Labor Market Dynamics in Germany," SFB Discussion paper December 2006.

Barro, Robert (1991) "Eastern Germany's Long Haul," *The Wall Street Journal* May 3, 1991.

Barro, Robert and Xavier Sala-i-Martin (1990) *Brookings Papers on Economic Activity*, 1991:1.

Barro, Robert and Xavier Sala-i-Martin (1995) *Economic Growth* New York: McGraw-Hill.

Burda, Michael (2006) "Factor Reallocation in Eastern Germany after Reunification," *American Economic Review* 96: 368-374.

Burda, Michael and Jennifer Hunt (2001) "From Reunification to Economic Integration: Productivity and the Labor Market in East Germany" *Brookings Papers on Economic Activity 2:* 2001, 1-71.

Dohmen, Thomas, Armin Falk, David Huffman, Jürgen Schupp, Uwe Sunde, and Gert Wagner (2005) "Individual Risk Attitudes: New Evidence from a Large, Representative, Experimentally-Validated Survey" DIW Discussion Paper 511, September.

Eichengreen, Barry (1990) "One Money for Europe: Lessons from the U.S. Currency Union," *Economic Policy* 10: 117–87.

Fuchs-Schuendeln, Nicola (2005) "Adjustment to a Large Shock - Do Households Smooth Low Frequency Consumption?" mimeo, Harvard University.

Kim, Su Jin (2006) "Inter- and Intra-Industry Shifts in the Aftermath of German (Re)unification." Masters Thesis, Humboldt-Universität zu Berlin, December.

Lucas, Robert E. Jr. (1967) "Optimal Investment with Rational Expectations", in R. Lucas and T. Sargent (eds.) *Rational Expectations and Econometric Practice* Volume 1, 55-66.

Merkl, Christian and Dennis Snower (2006) "The Caring Hand that Cripples: The East German Labor Market after Reunification" *American Economic Review* 96:275-382.

Neary, J. Peter (2001) "Of Hype and Hyperbolas: Introducing the New Economic Geography," *Journal of Economic Literature*, pp.536-561

Rogerson, Richard (2005). "Sectoral Shocks, Human Capital and Displaced Workers", *Review of Economic Dynamics*, 8:89-105.

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

Sinn, Hans-Werner, and Gerlinde Sinn (1992) *Jumpstart* Cambridge, USA: MIT Press.

Uhlig, Harald (2006) "Regional Labor Markets, Network Externalities and Migration: The Case of German Reunification,"*American Economic Review* 96:383-385.

Table 1. East German Convergence, 1991-2005 (% of West German value)

Year	Consumption	Nominal Wages	Labor Productivity	GDP per capita	Unemployment rate	Nonemployment rate	Participation rate
1991	74	50	44	49	170	103	137
1992	74	65	57	53	261	112	121
1993	76	71	67	60	240	111	111
1994	78	72	70	64	224	108	108
1995	81	74	71	66	206	106	108
1996	83	72	72	67	198	106	106
1997	82	76	72	67	206	106	107
1998	82	76	70	66	207	107	107
1999	83	76	71	66	211	107	106
2000	83	73	72	66	233	109	104
2001	83	74	72	65	248	110	102
2002	82	74	73	66	243	110	102
2003	83	75	73	67	236	110	101
2004	83	75	75	67	231	109	100
2005	na	74	79	69	211	116	103

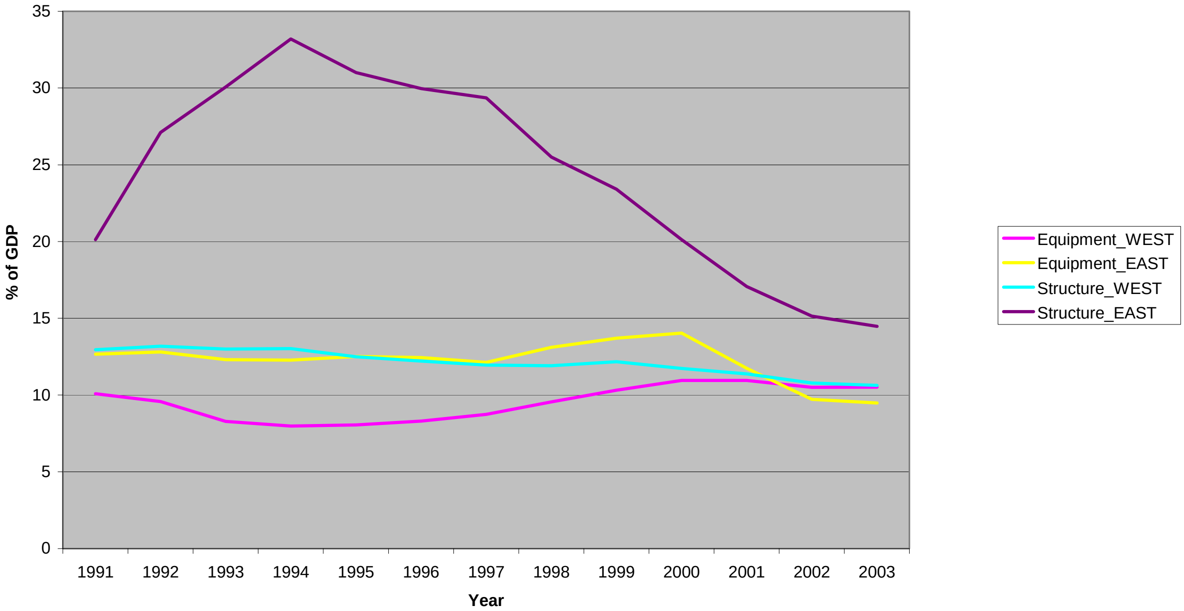
Source: Statistisches Bundesamt

Table 2. Capital formation in East and West, 1991-2004

	Investment rate (% of GDP)		*Annual investment per capita (EUR, 2000 prices)*		*Cumulative Investment (bill.EUR,2000 prices)*	
Region	*Equipment*	*Structures*	*Equipment*	*Structures*	*Equipment*	*Structures*
East	12.1	23.6	1807.1	3486.7	795.3	854.5
West	9.6	11.9	2236.2	2736.8	2016.4	2463.1

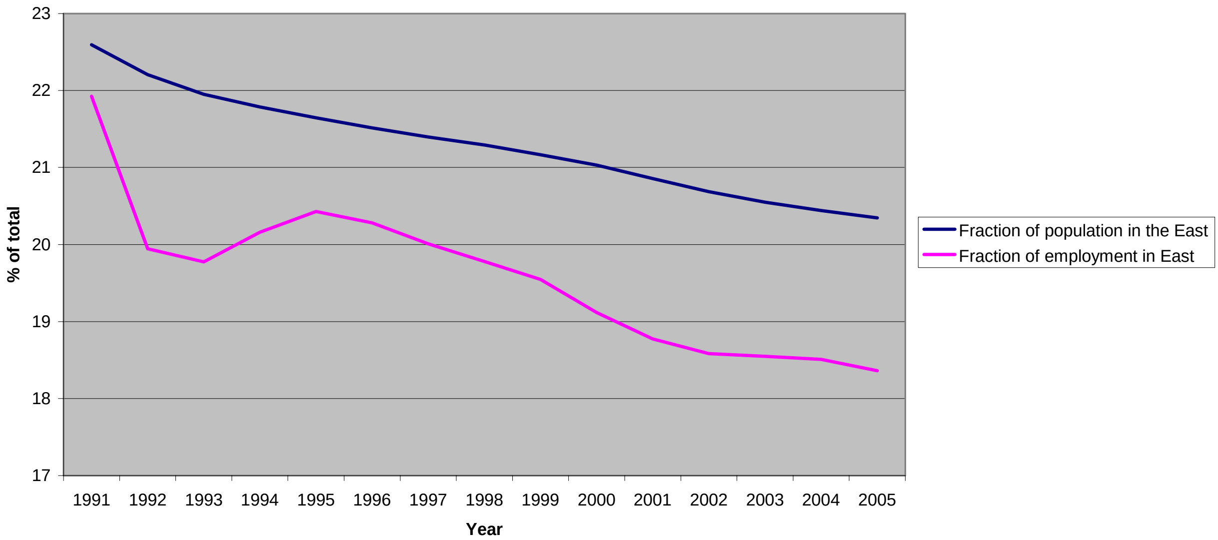
Source: Statistisches Bundesamt

Figure 1. Investment in East and West Germany



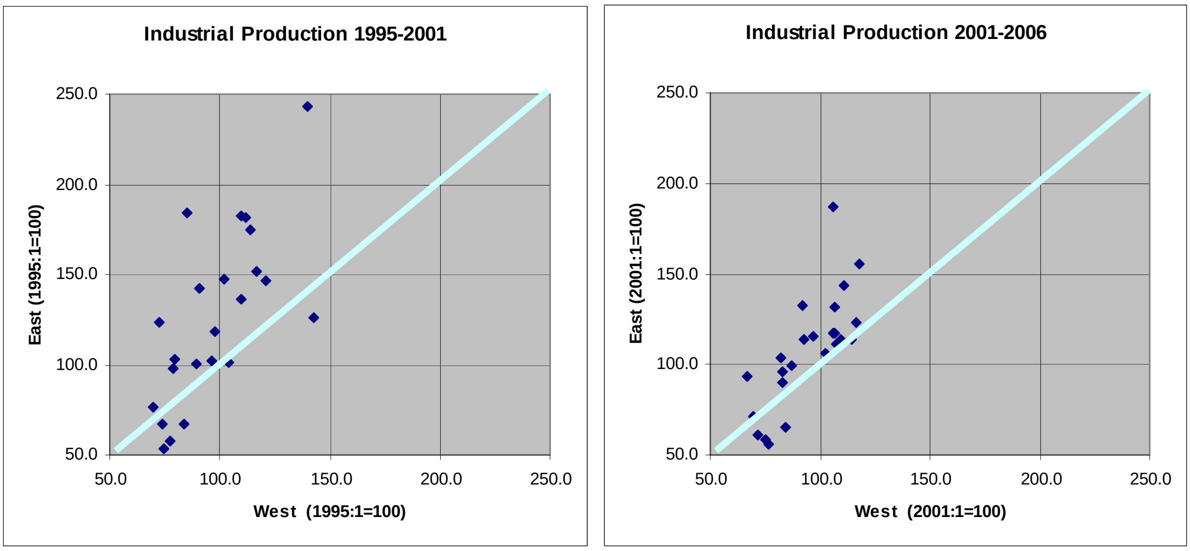
Source: Statistisches Bundesamt

Figure 2. German Employment and Population in East



Source: Statistisches Bundesamt

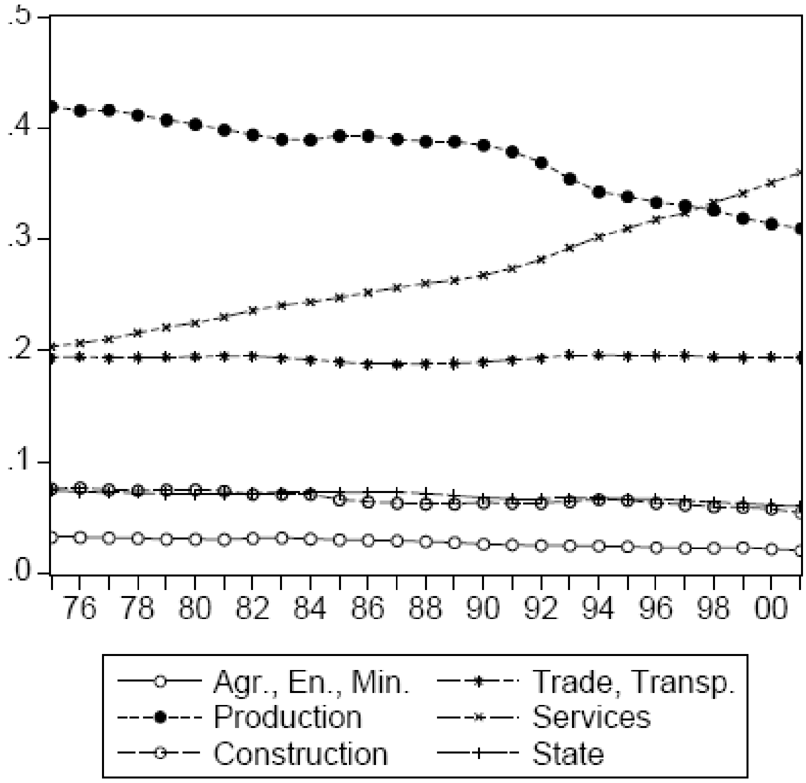
Figure 3. East-West Shifts in Industrial Production, 1995-2006



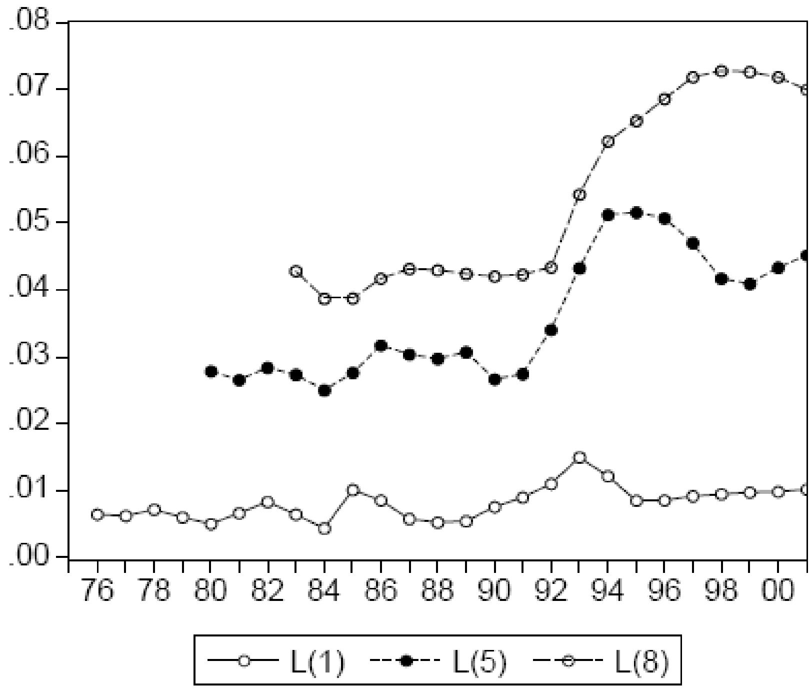
Note: Each point corresponds to one of the following industrial sectors: energy production; mining and quarrying; coal mining, peat, oil and gas production; food processing and tobacco; textiles and clothing; leather; wood products excluding furniture; paper and printing; coke and oil refining; chemical manufactures; rubber and plastic products; glass, ceramics and processing of stone; metal production and processing; machinery and machine tools; office equipment, data processing and electronics; automotive and automobile production; furniture, jewelry and musical instruments; energy and water provision, building construction; civil engineering/public works.
Source: Statistisches Bundesamt

Figure 4. Indicators of Structural Change in West

Sectoral fraction of socially insured employment



Lillien index of employment growth turbulence at different lags



Source: Bachmann and Burda (2006)