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GERMAN REUNIFICATION: LESSONS AND LEGACY†

Factor Reallocation in Eastern Germany after Reunification

By Michael C. Burda*

Fifteen years after reunification, the economy of the former East Germany is on the mend. Industrial production excluding construction has expanded by more than 60 percent since 1995 and by 28 percent since 2000, compared with only about 4 percent in West Germany, for the latter period. Real GDP has grown 3.5 percent per year since 1991 and 8.2 percent annually in the manufacturing industry alone. More than half of the measured labor productivity gap and more than a third of the GDP per capita gap between East and West have been closed, in considerably less time than predicted by Robert J. Barro (1991). As Table 1 shows, convergence has been impressive on a wide array of indicators, although it has slowed in recent years and remains most difficult in the labor market.

Despite this positive news, net migration continues from East to West—about 70,000, or 0.5 percent of the population, per annum since 2000, especially concentrated among 18- to 25-year-olds. At the same time, new physical capital continues to flow into the East—80 to 90 billion euros, or about 20 percent of GDP each year. The reallocation of production factors is one of the most impressive aspects of German unification. Since 1991, more than 1.2 trillion euros of new investment (in 1995 prices) was spent in the East, yet the workforce of East Germany shrank by roughly 1.2 million, or 15 percent, over the same period; employment rose in the West by 4.1 percent. As Figure 1 shows, the intensity of factor movement was not constant, but rather high at first, and declining into the 1990s. Migration was greatest in the early 1990s, falling until mid-decade, rising again until 2001, and declining since. In addition, a large fraction (two-thirds) of the cumulated investment flow in Eastern Germany was dedicated to residential and business structures, compared with about one-third in business equipment. The large runup in investment spending on structures is often blamed on distorted investment incentives, with possible longer-run consequences for the structure of output and factor demands (Hans-Werner Sinn and Gerlinde Sinn, 1992).

This intensive movement of production factors in opposite directions is difficult to explain as a reaction to disturbances in technology, preferences, or demand. To use Horst Siebert's (1992) terminology, Germany was hit by a massive integration shock.† I offer the following definition of economic integration: the achievement of the efficient production pattern by two or more geographic regions made possible by their union, measured at world market prices.‡ The German integration episode presents a unique opportunity to study this form of economic integration and the roles of the relative importance of adjustment costs in determin-

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† Several mechanisms are associated with economic integration: internal accumulation of production factors in the poorer region, labor mobility from the capital-poor to the capital-rich region, capital mobility to the capital-poor region, Heckscher–Ohlin trade between incompletely specialized regions, and technology transfer. In the following, I focus exclusively on factor mobility.

‡ See Barry Eichengreen (1990).
ing the speed of efficient economic integration, as well as the interpretation of regional factor price differentials in the process of dynamic adjustment to a new steady state. The episode can serve as a foil for other integration episodes, such as the European Monetary Union or the recent wave of European Union accessions.

I. Elements of a Formal Model of Factor Mobility and Regional Integration

A. Model Setup

Two regions, East (E) and West (W), produce output \( Y_t \) at time \( t \), employing the same neoclassical constant returns production function, \( Y_t = F(K_t, G_t, L_t) \), with standard properties.\(^3\) Factor inputs consist of two types of capital—equipment \( (K) \) employed in production and structures \( (G) \), both used to shelter enterprises and households—and labor \( (L) \). Both types of capital are internationally mobile and depreciate at rates \( \delta_K \) and \( \delta_G \), respectively, with \( \delta_K > \delta_G \). The world rate of interest is exogenously given at \( r \). In contrast, labor mobility is possible only between the two regions, and with total supply normalized to 1. The population of the East is denoted by \( L^E \), so under full employment

\(^3\) That is, \( F_K > 0, F_G > 0, F_L > 0, F_{KK} < 0, F_{GG} < 0, F_{LL} < 0, \) and \( \det(D^F) = 0 \). I also assume that \( F_0 > 0 \ \forall i \neq j. \)
assumptions $L^W = 1 - L^E$. The model is deterministic, and economic growth is suppressed.

Let $f(k, g) = F(K, G, L)/L$ be the intensive form of $F$ with per capita inputs $k = K/L$ and $g = G/L$. With identical technologies in both regions, static efficiency in regional factor endowments is achieved along the grand diagonal of a three-dimensional Edgeworth box, with dimensions $1, k^*, g^*$, where $(k^*, g^*)$ is the solution to $f_k(k, g) = R_K = r + \delta_K$ and $f_g(k, g) = R_G = r + \delta_G$. All points on that diagonal are efficient in the sense that the marginal product of capital equals the world interest rate plus depreciation; the common real wage can be read off the factor price frontier (the residual output after capital is paid its gross marginal product in competitive factor markets). The multiplicity of these allocations hints that an output- or welfare-maximizing trajectory for the economy will be determined by factor adjustment costs required to reach the steady state. Capital adjustment costs for both types of capital are assumed to be external and convex in the net change of the capital stock. I also assume convex costs of migration. In particular, these costs are borne fully by migrants (there are no externalities). Quadratic forms are chosen for tractability.

B. Social Planner’s Problem

Because the economy I consider fulfills the conditions for the first and second welfare theorems, a decentralized, competitive market equilibrium can replicate the migration and investment policies in the East and West chosen by a hypothetical social planner who maximizes the present discounted value of national output (net of migration and investment costs). I seek functions of time, $t \in [0, \infty)$, governing investment in equipment ($I^W_t$ and $I^E_t$) and in structures ($J^W_t$ and $J^E_t$) in the West and East, respectively, as well as net migration from West to East ($X_t$) to make

\[ (1) \quad \int_0^\infty e^{-\gamma t} \left[ F(K^W_t, G^W_t, L^W_t) - I^W_t - J^W_t ight. \\
\left. + F(K^E_t, G^E_t, L^E_t) - I^E_t - J^E_t - \frac{\psi_I}{2} (\bar{f} - \delta_K K)^2 \\
- \frac{\psi_J}{2} (\bar{f} - \delta_G G)^2 - \frac{\phi}{2} X^2 \right] dt \]

as large as possible, subject to initial conditions (at $t = 0$) on factor supplies in both regions. Gross and net migration flows are thus equal; negative values of $X$ imply net migration from West to East. The positive parameters $\psi_I$, $\psi_J$, and $\phi$ capture the intensity of adjustment costs. Labor and capital stocks obey the following equations of motion:

\[ (2) \quad \ddot{K}_t = \dot{I}_t - \delta K_t^2 \quad \text{for } i = E, W \]
\[ (3) \quad \ddot{G}_t = \dot{J}_t - \delta G_t^2 \quad \text{for } i = E, W \]
\[ (4) \quad \dot{L}_t^E = -L_t^W = X_t. \]

By assuming that adjustment of Western capital stocks is costless, I shift emphasis to relative adjustment costs in the East. These reflect bureaucracy and regulation, conflict over property rights, and the quality of business-related public infrastructure.

C. Planner’s Optimum as Market Equilibrium

Define $q^E$, $\rho^E$, and $\mu$ as the costate variables corresponding to the constraints (2), (3), and (4). 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 optimal policy are, for all $t \geq 0$:

\[ (5) \quad I^E_t = (q^E_t - 1)/\psi_I + \delta_K K^E_t \]
\[ (6) \quad J^E_t = (\rho^E_t - 1)/\psi_J + \delta_G G^E_t \]
\[ (7) \quad X = \mu/\phi \]
\[ (8) \quad q^W = 1 \]
\[ F^w_k = r + \delta_k = \bar{R}_k \]  
\[ F^w_G = r + \delta_G = \bar{R}_G \]  
\[ q^E + F^E_k \delta_k \psi_j k^E = (r + \delta_k) q^E \]  
\[ \rho^E + F^E_G \delta_G \psi_j G^E = (r + \delta_G) \rho^E \]  
\[ \mu + (F^E_L - F^w_L) = r \mu, \]

as well as the equations of motion (2), (3), and (4). Equations (5), (6), and (7) relate optimal investment in the East and migration to the East as positive and linear functions of their respective shadow prices, which are sufficient statistics for determining these activities. The greater the associated adjustment costs, the lower the respective investment rates, *ceteris paribus*. Equations (8) and (9) represent outcomes 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 with the same level of capital used by other Western residents, and earn the Western wage \( \tilde{w} = F^w_L \).

By assumption, the three-state variables in the model \( K^E, C^E \), and \( L^E \) cannot be changed instantaneously; the costate variables \( q, \rho \), and \( \mu \) represent the marginal gain of moving them to the East, given the economy is on the optimal adjustment path. Equations (11), (12), and (13) are arbitrage relations governing these shadow values. When integrated forward from initial values at \( t \), with appropriate transversality conditions, \( q^E \) and \( \rho^E \) reflect the present discounted value of present and future marginal products of an additional unit of capital installed in the East. Similarly, the shadow value of a worker in the East, \( \mu \), represents the present value of the difference in future marginal products of labor between the East and West. Given the initial conditions \( k_0^w > k_0^E \) and \( g_0^w > g_0^E \), \( \mu \) is negative. The model implies a persistent wage gap between East and West which disappears asymptotically as capital accumulates in the East and labor migrates to the West.

### III. Steady State and Dynamics

#### A. Steady State

The economy's steady state is given by constancy of \( K^E, C^E \), and \( L^E \), so \( q^E = \rho^E = 1, F^E_k = \bar{R}^E, F^E_G = \bar{R}^G \), and \( \mu = 0 \iff F^E_L = F^w_L = \tilde{w} \). The dynamic properties of the linearized model are encoded in the eigenvalues \( \{ \lambda_1, ..., \lambda_6 \} \) of the \( 6 \times 6 \) matrix relating changes in the endogenous variables \( (q^E, \rho^E, \phi, K^E, G^E, L^E) \) to deviations from steady-state values:

\[
\{ \lambda_1, ..., \lambda_6 \} = \begin{pmatrix}
0, r, \frac{1}{2} \left[ r + \sqrt{r^2 + 2(A - \sqrt{A^2 - 4B})} \right], \\
\frac{1}{2} \left[ r - \sqrt{r^2 + 2(A + \sqrt{A^2 - 4B})} \right], \\
\frac{1}{2} \left[ r + \sqrt{r^2 + 2(A + \sqrt{A^2 - 4B})} \right], \\
\frac{1}{2} \left[ r - \sqrt{r^2 + 2(A - \sqrt{A^2 - 4B})} \right], \\
\end{pmatrix}
\]

where \( A = -(\psi_l^{-1}F^E_{kk} + \psi_j^{-1}F^E_{gg} + \phi^{-1}F^E_{ll}) > 0 \) and

\[
B = \psi_j^{-1} \phi^{-1} \left( F^E_{gg} F^E_{ll} - (F^E_{gl})^2 \right) + \psi_j^{-1} \psi_l^{-1} \left( F^E_{kk} F^E_{gg} - (F^E_{kg})^2 \right) + \psi_l^{-1} \phi^{-1} \left( F^E_{kk} F^E_{ll} - (F^E_{kl})^2 \right) > 0.
\]

For \( A^2 - 4B \geq 0 \), the model has meaningful solutions. By inspection, all eigenvalues are real-valued; three \( (\lambda_2, \lambda_3, \lambda_4) \) are always greater than zero, while two \( (\lambda_5, \lambda_6) \) are negative. This corresponds to a typical perfect foresight model with saddle-path stability, plus the important novelty of a zero root, implying hysteresis (path dependence). Initial conditions of Eastern factor supplies \( K^E, G^E, \) and \( L^E \), as well as the constellation of adjustment costs and other parameters, determine the system’s steady state. In a stochastic version of this model,
temporary disturbances to initial factor allocations, such as migration or privatization policies, could have permanent effects on the region’s steady-state size.\footnote{Blanchard and Lawrence F. Katz (1991) obtain a similar result in a model of regional unemployment in which mobile labor is the sole production factor.}

B. The Central Role of Adjustment Costs

The results of the last section establish 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 correctly anticipated future paths of their shadow prices relative to their costs of adjustment. Inspection reveals that the two stable (negative) roots are increasing in the adjustment cost parameters $\psi_\ell$, $\psi_p$, and $\varphi$, so the adjustment speed or persistence of the model is determined by the largest negative eigenvalue, which is increasing in adjustment costs. In addition, adjustment costs enter multiplicatively and, thus, amplify each other’s effect on persistence. Local concavity of the production function, in contrast, accelerates adjustment.

C. 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 Western levels for some time. Throughout this period, wages will be lower and return on capital will be higher. Persistent factor price differentials are consistent with finite factor flows over time, disappearing only in the long run. With competitive factor remuneration, (11), (12), and (13) can be rewritten as

\begin{align}
R_E^E &= \tilde{R}_K + \delta_K \left( \frac{q^E - 1}{q^E} \right) + \frac{q^E}{q^E} \\
R_E^G &= \tilde{R}_G + \delta_G \left( \frac{\rho^E - 1}{\rho^E} \right) + \frac{\rho^E}{\rho^E}
\end{align}

Since $\mu < 0$ and $\tilde{\mu} > 0$, wage differentials are consistent with a persistent wage gap across regions over time ($w^E < \tilde{w}$). Similarly, $q^E > 1$, $\rho^E < 0$, and $\rho^E > 1; \rho^E < 0$ along the adjustment path, so $R_E^E > \tilde{R}_K$ and $R_E^G > \tilde{R}_G$. These theoretical results can thus reconcile finite rates of factor movements with persistently lower wages and higher rates of return in Eastern Germany.

The model lends itself to back-of-the-envelope calculations of adjustment costs as well as shadow values consistent with recent historical experience. Suppose, for example, that $r = 0.03$ and the average rate of wage convergence is $\lambda$ over some time period; the historical record of Eastern Germany since 1991 suggests $\lambda = 0.07$.\footnote{With initial condition and steady state $w_0$ and $\tilde{w}$ respectively, this approximation implies $w^E = w_0 e^{-\lambda s} + \tilde{w} (1 - e^{-\lambda s})$, or $w^E - \tilde{w} = (w_0 - \tilde{w}) e^{-\lambda s}$ for $s \geq 0$. The model’s true adjustment speed will vary over time, since both stable eigenvalues jointly determine persistence. For more precise details on calibrations and implied dynamics, see my working paper (Burda, 2006).} Measuring the Eastern wage in units of the Western equivalent, $w^E_1991 = 0.50$. It follows that $\mu_{1991} = -5$, i.e., the implied value of moving a worker from the East to the West was 500 percent of the annual Western wage in 1991. According to the German Federal Statistical Office, net migration to Eastern Germany was $-165,000$ in 1991.\footnote{Source: Statistisches Bundesamt, “Abwanderung von Ostnach Westdeutschland schwächt sich weiter ab,” press release, September 28, 2005.} Using (7) plus the observed net East–West migration in that year, I can compute the value of $\phi$ consistent with that migration flow, $5/165,000$, or 0.00303 percent of the annual Western wage per person squared. Put in perspective, by 2004, $w^E = 0.75$, so the wage gap had declined to 0.25, implying a shadow value of the marginal migrant of 2.5, or 250 percent, of the Western wage. Using this estimate of $\phi$, the model predicts annual migration of $2.5/(0.0000303) = 82,500$, compared with the average of 72,000 over the period 2000–2004 (in fact, net migration in 2004 had declined to $-52,000$). Net migration cumulates to about 1.7 million, or 10
percent, of the initial Eastern German population. In a more pessimistic scenario with λ = 0.02, the region would lose roughly 3.5 million inhabitants.

IV. Conclusion

One of the distinctive aspects of the reunification episode has been a significant reallocation of factors of production. German economic integration has been a puzzle, with production factors moving in opposite directions, even as output is rising. Real regional integration is a macroeconomic process, which may be sufficiently unique to merit special attention. I characterize regional integration as a mobility race between factors of production, which is decided by costs of moving them, even if these costs are not relevant in the long run.10 Steady-state production has constant returns to scale, and agglomeration effects are excluded a priori. Central to the analysis are adjustment costs. While much attention has been paid to agglomeration effects, adjustment costs associated with moving factors of production across space have generally been neglected in the formal study of economic integration.11 If at all relevant, these costs must be important for the massive redeployment of labor and capital associated with the reconstruction of Germany. Unlike the economic integration of the United States, Canada, and Mexico, or the European Union, German reunification also involves significant labor mobility in addition to capital mobility and international trade. Barriers related to language, institutions, and culture in 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.12 Yet even under these ideal conditions, factor price convergence has been incomplete.

Clearly, there is much more to the reunification episode than factor mobility. The assumption of perfectly competitive factor markets is grossly violated. Table 1 suggests a convergence of labor supply behavior, with East German labor force participation falling from nearly 90 percent in the early 1990s and the West German rate rising from under 50 percent to converge to an almost identical value of 60 percent in the early 2000s. The fact that unemployment is higher in the East, despite almost identical participation rates with the West, 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. Yet one can concede the importance of all these aspects, and still learn a great deal by abstracting from them—especially when what is left is sufficiently interesting.

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