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Reversal of Migration Flows: A Fresh Look at the German Reunification

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Reversal of Migration Flows: A Fresh Look at the German Reunification*

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September 14, 2016

Abstract

We investigate the dynamic effects of interregional labor market integration on migration flows, capital formation, and the price for housing services. The co-evolution of these variables depends on initial conditions at the time of labor market integration. In an initially capital-poor economy, there may be a reversal of migration flows during the transition to the steady state, while housing costs are increasing over time. Although capital may accumulate while labor emigrates early in the transition, the causal effect of immigration on capital investments and housing costs is positive. We present new data on the evolution of net migration flows and rental rates for housing in East Germany after 1990. Our results are consistent with the presented evidence in the reverse migration scenario.

Key words: Capital formation; German reunification; Housing services; Labor market integration; Reverse migration.

JEL classification: D90, F20, O10.

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“Today, the decision was taken that makes it possible for all citizens to leave the country through East German border crossing points. [...] As far as I know - effective immediately, without delay.”¹

1 Introduction

The fall of the Berlin Wall in November of 1989 can be viewed as a quasi-natural experiment of the effects of interregional labor market integration. From one day to the next, literally overnight, East German citizens had the opportunity to move to West Germany (and vice versa), after the sudden removal of all institutional migration barriers. To begin with, there were no language barriers. Moreover, there were plenty of family ties that made migration costs, other than costs associated with finding a new shelter, almost negligible. In other words, we have seen a historically unique case of an exogenous integration shock from fully closed to fully open borders.

This paper examines the dynamic effects of interregional labor market integration on migration patterns, private investment, wages, and the price for housing services. In particular, we take up the challenge to explain the mechanics of the remarkable migration pattern in East Germany for the period 1991-2014. This period is characterized by a “reversal of migration flows”, i.e. prolonged net outward migration followed by net inward migration later on. Fig. 1 shows the net migration flows for East Germany (“New Laender”), excluding Berlin. To smooth out business cycle fluctuations, we take five-year annual averages for the periods 1991-1995, 1996-2000, 2001-2005 and 2006-2010 as well as the four-year annual average for the period 2011-14. According to Fig. 1, there was a massive outflow in the 1990s and 2000s for East Germany as a whole.² The outflow was larger for the 1990s when leaving out the state of Brandenburg that is special in the following sense. Many workers of Berlin-based firms are commuting

¹Guenther Schabowski (First Secretary of the East Berlin chapter of the Socialist Unity Party - SED - in the former German Democratic Republic - GDR - and a member of the SED Politbuero), November 9, 1989. Translated from German.

²Burda (2006) also documents for the 1990s labor outflows from East Germany that were directed to West Germany.

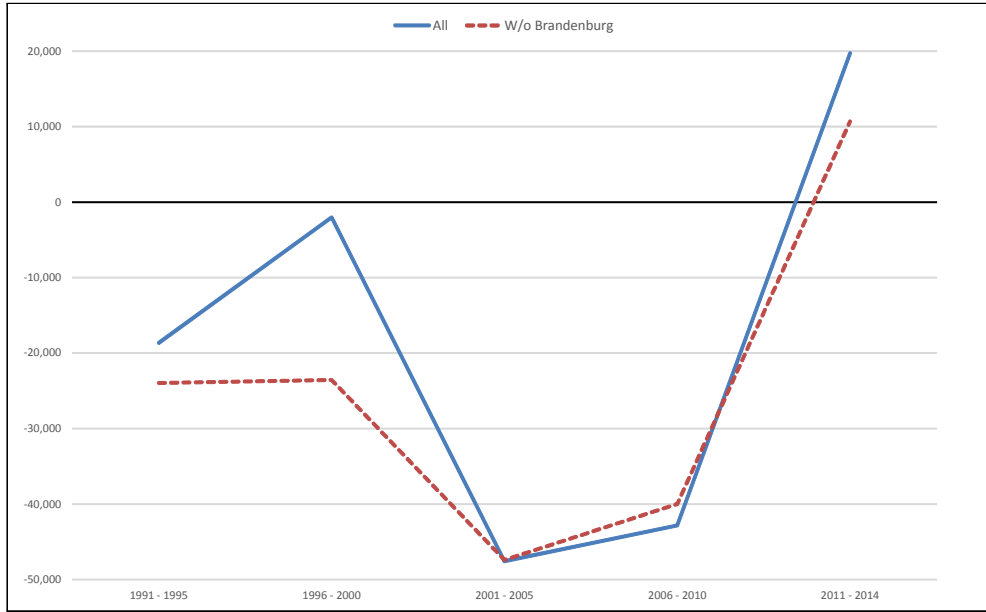


Figure 1: Net migration flows (annual averages) to the New Laender (Brandenburg, Mecklenburg-Western Pomerania, Saxony-Anhalt, Saxony, and Thuringia), 1991-2014. Data: See Online Appendix.

to work from Brandenburg that surrounds the city of Berlin (partly having belonged to West Germany).³ The migration pattern in the New Laender has reversed to net inflows after 2011. As displayed in Figure 2, the reversal of migration flows is particularly apparent for cities with more than 100,000 inhabitants. It has started already in the 2000s, with the largest inflows to the two largest cities, Dresden and Leipzig. More recently there have been positive net inflows to all East German cities.

To explain such a migration pattern, we develop a neoclassical, overlapping generations model with a tradable goods sector and a housing sector. The housing sector combines land and residential structures, that is accumulated through construction activities, to produce housing services.⁴ Firms in the tradable goods sector face capital adjustment costs to install new physical capital. We study the effects of implementing

³Associated with Berlin having become an economic and political center soon after the German reunification, Brandenburg experienced net immigration in the mid 1990s.

⁴This borrows from the business-cycle literature on housing and macroeconomics (Davis and Heathcote, 2005; Hornstein, 2008, 2009; and Favilukis et al., 2015). Chambers et al. (2009a, 2009b) employ an OLG model with housing and mortgage markets, excluding the fixed factor land, to explain the evolution in homeownership rates. Grossmann and Steger (2016) develop a long-term macroeconomic model. Piazzesi and Schneider (2016) provide an excellent survey.

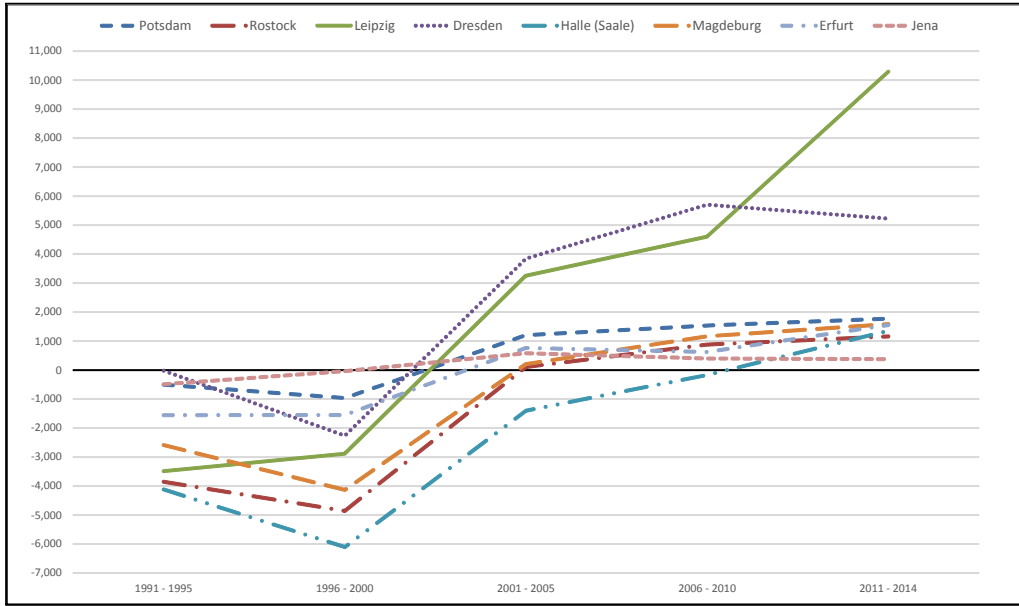


Figure 2: Net migration flows (annual averages) to cities with more than 100,000 inhabitants in the New Laender, 1991-2014. Data: See Online Appendix.

free interregional labor movement, conditional on initial differences (across regions) in the two capital stocks (physical capital and residential structures) and on initial differences in productivity levels. These interregional differences drive migration decisions by determining differences in both wage rates and the price for housing services across regions.

Our analysis suggests a causally positive (negative) effect of immigration (emigration) on capital accumulation. Nevertheless, interregional flows of labor and regional changes in capital stocks may transitorily evolve in opposite directions.⁵ We demonstrate how initial conditions and the time that has elapsed after labor market integration determine how migration flows are related to the evolutions of capital stocks and housing costs over time. In particular, we show that in the case of low initial productivity levels and / or low initial capital stocks, such as in East Germany vis-à-vis

⁵Historically, there are examples for labor and capital to flow in the same or in opposite directions. For instance, the Atlantic globalization in the 19th century was characterized by simultaneous capital and labor flows from Europe to the US (e.g. O'Rourke and Williamson, 1999; Solimano and Watts, 2005). Moreover, in response to the enlargement of the European Union (EU), labor was migrating from Southern and Eastern EU members to countries like Germany and the UK, while there were net capital inflows in some countries with net emigration.

West Germany at the time of the German reunification, a net outflow of migrants may occur, in an early transition phase, despite accumulation of capital stocks. In later phases, the migration pattern is reversed along with still positive net investments. Net investments in physical capital and structures are indeed positive if the neoclassical convergence force is sufficiently strong or if productivity levels increase over time (e.g. following technology transfers like those from the Old Laender to the New Laender). The price for housing services is increasing as the economy develops, reflecting the scarcity of land and the increase of wage rates over time.

Noteworthy, the suggested model can also explain, under alternative initial conditions, other migration patterns, such as continuous immigration or continuous emigration in response to labor market integration. For instance, consistent with our framework, there were massive net immigration flows to Switzerland (a high-productivity economy with a high capital-to-labor ratio) along with rising prices for housing services in the aftermath of the bilateral agreement with the European Union on the free movement of labor.⁶ We focus on the German case after 1989, however, because this historical episode was shaped by a unique experiment that allows us to better understand the dynamic general equilibrium mechanics of migration and capital accumulation in general and the reverse migration phenomenon in particular.

We also show that higher population density causally raises housing costs even in the long run, i.e. after housing supply fully adjusted to the increase in housing demand as a response to immigration. This finding is consistent with the evidence on causally positive effects of immigration on both the price for housing services and residential construction (e.g. Gonzalez and Ortega, 2013).⁷ The reason is that the production of

⁶The agreement was signed in 2002 and came into full effect (with respect to 17 EU countries, excluding Eastern Europe) in 2007. The case of Switzerland is discussed in detail in the working paper version of this paper (Grossmann, Schäfer and Steger, 2013).

⁷Gonzalez and Ortega (2013) employ Spanish regional data for the period 2001-2010 (characterized by an annual population growth rate of 1.5 percent). They instrument changes in population density by past migration stocks of the foreign-born population in a region. About half of the construction boom in the 2000s is attributed to immigration. Saiz (2003, 2007) and Nygaard (2011) find substantial effects of immigration on rental rates and sales prices for housing in the US and UK. Jeanty et al. (2010) estimate a two-equation spatial econometric model which captures the two-way interaction between net migration flows and the price for housing services. Employing data from the metropolitan area of Michigan, they find that a one percentage point increase in the rate of population growth leads to a

housing services is land-intensive and land is a fixed factor that becomes increasingly scarce in a growing economy. Thus, the price of housing services is closely related to the rental rate of land (Knoll, Schularick and Steger, 2016; Grossmann and Steger, 2016).

The main contribution of the paper is twofold. *First*, whereas a large literature on the dynamic effects of migration was confined to either the labor market or the housing market separately, we shift the focus to the interaction between housing costs and wage rates over time in determining migration patterns.⁸ We show that a reversal of migration patterns can be explained by the interaction between migration, capital investment, and construction activities. Standard neoclassical models cannot explain the reversal of migration flows.⁹ While our model shares the features of capital adjustment costs, exogenous interest rates and interregional labor mobility with the one-sector frameworks developed in Rappaport (2005) and Burda (2006), their focus is on wage convergence rather than on the reversal of migration flows.¹⁰ We show that the reversal of migration flows is generated by the dynamics of residential construction and the price for housing services that we additionally examine in our two-sector framework. Moreover, whereas non-monotonic time paths of a region's population size may occur in models with increasing returns to scale, our framework explains non-monotonic transitions despite constant returns to scale.¹¹ *Second*, the paper provides a

0.24 percent increase in housing costs.

⁸Important studies on wage effects of immigration include Friedberg (2001) for Israel, Dustmann, Fabbri, and Preston (2005) for the UK, and Borjas (2003) as well as Ottaviano and Peri (2012) for the US.

⁹Felbermayr, Grossmann and Kohler (2015) provide an extensive literature survey on the interaction between migration and capital formation.

¹⁰Rappaport (2005) argues that higher labor mobility that leads to an increased outflows of workers does not necessarily increase the speed of income convergence. For a given capital stock, emigration leads to increased wages in the source country. However, emigration also drives down the shadow value of capital and therefore slows down capital investment. The latter effect results in delayed income convergence. Burda (2006) studies the dynamics of labor migration and capital accumulation under factor adjustment costs. Per capita income of the East German economy fully converges to the West German level as labor moves towards West Germany and capital accumulates in the East Germany economy.

¹¹Faini (1996) contrasts models of exogenous and endogenous growth, arguing that income convergence is not necessarily less likely in the case of learning-by-doing effects. Reichlin and Rustichini (1998) employ an endogenous growth model with learning-by-doing effects to show that immigration enhances interregional wage differences due to a scale effect, benefitting the receiving destination.

new comprehensive data set for the New Laender in Germany at the regional (county and state) level on net migration flows and on the rental costs of housing services for the period after the German reunification until 2014. It is demonstrated that our results are qualitatively consistent with the presented evidence.

The paper is organized as follows. Section 2 presents the model. Section 3 provides analytical results for the long run equilibrium. In Section 4, we solve the model numerically for the transition path to the steady state in response to labor market integration. We demonstrate the model's potential to explain a reversal of migration flows and discuss the salient role of the housing sector for this outcome. Section 5 demonstrates that the suggested explanation for the reverse migration phenomenon is also consistent with the joint evolution of housing rental rates and wage rates in East Germany after 1990. The last section concludes.

2 The Model

Consider a simple neoclassical model economy with two sectors. The tradeable goods sector produces a final good (the "numeraire"). The non-tradable goods sector produces housing services by combining accumulable "structures" and a fixed amount of land. Labor can be reallocated across sectors without any frictions. There is international mobility of physical capital at an (exogenous) interest rate $r > 0$. Labor market integration allows individuals to move between two regions ("domestic" and "foreign"). We distinguish the cases of interregionally immobile and mobile labor, investigating the effects of labor market integration. Time is discrete and indexed by $t = 0, 1, 2, \dots$

Moreover, migration may change the skill composition of the workforce in a way which may also benefit the source economy. Schäfer and Steger (2014) emphasize how equilibrium selection and dynamics depend on both expectations and initial conditions in a multi-region model where increasing returns give rise to multiple equilibria.

2.1 Domestic Economy

2.1.1 Firms

There is a tradable goods sector producing a homogenous good, which is chosen as numeraire (i.e. output price $p^Y \equiv 1$). The production technology of the representative firm is given by

$$Y_t = A \cdot (L_t^Y)^\alpha (K_t)^{1-\alpha}, \quad (1)$$

$\alpha \in (0, 1)$, where L^Y denotes the amount of labor, K physical capital, and $A > 0$ total factor productivity (TFP) in the tradable goods sector.¹² Accumulating physical capital is subject to (convex) capital-adjustment costs (Abel, 1982; Hayashi, 1982). Let I^K denote the amount of the tradable good that is devoted to gross investment in the tradable goods sector. Taking the time path of the wage rate, w , as well as the (exogenous) interest rate, r , as given, the representative firm solves

$$\max_{\{L_t^Y, I_t^K\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \frac{A \cdot (L_t^Y)^\alpha (K_t)^{1-\alpha} - w_t L_t^Y - I_t^K \left[1 + \theta \left(\frac{I_t^K}{K_t} \right)^\eta \right]}{(1+r)^t} \quad (2)$$

$$\text{s.t. } K_{t+1} = I_t^K + (1 - \delta^K) K_t, \quad (3)$$

where $\delta^K > 0$ is the depreciation rate of physical capital and $K_0 > 0$ is given.

The non-tradable sector produces residential structures (a non-tradable stock) and housing services (a non-tradable flow). The representative construction firm combines labor, L^X , and materials (e.g. cement), M , to manufacture gross investment in structures, I^X , according to

$$I_t^X = B \cdot (L_t^X)^\beta (M_t)^{1-\beta}, \quad (4)$$

$\beta \in (0, 1)$, where $B > 0$ is TFP in the construction sector. Materials are produced from the tradable good on a one-by-one basis. The stock, X , depreciates at rate $\delta^X > 0$ and

¹²The time index t is often omitted, provided that this may not lead to confusion.

accumulates according to

$$X_{t+1} = I_t^X + (1 - \delta^X)X_t \quad (5)$$

$$= B \cdot (L_t^X)^\beta (M_t)^{1-\beta} + (1 - \delta^X)X_t, \quad (6)$$

where $X_0 > 0$ is given. The representative construction firm then solves

$$\max_{\{L_t^X, M_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \frac{p_t^X X_t - w_t L_t^X - M_t}{(1+r)^t} \quad \text{s.t. (6)}, \quad (7)$$

taking p^X , w , and r as given. The representative housing services firm produces a non-tradable consumption good by combining structures and a fixed (i.e., time-invariant) amount of land Z (which equals land supply), according to

$$H_t = (X_t)^\gamma Z^{1-\gamma}, \quad (8)$$

$\gamma \in (0, 1)$.¹³ Denote by p^H the price per unit of housing services, by p^X the rental rate per unit of structures, and by p^Z the rental rate of land. Each period t , the representative housing services firm solves

$$\max_{X_t, Z} (p_t^H (X_t)^\gamma Z^{1-\gamma} - p_t^X X_t - p_t^Z Z), \quad (9)$$

taking p^H , p^X , and p^Z as given.

2.1.2 Households

Each individual lives for two periods ("working-age" and "retirement") and has one child when old. In the first period, each individual supplies one unit of labor when young to the sector with the highest wage and chooses how much to save (or borrow). Moreover, individuals decide at the beginning of the first period whether to stay or to migrate to the large economy, seeking to maximize life-time utility. Our simple

¹³TFP in the housing services sector is set to unity. A higher B captures better technology in the housing sector as a whole.

overlapping-generations structure allows us to focus on one-shot migration decisions of workers. There may be (exogenous) institutional and social migration costs, denoted as $\Delta \geq 0$. We assume that a worker migrates if and only if the utility gain from migrating is equal to or higher than Δ . As will become apparent, even if $\Delta = 0$ (no exogenous migration costs) and despite persistent wage differentials, migration flows are limited via differences in the price of housing services across regions. Migration flows are therefore smoothed endogenously along with adjustments in the stocks of physical capital and residential structures.

The number of workers (i.e. the number of young individuals) in period t is denoted by L_t . Thus, total population size in period t is given by $L_t + L_{t-1}$. The number of initially old natives, $L_{-1} > 0$, is given. As each period the same number of individuals is born, $L_t = L_{-1}$ for all $t \geq 0$ if labor is not interregionally mobile. The population density is given by $D_t \equiv (L_t + L_{t-1})/Z$, where $D_{-1} > 0$ is given. Labor market clearing requires

$$L_t^X + L_t^Y = L_t. \quad (10)$$

Initially land is fully owned by the L_{-1} old natives, where $z(i)$ denotes the landholding of individual i . Landowners bequeath their landholding to their child when leaving the scene, such that the number of landowners and the land distribution among natives is time-invariant. For simplicity, we assume that firms in the non-tradable goods sector are owned by foreigners. In period t , a young individual i who stays in the domestic economy thus has a present discounted value of life-time income, $W_t(i)$, which is given by

$$W_t(i) = w_t + \frac{p_{t+1}^Z}{1+r} z(i). \quad (11)$$

For the sake of realism, suppose that a non-negligible fraction of natives is landless (for a landless individual i , $z(i) = 0$).

Let $c_{1,t}$ and $h_{1,t}$ denote the amount of tradable goods and housing services consumed by a working-age individual born in t , respectively. Analogously, $c_{2,t+1}$ and $h_{2,t+1}$ are consumption levels during retirement. Life-time utility of an individual born in period

t is given by¹⁴

$$U_t(i) = u(c_{1,t}(i), h_{1,t}(i)) + \rho \cdot u(c_{2,t+1}(i), h_{2,t+1}(i)), \quad (12)$$

$\rho \in (0, 1)$, with instantaneous utility function $u(c, h) = \chi \cdot \log c + (1 - \chi) \cdot \log h$, $\chi \in (0, 1)$. Recalling that $p^Y = 1$, the intertemporal budget constraint of consumer i reads as

$$c_{1,t}(i) + p_t^H h_{1,t}(i) + \frac{c_{2,t+1}(i) + p_{t+1}^H h_{2,t+1}(i)}{1 + r} \leq W_t(i). \quad (13)$$

We assume that the time discount rate is given by the standard condition

$$\rho \cdot (1 + r) = 1. \quad (14)$$

2.2 Foreign Economy

The foreign economy is in steady state and large in the sense that migration from or towards the domestic economy has no effect on its population density. The population density, denoted by $D^*(= L^*/Z^*)$, is therefore time-invariant. TFP levels in the tradable goods sector of the foreign economy, A^* , and in the housing sector, B^* , may differ from the domestic levels, A and B , respectively. Apart from productivity levels, population density, and initial conditions, the domestic and the foreign economy are identical.

3 Equilibrium Analysis

As shown in the appendix, individual i has life-time utility

$$V(W_t(i), p_t^H, p_{t+1}^H) \equiv \max_{c_{1,t}(i), h_{1,t}(i), c_{2,t+1}(i), h_{2,t+1}(i)} U_t(i) \text{ s.t.} \quad (15)$$

$$= \Omega + (1 + \rho) \log W_t(i) - (1 - \chi) [\log p_t^H + \rho \log p_{t+1}^H], \quad (16)$$

¹⁴This preference specification can be viewed as a dynamic extension of the static model of locational choice by Roback (1982), who argues that differences in wage income across regions can be explained by different amenities associated with the chosen location, also endogenizing the rental rate of land.

with $\Omega \equiv (1 + \rho) \log \left(\frac{\chi^\chi (1-\chi)^{1-\chi}}{1+\rho} \right)$. Let w^* denote the wage rate and p^{H^*} the price for housing services in the foreign economy. Moreover, define by $\mathcal{V}_t \equiv V(w_t, p_t^H, p_{t+1}^H)$ and $\mathcal{V}^* \equiv V(w^*, p^{H^*}, p^{H^*})$ the life-time utility (in equilibrium) of a landless native in the domestic and foreign economy, respectively. If labor is interregionally mobile, landless domestic residents born in t do not want to migrate to the foreign economy as long as $\mathcal{V}_t \geq \mathcal{V}^* + \Delta$. Similarly, landless foreign residents born in t do not want to migrate to the domestic economy as long as $\mathcal{V}_t + \Delta \leq \mathcal{V}^*$. If $\Delta > 0$, there is the possibility that, for a given set of parameters, a multiplicity of equilibria $L_t = L_{t-1}$ (no migration) exists whenever $|\mathcal{V}_t - \mathcal{V}^*| \leq \Delta$ (indeterminacy of equilibrium).¹⁵ To avoid such difficulty and to capture the absence of institutional migration costs within Germany after the fall of the Berlin Wall, we follow Roback (1982) and abstract from exogenous migration costs in the remainder of this paper, assuming $\Delta = 0$. We focus on equilibria where landless individuals are indifferent whether or not to migrate under integrated labor markets, such that

$$\mathcal{V}_t = \mathcal{V}^* \text{ for any } t \geq 1. \quad (17)$$

If $\Delta = 0$, a domestic native i born in t with land holding $z(i)$ does not want to migrate to the foreign economy if

$$V(w_t + \rho \cdot p_{t+1}^Z z(i), p_t^H, p_{t+1}^H) > V(w_t^* + \rho \cdot p_{t+1}^Z z(i), p^{H^*}, p^{H^*}). \quad (18)$$

Using (16) in (18), the incentive-compatibility constraint for a domestic native i born in t with land holding $z(i)$ to remain in the domestic region reads

$$\frac{1 + \rho}{1 - \chi} \log \left(\frac{w_t + \rho \cdot p_{t+1}^Z \cdot z(i)}{w_t^* + \rho \cdot p_{t+1}^Z \cdot z(i)} \right) > \log \left(\frac{p_t^H}{p^{H^*}} \right) + \rho \cdot \log \left(\frac{p_{t+1}^H}{p^{H^*}} \right). \quad (19)$$

Notice that for $z > 0$, we have $\frac{w + \rho \cdot p^Z \cdot z}{w^* + \rho \cdot p^Z \cdot z} > (<) \frac{w}{w^*}$ if $w < (>) w^*$. Thus, if $w < w^*$ and $V_t = V^*$ holds, a land-owning domestic native does not want to migrate to the

¹⁵Armenter and Ortega (2011) employ a static multi-regions model with skilled and unskilled workers under endogenous redistribution and mobility costs. In their setup, redistribution and mobility costs affect the incentives for skilled workers to migrate. Interestingly, they obtain multiple equilibria if migration costs are relatively low.

foreign economy, as the incentive-compatibility constraint (19) is satisfied. In contrast, if $w > w^*$ and $\mathcal{V}_t = \mathcal{V}^*$ holds in equilibrium, a land-owning foreign native does not want to migrate to the domestic economy. In other words, when landless individuals are indifferent in equilibrium whether or not to migrate, triggered off by emigration of some landless individuals motivated by gaining wage income, no landowner wants to migrate.¹⁶ The intuition why the incentive to migrate is higher for landless individuals is as follows. Because land rents are received from the home region irrespective of the location decision, income-related migration benefits come from wage differentials only. As the marginal utility from consumption is declining, wage gains from migration matter more for landless individuals.

3.1 Interregionally Immobile Labor

It turns out that, for all t , the equilibrium levels of all factor inputs per unit of land, $l_t^X \equiv L_t^X/Z$, $l_t^Y \equiv L_t^Y/Z$, $m_t \equiv M_t/Z$, $k_t \equiv K_t/Z$, $x_t \equiv X_t/Z$, are independent of total land supply Z . Before entering the numerical analysis in Section 4, we characterize the long-run equilibrium analytically. Denote the long-run equilibrium value *before* labor market integration of any variable y by \tilde{y} . All proofs are relegated to the Appendix.

Proposition 1. *In an interior long run equilibrium before labor market integration,*

(i) *an increase in population density, D , raises factor inputs \tilde{l}^X , \tilde{l}^Y , \tilde{m} , \tilde{k} , \tilde{x} , the price of housing services, \tilde{p}^H , and the rental rate of land, \tilde{p}^Z , whereas the wage rate, \tilde{w} , and the price of structures, \tilde{p}^X , do not depend on D ;*

(ii) *an increase in the tradable goods sector's TFP level, A , raises capital inputs \tilde{k} , \tilde{x} , as well as the input of materials, \tilde{m} , the price of housing services, \tilde{p}^H , the rental rate of land, \tilde{p}^Z , the wage rate, \tilde{w} , and the price of structures, \tilde{p}^X , whereas labor inputs \tilde{l}^X , \tilde{l}^Y remain unaffected;*

¹⁶Conversely, if landless individuals are indifferent whether or not to migrate although wages are higher in the region of birth (but the price of housing services is so low that some landless individuals migrate anyway), all landowners migrate. Although this is a theoretical possibility, wages in East Germany were lower than in West Germany for the entire post-reunification period. Thus, we will not consider this case.

(iii) an increase in the non-tradable goods sector's TFP level, B , raises \tilde{x} , lowers both the price of housing services, \tilde{p}^H , and the price of structures, \tilde{p}^X , while the rental rate of land, \tilde{p}^Z , the wage rate, \tilde{w} , and inputs \tilde{l}^X , \tilde{l}^Y , \tilde{m} , \tilde{k} remain unaffected.

An increase in population density D leads to higher employment in both sectors, in turn stimulating investments in both physical capital and structures. The long run price of housing services, \tilde{p}^H , is increasing in D despite a higher stock of residential structures. The result reflects a dilution effect of higher population density with respect to the fixed factor (land) when producing housing services, associated with an increase in the long run rental rate of land, \tilde{p}^Z .¹⁷

In the absence of labor mobility, the allocation of labor is independent of productivity parameters, A and B . Higher productivity in the tradable goods sector, A , means higher output of the tradable good for given inputs, and thus a higher relative price of housing services, p^H . Consequently, it spurs accumulation of both physical capital and structures. A higher p^H is positively associated with a higher rental rate of land, p^Z , and a higher value of the marginal product of labor in the housing sector. This explains why both the long run wage rate, \tilde{w} , and the long run price of structures, \tilde{p}^X , are increasing in A . Because of lower demand for housing services associated with a higher \tilde{p}^H , the long run allocation of labor across sectors is independent of A .

Higher productivity in the housing sector, B , leads to higher supply of structures, thus being negatively associated with the price for housing services, p^H . At the same time, an increase in B means that the marginal product of inputs in the housing sector is higher for a given p^H . This explains why physical capital formation, the rental rate of land and the wage rate are independent of B in the long run.

¹⁷These comparative-static results have interesting welfare implications. If and only if the land estate of an individual is sufficiently high, the positive welfare effect of immigration via higher income from land ownership dominates the negative welfare effect of an increase in housing costs. Thus, there is a threshold amount of landholding, $\bar{z} > 0$, such that all individuals with $z(i) > \bar{z}$ win from labor market integration, whereas those with $z(i) < \bar{z}$ lose. If there is emigration, the result is reversed. These insights give potentially rise to polarization of attitudes towards immigration in a heterogenous population, similar to the political economy perspective of Benhabib (1996). In Benhabib (1996), individuals differ along capital holdings and develop different attitudes depending on the fact whether the capital-labor ratio rises or falls in response to immigration.

3.2 Integrated Labor Markets

Denote the long run equilibrium value *after* labor market integration of any variable y by \hat{y} .

Proposition 2. *Under integrated labor markets, the long run equilibrium population density, \hat{D} , is proportional to the foreign population density, D^* , and increases in the relative productivity level across regions in both sectors, A/A^* and B/B^* .*

The higher the foreign population density, D^* , the higher is the (long run) price of housing services in the foreign economy, p^{H*} , reducing its attractiveness. This explains why more individuals want to live in the domestic economy. An increase in the relative productivity across regions of the tradable goods sector, A/A^* , has two counteracting effects on the steady state population density of the domestic economy when labor is interregionally mobile. First, before labor market integration, an increase in A/A^* raises the long run wage rate of individuals in the domestic relative to the foreign economy, \tilde{w}/w^* (part (ii) of Proposition 1) such that the domestic economy becomes more attractive for workers. Second, for a given population density, it also raises the long run price for housing services in the domestic region relative to the foreign region, \tilde{p}^H/p^{H*} , lowering the attractiveness of the domestic economy. With respect to long population density in response to labor market integration, the first effect dominates the second one. Moreover, an increase in the relative productivity of the non-tradable goods sector, B/B^* , has no effect on \tilde{w}/w^* (part (iii) of Proposition 1), but lowers \tilde{p}^H/p^{H*} for given labor inputs, making the domestic economy more attractive.

4 Numerical Analysis

We now turn to numerical analysis in order to investigate the role of initial conditions and the evolution of TFP for the evolution of migration flows in response to labor market integration. In addition, we focus on the dynamic interaction of migration flows on the one hand and the evolution of the wage rate, the price for housing services, the

formation of physical capital and structures on the other hand. We will argue that the model can explain migration *outflows* and positive net investments in both physical capital and structures at the same time, while the *causal* effect of higher migration *inflows* on investments is positive. Most importantly, we will show that migration flows can be reversed over time if the integration shock happens in a capital-poor economy (possibly also characterized by low TFP levels), such as in East Germany shortly after the fall of the iron curtain.

4.1 Calibration

We shall emphasize that, despite implementing a reasonable model calibration, our goal is to characterize transitional dynamics qualitatively rather than quantitatively. On the one hand, for a quantitative analysis, our two-period overlapping-generations structure is too stylized. On the other hand, the simplicity allows us to gain solid intuitions into the underlying economic mechanisms.

Assuming an annual real interest rate of 2 percent and a length of a generation of about 35 years suggests that $r = 1$; thus $\rho = 0.5$, according to (14). Empirical evidence points to a budget share on housing of about one third (e.g. Johnson, Rogers and Tan, 2001), which suggests $\chi = 2/3$. Moreover, we set $\delta^X = 0.25$ and $\delta^K = 0.5$ which reflects an annual depreciation rate of about two percent in the housing sector and four percent in the tradable goods sector, respectively.

We also employ the standard quadratic specification of capital adjustment costs, which means that we set $\eta = 1$. In addition, we assume $\theta = 0.5$ which implies that, in a steady state with $I^K/K = \delta^K = 0.5$, one unit of gross investment in physical capital requires $1 + \theta \cdot (I^K/K)^\eta = 1.25$ units of the tradable good.

Since all quantities can be expressed relative to land endowment Z , we set $Z = 1$ without loss of generality. For output elasticities in the housing sector, we set $\beta = \gamma = 0.5$. Finally, we normalize the foreign (exogenous) population density to $D^* = 1$.

4.2 Labor Market Integration Effects

The dynamic effects of labor market integration on the labor force, wage rate and the price for housing services are visualized, whereas for the sake of brevity we display the evolution of the other variables in the Online Appendix. We focus on the case that captures the initial conditions of East Germany at the time of the re-unification with West Germany. Suppose that initial stocks of both physical capital and structures are below the long run values under labor market integration, i.e., $K_0 < \tilde{K}$, $X_0 < \tilde{X}$. Moreover, the domestic TFP levels at $t = 0$ do not exceed the foreign TFP level, i.e., $A_0 \leq A^*$ and $B_0 \leq B^*$. To isolate different effects, the first experiment (Fig. 3 below) assumes time-invariant TFP parameters that are equal to the foreign economy. The second experiment (Fig. 4 below) then allows for time-dependent TFP levels that start below the foreign levels: $A_0 < A^*$ and $B_0 < B^*$. This constellation represents a plausible description of East Germany vis-à-vis West Germany (or, more generally, Eastern Europe vis-à-vis Western and Northern Europe) at the time of the fall of the iron curtain.¹⁸

First, in order to illustrate the implications of low initial capital stocks in isolation, Fig. 3 displays the transitional dynamics for the case where $A_t = A^*$ and $B_t = B^*$ for all t . Because TFP is the same as in the foreign economy, steady states coincide with the domestic economy. Moreover, steady state values before and after labor market integration are the same. That is, $\tilde{w} = \hat{w} = w^*$, $\tilde{p}^H = \hat{p}^H = p^{H*}$, $\hat{L} = L^* = L_{-1} = \tilde{L}$, $\tilde{K} = \hat{K} = K^*$, $\tilde{X} = \hat{X} = X^*$. The dotted lines show the transitional dynamics that occur without integrated labor markets, whereas the solid lines illustrate transitional dynamics when the labor market is opened up at time $t = 0$. Because the economy is initially capital-poor ($K_0 < \tilde{K}$, $X_0 < \tilde{X}$), the initial wage rate is lower than the foreign level in the closed economy ($w_0 < w^*$). In response to labor market integration, this triggers off emigration on impact ($L_0 < L_{-1}$), associated with a drop in sectoral labor inputs, L^X and L^Y (see Online Appendix), and an associated increase in the wage rate,

¹⁸We ignore the effects that come from initially different population densities, assuming it is the same in the domestic economy as abroad ($D_{-1} = D^* = 1$).

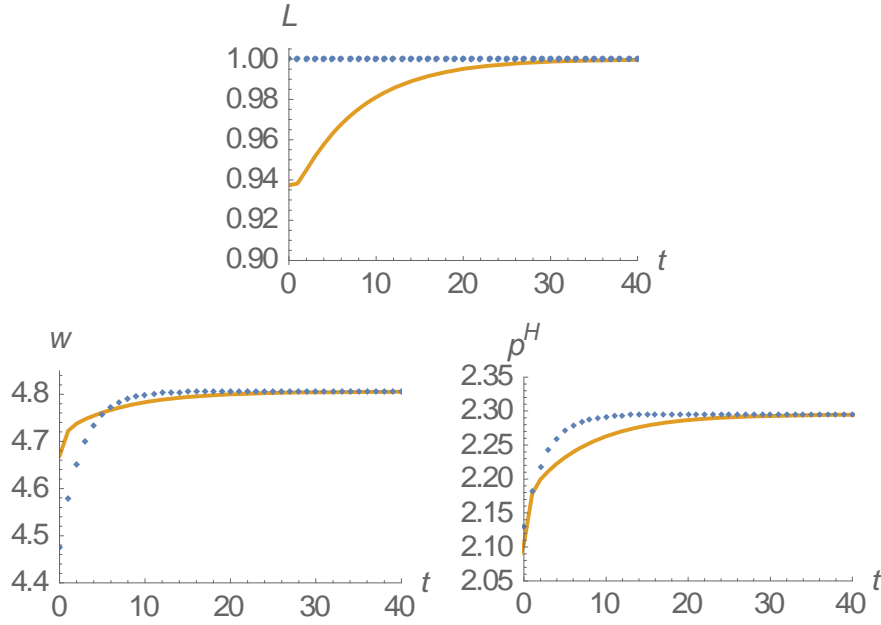


Figure 3: Transitional dynamics for an initially capital-poor economy assuming labor market integration at $t = 0$ (solid lines) and assuming that labor markets remain closed (dotted lines). Parameter configuration: $A = A^* = B = B^* = 5$, $K_0 = 0.8\tilde{K}$, $X_0 = 0.8\tilde{X}$.

w , compared to the pre-integration case. In the displayed numerical example, there is emigration despite the price for housing being initially lower than in the foreign economy. The property $p_0^H < p^{H*}$ arises because the stock of structures is low, implying that the marginal product of land in the production of housing services is low. Notably, despite emigration, there is accumulation of both physical capital, K , and structures, X , reflecting the standard neoclassical convergence force (Rappaport, 2005). Because emigration reduces the investment incentives compared to the pre-integration case, both types of capital accumulate more slowly than in the pre-integration case, as displayed in the Online Appendix. That is, the causal effect of emigration is to lower investment in both sectors. Over time, and after the initial drop of population density, the size of the workforce rises along with accumulation of physical capital and structures from $t = 1$ onwards. This is the reverse migration phenomenon we observe in East Germany, according to Fig. 1 and 2, particularly in cities that are the economically most active regions. The price of housing services, p^H , is lower on impact than it

would be in the closed economy because of emigration. It then rises over time because of increased demand for housing that is associated with increasing wages and (for the solid line) the reversal of the migration flows to immigration. The transition to the steady state level \hat{p}^H is slower than without labor market integration, where the labor force is higher.

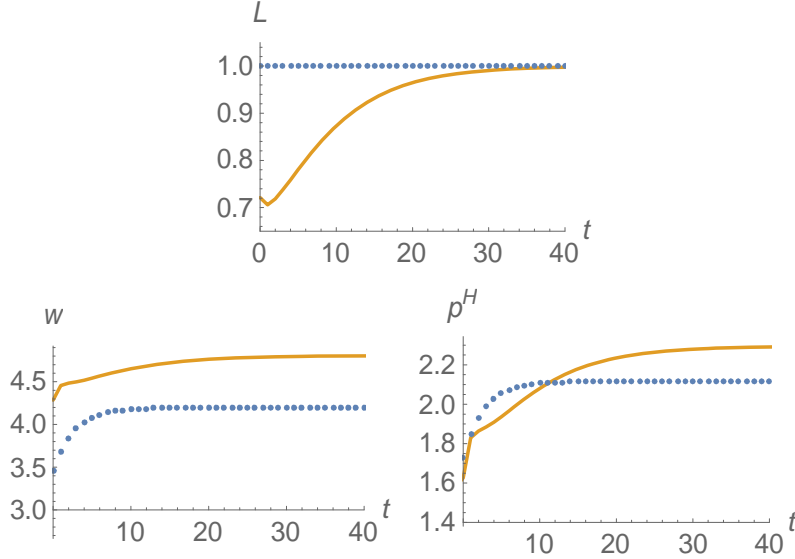


Figure 4: Transitional dynamics for an economy that initially is capital-poor and has low TFP levels assuming labor market integration at $t = 0$ (solid lines) and assuming that labor markets remain closed (dotted lines). Parameter configuration: $A_0 = 0.96A^* = 4.8$, $B_0 = 0.96B^* = 4.8$, $K_0 = 0.55\tilde{K}$, $X_0 = 0.85\tilde{X}$. A and B increase according to a logistic function to 100 percent of the foreign TFP level only for the case of labor market integration (solid lines).

The experiment displayed in Fig. 4 not only assumes that initial state variables start below the pre-integration steady state values ($K_0 = 0.55\tilde{K}$ and $X_0 = 0.85\tilde{X}$). It also assumes that domestic TFP parameters start below the foreign levels ($A_0 = 0.96A^*$ and $B_0 = 0.96B^*$). These border conditions capture the economic fundamentals of the East German economy at the time of the reunification most accurately. For the long run, we assume that TFP levels converge gradually to 100 percent of the foreign level ($\lim_{t \rightarrow \infty} A_t = A^*$ and $\lim_{t \rightarrow \infty} B_t = B^*$). Increasing TFP levels over time are certainly plausible for the post-reunification transition in East Germany because of technology

transfers and institutional improvements from advanced economies to East Germany (particularly from West German firms that opened plants in the New Laender after 1990). Physical capital and structures decumulate for a while shortly after labor market integration, whereas the stocks accumulate in the pre-integration case (as displayed in the Online Appendix) due to a standard neoclassical convergence mechanism. When TFP levels become sufficiently high, there is again a reversal of migration flows in parallel with rising wage rates, a rising price for housing services, and rising capital stocks.

Only if TFP levels remain sufficiently low also in the long run, it is possible that $\tilde{K} > K_0 > \hat{K}$ and $\tilde{X} > X_0 > \hat{X}$. In this case, emigration and decumulation of capital occurs at the same time and there is no reverse migration. In the case of East Germany, however, there was technology transfer from advanced regions, foremost West Germany, along with capital accumulation. Hence, the premises underlying Fig. 4 are more plausible.

4.3 Reverse Migration: The Role of the Housing Sector

In a one-sector model, with the tradable goods sector only (i.e. $\chi = 1$), the no-arbitrage condition $\mathcal{V}_t = \mathcal{V}^*$ that makes workers indifferent between migrating and staying in an integrated labor market boils down to wage rate equalization, $w_t = w^*$. As the wage rate equals the marginal product of labor, it holds that $A \cdot (K_t/L_t)^{1-\alpha} = A^* \cdot (K^*/L^*)^{1-\alpha}$. Suppose again that labor markets integrate in period $t = 0$. Also suppose that, one period in advance (in $t = -1$), we have $A \cdot (K_{-1}/L_{-1})^{1-\alpha} < A^* \cdot (K^*/L^*)^{1-\alpha}$. Then, in $t = 0$, the capital stock remains at the previous level at all times and labor moves out with constant population thereafter. Formally, for all $t \geq 0$, we have $K_t = K_{-1}$, sustained by gross investment $I_t^K = \delta^K K_{-1}$, and $L_t = (A/A^*)^{\frac{1}{1-\alpha}} K_{-1} L^*/K^* < L_{-1}$. In other words, the economy – that may have been on a transition path with gradual capital accumulation before labor markets integrate – jumps into the steady state by adjusting the amount of workers through emigration at the time of labor markets integration. This is similar to the case in Burda (2006). A reversal of migration flows

over time cannot occur.

In the one-sector model of Rappaport (2005), there are exogenous limits to labor force adjustments each period such that emigration is stretched over time until wage rates have converged. A reversal of migration flows cannot occur either.

Reverse migration occurs in our model because of the presence of the housing sector. In the case where housing costs are lower in the domestic economy (as in Fig. 3 and 4), emigration early in the transition in response to labor market integration does not occur to a point where the domestic wage rate rises to the foreign level, despite the absence of exogenous migration costs.

5 Empirical Evidence: The Case of East Germany

In this section, we argue that the reverse migration scenario displayed in Fig. 3 and 4 is consistent with the evidence on net migration flows, the evolution of wages and the evolution of housing costs in the New German Laender after the fall of the Berlin Wall. Details on the data construction and robustness checks are relegated to the Online Appendix.

5.1 Net Migration Flows

Fig. 1 and 2 in the introduction are based on a new data set on net migration flows for the period 1991-2014 at the district level in East Germany. So far, the data were not publicly available for any district in the New Laender before 1995 and were also not available for most districts after 2007.¹⁹

The migration data set used for Fig. 1 and Fig. 2 is based on net migration balances, accounting for movements across the borders of administrative districts (NUTS 3 units in the EUROSTAT typology for all five New Laender in Germany). The districts in the New Laender were subject to numerous border reforms between 1991 and 2014,

¹⁹The reason for this limited data availability up to now were subsequent changes in county borders resulting from administrative reforms. We worked with the Statistical Offices of the New Laender to complete the data set. Their collaboration with us is gratefully acknowledged.

reducing their number considerably. To get consistent data over the entire period 1991 to 2014, one territorial status was chosen and reconstructed for the periods with differing district borders. The longest period not marked by significant territorial reforms lasted from 1995 to 2006. Thus, we selected the territorial boundaries during that period of time. For the periods before (1991-1994) and after the reference period (2007-2014), the municipalities (corresponding to LAU2 units) were assigned to the districts to whom they belonged during the reference period and their net migration balances were added up to reconstruct the data at the district-level.

To sum up the discussion in the introduction, we see a reversal of migration flows particularly in East German cities. Fig. 4 based on the theoretical model suggests that outflows are highest early in the transition, whereas Fig. 1 and 2 shows that migration outflows was higher in the second half than in the first of the 1990s. This may not only reflect a kind of behavioral inertia of workers, especially in more rural areas (Burda, 1993), but may also reflect massive public investment in the early 1990s in East Germany ("Aufbau Ost"), as discussed in OECD (2001). Overall, Fig. 3 and 4 are consistent with the evidence on the decline in emigration flows and an eventual reversal to net inflows.

5.2 Wages

Fig. 3 and 4 also suggest that the reverse migration pattern is associated with gradual increases in both wage rates and rental rates of housing that are pronounced in the early transition phase. According to Fig. 5, the average wage income per worker in all the New Laender shows incomplete convergence to the West German level.

Wages increased particularly fast in the 1990s. Not all of that was market-driven, as trade unions pushed to harmonize wages in Germany. This was associated with comparatively high unemployment rates in East Germany. Consistent with the theoretical considerations, however, wages in the Eastern Laender relative to the Western German wage level continued to increase (along with a decline in unemployment rates) in the 2000s as well, suggesting that TFP levels do not yet coincide.

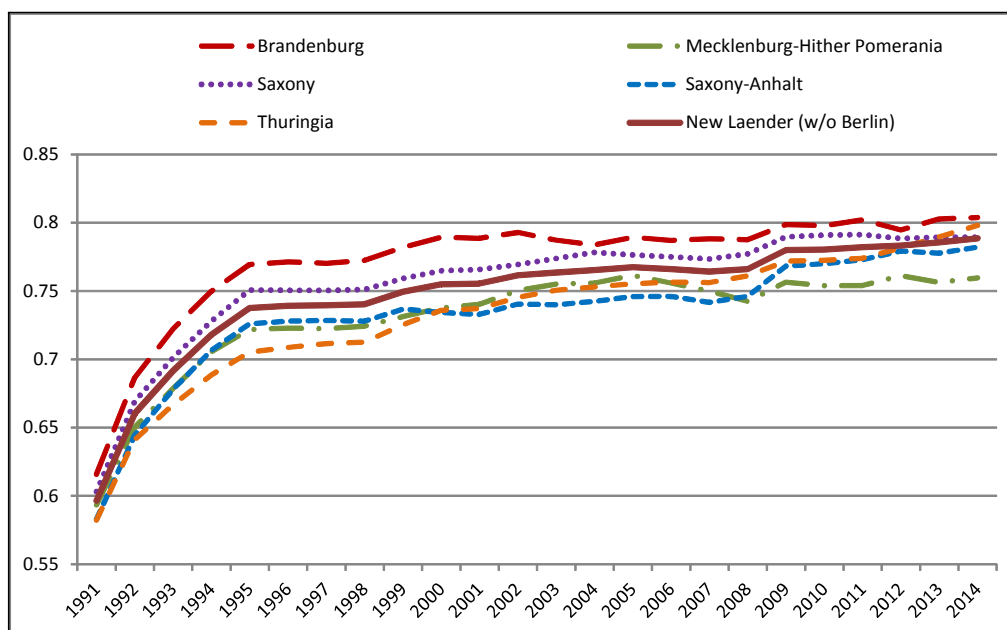


Figure 5: Real wage income per worker relative to West Germany (without Berlin) in the New Laender, 1991-2014. Data: Federal Ministry of Finance, Germany.

5.3 Rental Rates for Housing

Finally, we relate the evolution of rental rates for housing over time in the New Laender to our model, by constructing a comprehensive data set on rental housing in East Germany that has not yet been used elsewhere (for West Germany, see Fitzenberger and Fuchs, 2016). The data on housing costs come from the German Socio-Economic Panel Study (SOEP), a representative annual household panel survey that offers detailed information on rental housing from the perspective of tenants. The final data set consists of 107,514 private households who live in rental apartments between 1984 and 2014 in West Germany and 34,248 private households who live in rental apartments between 1990 and 2014 in East Germany.

Fig. 6 visualizes the evolution of the "raw" average monthly rental payments per square metre for East Germany (since 1990) and West Germany (since 1984) over time, employing the full sample. While West German rental rates show no trend since the early 1990s (consistent with a steady state), the price for housing services increased fast in East Germany in the 1990s. In the 2000s it was six times as high as in 1990.

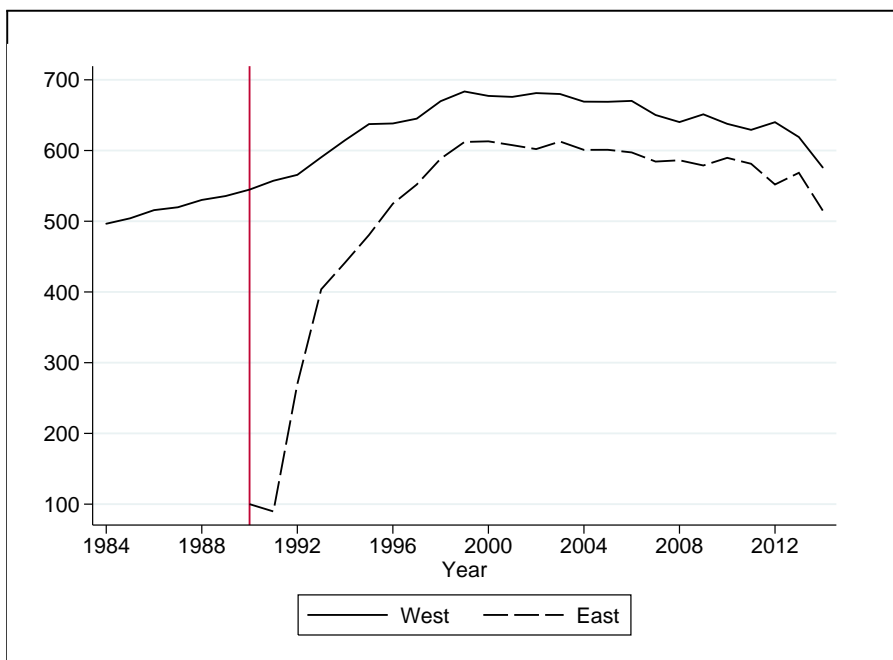


Figure 6: Evolution of raw average rental payments per square meter per month in East Germany vs. West Germany. Note: Index with the average rent in East Germany in year 1990 as basis value (= 100). Data: German Socio-Economic Panel (SOEP), version 31.

As for wages, we observe incomplete convergence to West German levels.²⁰

Fig. 7 shows the evolution of average rental payments per square metre for the New Laender (including East Berlin) based on a standard hedonic pricing model that accounts for variation in apartment quality. We control for the year of construction, the type of location area (new residential, old residential, mixed or other), the general apartment condition, and whether the apartment is equipped with a garden, a balcony/terrace, central heating and a basement. Because of the panel structure of the data, we are also able to control for fixed effects at the apartment level.²¹ Comparing Fig. 7 to Fig. 6 shows that the evolution of quality-adjusted housing costs is similar

²⁰The speed of the increase in the 1990s was certainly slowed down by regulations that limited upward rent adjustments, especially but not exclusively for those already living in the same apartment before October 1990 (Neumann and Schaper, 2008). These special regulations ended in January 1998 after which the regulations coincided with those in West Germany (i.e. rental rates for housing must not exceed a certain percentage of the local average for comparable apartments).

²¹The Online Appendix describes the underlying estimation procedure and the data in detail. We also present further results that demonstrate robustness.

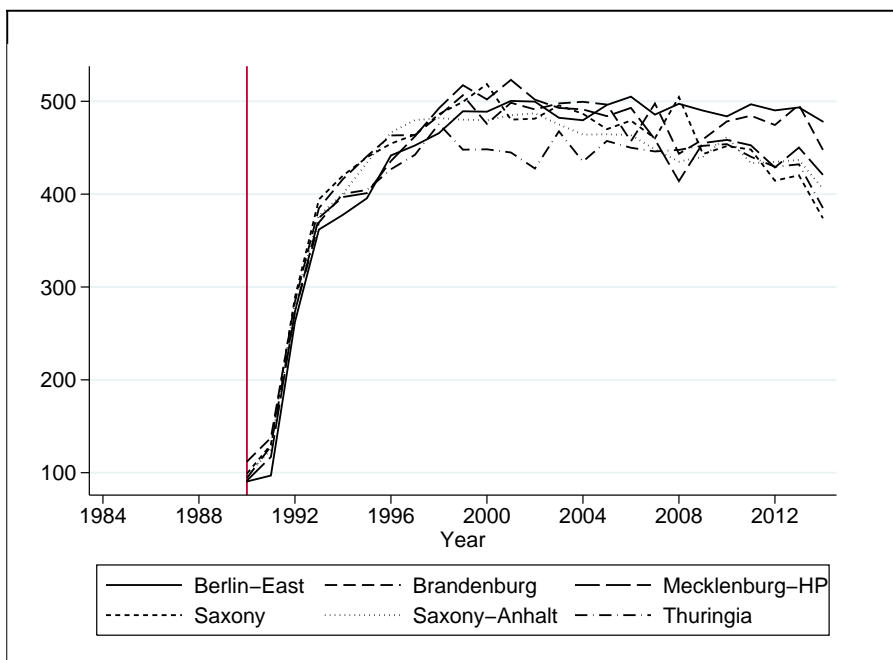


Figure 7: Evolution of quality-adjusted average rental payments per square meter in the New Laender. Note: Index with the average rent in East Germany in year 1990 as basis value (= 100). Data: German Socio-Economic Panel (SOEP), version 31.

to the raw average in East Germany in Fig. 6 across all New Laender (including East Berlin).

The evolution of p^H in Fig. 3 and 4, based on the reverse migration case of the theoretical model, is qualitatively consistent with Fig. 6 and 7, particularly for the 1990s where we see gradual increases in rental rates for East Germany. The reason why rental rates have been rather flat during the 2000s (while the theoretical model would predict further increases) may be rooted in new rental price regulation policy, beside slow economic growth in Germany as a whole during the 2000s. In a study for the Old Laender, Fitzenberger and Fuchs (2016) show that the tenancy law reform act in 2001 reduced apartment rents significantly for new leases. The negative reform effect diminishes with the duration of a tenancy. Thus, households who live in tenancies that are affected by the reform benefit less from being sitting tenants than households in tenancies that started before September 2001. However, there are also regulations that limit rental rate increases for sitting tenants in Germany. These regulations may have

contributed to slow growth of rental rates after 2001 for reasons that are not captured in our simple theoretical model.

6 Conclusion

This paper has examined the impact of labor market integration on migration, capital formation, wages, the rental rate of land, and the price for housing services in an intertemporal model with a tradable goods sector and a housing sector. Our framework is capable to explain the phenomenon of reverse migration patterns that, for instance, occurred in (urban) East Germany in the aftermath of the sudden fall of the iron curtain (and the Berlin wall) in 1989. The reverse migration scenario is driven by low initial capital stocks and possibly also by low productivity levels that are increasing over time. The mechanism which acts as a drag on migration flows and prevents that everyone moves to high-income regions, once this is legally made feasible, works through the relative price of housing across regions. Once labor productivity is rising over time, the migration flow may reverse despite the co-evolution of rising housing costs. According to the best of our knowledge, previous studies based on neoclassical models were unable to explain that labor market integration may lead to labor outflows in early phases and immigration in later phases of the transition to the new long run equilibrium. The reverse migration scenario has suggested an evolution of wages and rental rates of housing that is consistent with the evidence for post-unification East Germany, exploiting the unique case of complete labor market integration and institutional harmonization across regions.

More generally, we have examined how initial conditions (i.e. initial levels of population density, productivity levels, and capital stocks) affect the direction of migration flows over time along with other key variables. We have demonstrated that capital inflows and emigration can occur at the same time, leading to a reversal of migration flows in the aftermath. Our analysis also suggests that, nevertheless, the causal effect of immigration on capital investments, the land price and housing costs is unambiguously positive. It is thus useful for empirical analyses of the interaction between migration,

the price for housing services, and residential capital investment by helping to address potential endogeneity biases.²²

Future research may exploit our setup to study the political economy side of migration policy.²³ Heterogeneity in the ownership of land may be important for distributional consequences in response to labor market integration, caused by changes in the rental rate of land and housing costs. This may help to understand political debates on and resistance to immigration even when migration inflows have negligible effects on the domestic labor market.²⁴

Appendix

Derivation of (16). We omit household index i and solve the household's problem in two steps. In the first step, the intertemporal consumption problem is solved. Define a Cobb-Douglas consumption index, $\mathcal{C} := c^{\chi}h^{1-\chi}$ such that instantaneous utility is given by $\log \mathcal{C}$. Consumption expenditure in a given period can be expressed as

$$P \cdot \mathcal{C} = c + p^H h, \quad (20)$$

where P denotes an appropriately defined price index (see below). Life-time utility of an individual born in t reads as $U_t = \log \mathcal{C}_{1,t} + \rho \log \mathcal{C}_{2,t+1}$.

For later use, we also allow for second-period income. Denote income of an indi-

²²Empirical studies have emphasized the role of wage differences across regions (e.g. Grogger and Hanson, 2011) and the role of migrant networks (Beine, Docquier and Ozden, 2011) for migration flows. We emphasize the need to account for differences in housing costs as well.

²³See e.g. Benhabib (1906) for an important study based on heterogeneity of capital holdings of both natives and immigrants. De la Croix and Docquier (2014) propose a very interesting recent political economy perspective of a host country. In their model, higher immigration in a single country does not raise welfare from a nationalist point of view whereas a coordinated increase in immigration quotas of a group of rich countries may lead to a Pareto improvement under an appropriate tax-subsidy scheme. In our set up, the challenge would be to achieve a Pareto improvement within a region when immigration produces winners and losers.

²⁴Switzerland would be a prime example. In a widely discussed referendum on February 9, 2014, Switzerland voted for restricting immigration by opting out of its bilateral agreement with the European Union on the free movement of labor (with a 50.3 percent majority). This was seen as remarkable by commentators, as labor market effects were largely invisible despite massive immigration since the agreement came into full effect in 2007. However, the main discussion in Switzerland centered on rising prices for housing services.

vidual born in t in the first and second period of life by $y_{1,t}$ and $y_{2,t+1}$, respectively.

Moreover, define

$$W_t \equiv y_{1,t} + \frac{y_{2,t+1}}{1+r}. \quad (21)$$

First-period income is equal to the wage rate, $y_{1,t} = w_t$. Let Sav_t denote individual savings in working age at time t , i.e. $Sav_t := w_t - P_{1,t}C_{1,t}$. We have

$$C_{1,t} = \frac{w_t - Sav_t}{P_{1,t}}, \quad (22)$$

$$C_{2,t+1} = \frac{(1+r)Sav_t + y_{2,t+1}}{P_{2,t+1}}. \quad (23)$$

The intertemporal problem may be expressed as follows:

$$\max_{Sav_t} \{ \log(w_t - Sav_t) - \log(P_{1,t}) + \rho \log[(1+r)Sav_t + y_{2,t+1}] - \rho \log(P_{2,t+1}) \}. \quad (24)$$

The first-order condition with respect to savings implies

$$P_{1,t}C_{1,t} = \frac{1}{1+\rho}W_t, \quad (25)$$

$$\frac{P_{2,t+1}C_{2,t+1}}{1+r} = \frac{\rho}{1+\rho}W_t. \quad (26)$$

In the second step, we analyze the static problems. Given the amount of first-period consumption expenditure in (25), the household solves

$$\max_{c_{1,t}^T, c_{1,t}^N} \log[(c_{1,t})^\chi (h_{1,t})^{1-\chi}] \quad \text{s.t.} \quad \frac{1}{1+\rho}W_t = c_{1,t} + p_t^H h_{1,t}. \quad (27)$$

Hence,

$$c_{1,t} = \frac{\chi}{1-\chi} p_t^H h_{1,t}, \quad (28)$$

which combined with the first-period budget constraint in (27) implies

$$c_{1,t} = \frac{\chi}{1+\rho}W_t, \quad h_{1,t} = \frac{1-\chi}{1+\rho} \frac{W_t}{p_t^H}. \quad (29)$$

Similarly, given the amount of second-period consumption expenditures in (26), the household solves

$$\max_{c_{2,t+1}, h_{2,t+1}} \log [(c_{2,t+1})^\chi (h_{2,t+1})^{1-\chi}] \quad \text{s.t.} \quad \frac{\rho(1+r)}{1+\rho} W_t = c_{2,t+1} + p_{t+1}^H h_{2,t+1}. \quad (30)$$

Hence, we get

$$c_{2,t+1} = \frac{\chi}{1-\chi} p_{t+1}^H h_{2,t+1} \quad (31)$$

which combined with $(1+r)\rho = 1$ and the second-period budget constraint in (30) leads to

$$c_{2,t+1} = \frac{\chi}{1+\rho} W_t, \quad h_{2,t+1} = \frac{1-\chi}{1+\rho} \frac{W_t}{p_{t+1}^H}. \quad (32)$$

Inserting (29) and (32) into the intertemporal utility function (12) confirms (16). It remains to be shown that there exists a price index as used above. Using $C = c^\chi h^{1-\chi}$, the price index P may be expressed as

$$P = \frac{c + p^H h}{C} = \left(\frac{c}{h}\right)^{1-\chi} + p^h \left(\frac{h}{c}\right)^\chi. \quad (33)$$

Noting that $\frac{c}{h} = \frac{\chi}{1-\chi} p^H$ one gets

$$P = (p^H)^{1-\chi} \left[\left(\frac{\chi}{1-\chi}\right)^{1-\chi} + \left(\frac{1-\chi}{\chi}\right)^\chi \right]. \quad (34)$$

This concludes the proof. ■

Proof of Proposition 1. Denote by q^K the shadow price of physical capital in numeraire sector, i.e. the multiplier to capital accumulation constraint (3) in the profit maximization problem (2) of firms in the numeraire goods sector. The associated Lagrangian function is given by

$$\begin{aligned} \mathcal{L}^Y \equiv & \sum_{t=0}^{\infty} \left(\frac{1}{1+r}\right)^t (A \cdot (L_t^Y)^\alpha (K_t)^{1-\alpha} - w_t L_t^Y - \\ & I_t^K \left[1 + \theta \left(\frac{I_t^K}{K_t}\right)^\eta \right] + q_t^K \cdot [I_t^K + (1 - \delta^K) K_t - K_{t+1}]) \end{aligned} \quad (35)$$

The associated first-order conditions $\frac{\partial \mathcal{L}^Y}{\partial L_t^Y} = \frac{\partial \mathcal{L}^Y}{\partial I_t^K} = \frac{\partial \mathcal{L}^Y}{\partial K_{t+1}} = 0$ imply

$$\alpha \cdot A \cdot \left(\frac{K_t}{L_t^Y} \right)^{1-\alpha} = w_t, \quad (36)$$

$$\frac{I_t^K}{K_t} = \left(\frac{q_t^K - 1}{(\eta + 1)\theta} \right)^{\frac{1}{\eta}}, \quad (37)$$

$$(1 - \delta^K)q_{t+1}^K + (1 - \alpha) \cdot A \cdot \left(\frac{L_{t+1}^Y}{K_{t+1}} \right)^\alpha + \theta\eta \left(\frac{I_{t+1}^K}{K_{t+1}} \right)^{\eta+1} = (1 + r)q_t^K. \quad (38)$$

According to (9), we have the following first-order conditions of the representative housing services firm:

$$\gamma p_t^H \left(\frac{X_t}{Z} \right)^{\gamma-1} = p_t^X, \quad (39)$$

$$\frac{X_t}{Z} = \left(\frac{p_t^Z}{(1 - \gamma)p_t^H} \right)^{\frac{1}{\gamma}}. \quad (40)$$

Combining (39) and (40) yields

$$p_t^X = \gamma (p_t^H)^{\frac{1}{\gamma}} \left(\frac{1 - \gamma}{p_t^Z} \right)^{\frac{1-\gamma}{\gamma}} \quad (41)$$

Denote by q^X the shadow price of structures, i.e. the multiplier to constraint (6) in the profit maximization problem (7) of construction firms. The associated Lagrangian function is given by

$$\begin{aligned} \mathcal{L}^X \equiv & \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t (p_t^X X_t - w_t L_t^X - M_t + \\ & q_t^X \cdot [B (L_t^X)^\beta (M_t)^{1-\beta} + (1 - \delta^X) X_t - X_{t+1}]) \end{aligned} \quad (42)$$

The associated first-order conditions $\frac{\partial \mathcal{L}^X}{\partial L_t^X} = \frac{\partial \mathcal{L}^X}{\partial M_t} = \frac{\partial \mathcal{L}^X}{\partial X_{t+1}} = 0$ imply

$$q_t^X \cdot \beta \cdot B \cdot \left(\frac{L_t^X}{M_t} \right)^{\beta-1} = w_t, \quad (43)$$

$$q_t^X = \frac{1}{B \cdot (1 - \beta)} \left(\frac{M_t}{L_t^X} \right)^\beta, \quad (44)$$

$$p_{t+1}^X + (1 - \delta^X)q_{t+1}^X = (1 + r)q_t^X, \quad (45)$$

Combining (43) with (44) and using (36) implies

$$\alpha \cdot A \cdot \left(\frac{K_t}{L_t^Y} \right)^{1-\alpha} = \frac{\beta}{1 - \beta} \frac{M_t}{L_t^X}. \quad (46)$$

Combining (44) with (45) and using (41) implies

$$B \cdot (1 - \beta) \gamma (p_{t+1}^H)^{\frac{1}{\gamma}} \left(\frac{1 - \gamma}{p_{t+1}^Z} \right)^{\frac{1-\gamma}{\gamma}} + (1 - \delta^X) \left(\frac{M_{t+1}}{L_{t+1}^X} \right)^\beta = (1 + r) \left(\frac{M_t}{L_t^X} \right)^\beta, \quad (47)$$

Combining and (37) with (38) leads to

$$(1 - \delta^K)q_{t+1}^K + (1 - \alpha) \cdot A \cdot \left(\frac{L_{t+1}^Y}{K_{t+1}^Y} \right)^\alpha + \frac{\eta}{\theta^{\frac{1}{\eta}}} \left(\frac{q_{t+1}^K - 1}{\eta + 1} \right)^{\frac{\eta+1}{\eta}} = (1 + r)q_t^K. \quad (48)$$

Combining (3) and (37) we can write

$$\frac{K_{t+1}}{K_t} = \left(\frac{q_t^K - 1}{(\eta + 1)\theta} \right)^{\frac{1}{\eta}} + 1 - \delta^K. \quad (49)$$

The market clearing condition for non-tradables reads as

$$H_t = \int_0^{L_t} h_{1,t}(i) di + \int_0^{L_{t-1}} h_{2,t}(i) di. \quad (50)$$

According to (29), (32) and (11), demand for the non-tradable good of a young and an old individual i in period t , with landholding $z(i)$ in the second period of life, is

$$h_{1,t}(i) = \frac{1 - \chi}{1 + \rho} \frac{w_t + \rho p_{t+1}^Z z(i)}{p_t^H}, \quad h_{2,t}(i) = \frac{1 - \chi}{1 + \rho} \frac{w_{t-1} + \rho p_t^Z z(i)}{p_t^H}, \quad (51)$$

respectively, where we used (14). Substituting (51) into (50) and using (8) yields

$$\left(\frac{X_t}{Z}\right)^\gamma = \frac{1 - \chi}{1 + \rho} \frac{w_t \frac{L_t}{Z} + w_{t-1} \frac{L_{t-1}}{Z} + \rho(p_{t+1}^Z + p_t^Z)}{p_t^H}. \quad (52)$$

Using (40) in (52) leads to

$$p_t^Z = \frac{(1 - \chi)(1 - \gamma)}{1 + \rho} \left[w_t \frac{L_t}{Z} + w_{t-1} \frac{L_{t-1}}{Z} + \rho \cdot (p_{t+1}^Z + p_t^Z) \right]. \quad (53)$$

Recall notation $l^X = L^X/Z$, $l^Y = L^Y/Z$, $m = M/Z$, $k = K/Z$ and $x = X/Z$. Also let $l \equiv L/Z$. Prior to labor market integration, for a given sequence of cohort sizes per unit of land, $\{l_t\}_{t=-1}^\infty$, the sequences of quantities $\{l_t^X, l_t^Y, m_t, k_{t+1}, x_{t+1}\}_{t=0}^\infty$ and prices $\{w_t, p_t^Z, p_t^H, q_t^K\}_{t=0}^\infty$ are given by

$$x_{t+1} = B (l_t^X)^\beta (m_t)^{1-\beta} + (1 - \delta^X)x_t. \quad (54)$$

$$l_t^X + l_t^Y = l_t, \quad (55)$$

$$\frac{k_{t+1}}{k_t} = \left(\frac{q_t^K - 1}{(\eta + 1)\theta} \right)^{\frac{1}{\eta}} + 1 - \delta^K, \quad (56)$$

$$w_t = \alpha \cdot A \cdot \left(\frac{k_t}{l_t^Y} \right)^{1-\alpha}, \quad (57)$$

$$x_t = \left(\frac{p_t^Z}{(1 - \gamma)p_t^H} \right)^{\frac{1}{\gamma}}. \quad (58)$$

$$B \cdot (1 - \beta) \gamma (p_{t+1}^H)^{\frac{1}{\gamma}} \left(\frac{1 - \gamma}{p_{t+1}^Z} \right)^{\frac{1-\gamma}{\gamma}} + (1 - \delta^X) \left(\frac{m_{t+1}}{l_{t+1}^X} \right)^\beta = (1 + r) \left(\frac{m_t}{l_t^X} \right)^\beta, \quad (59)$$

$$(1 - \delta^K) q_{t+1}^K + (1 - \alpha) \cdot A \cdot \left(\frac{l_{t+1}^Y}{k_{t+1}} \right)^\alpha + \frac{\eta}{\theta^{\frac{1}{\eta}}} \left(\frac{q_{t+1}^K - 1}{\eta + 1} \right)^{\frac{\eta+1}{\eta}} = (1 + r) q_t^K, \quad (60)$$

$$p_t^Z = \frac{(1 - \chi)(1 - \gamma)}{1 + \rho} [w_t l_t + w_{t-1} l_{t-1} + \rho(p_{t+1}^Z + p_t^Z)], \quad (61)$$

$$\alpha \cdot A \cdot \left(\frac{k_t}{l_t^Y} \right)^{1-\alpha} = \frac{\beta}{1 - \beta} \frac{m_t}{l_t^X}, \quad (62)$$

according to (6), (10), (49), (36), (40) (47), (48), (53), (46), respectively. The solutions

then give us the sequence $\{p_t^X\}_{t=0}^\infty$ according to (41) and, using (44), the sequence $\{q_t^X\}_{t=0}^\infty$ according to

$$q_t^X = \frac{1}{B \cdot (1 - \beta)} \left(\frac{m_t}{l_t^X} \right)^\beta. \quad (63)$$

In long-run equilibrium, the values of quantities $\{l^X, l^Y, m, k, x\}$ and prices $\{w, p^Z, p^H, p^X, q^X, q^K\}$ are time-invariant. According to (56), we obtain the long run shadow values of physical capital as

$$\tilde{q}^K = 1 + \theta(\eta + 1)(\delta^K)^\eta. \quad (64)$$

Using (64) in (60) gives us

$$\frac{\tilde{k}}{\tilde{l}^Y} = \left(\frac{(1 - \alpha) \cdot A}{r + \delta^K + \theta r(\eta + 1)(\delta^K)^\eta + \theta(\delta^K)^{\eta+1}} \right)^{\frac{1}{\alpha}}. \quad (65)$$

Let us define

$$\Omega \equiv \alpha \left(\frac{1 - \alpha}{r + \delta^K + \theta r(\eta + 1)(\delta^K)^\eta + \theta(\delta^K)^{\eta+1}} \right)^{\frac{1-\alpha}{\alpha}}. \quad (66)$$

Substituting (65) into (57) leads to

$$\tilde{w} = \Omega \cdot A^{\frac{1}{\alpha}}. \quad (67)$$

Substituting (65) into (46) we obtain

$$\frac{\tilde{m}}{\tilde{l}^X} = \frac{1 - \beta}{\beta} \Omega \cdot A^{\frac{1}{\alpha}}. \quad (68)$$

Using (68) in (63), we find

$$\tilde{q}^X = \beta^{-\beta} (1 - \beta)^{-(1-\beta)} \Omega^\beta \cdot \frac{A^{\frac{\beta}{\alpha}}}{B}. \quad (69)$$

Without labor mobility, $l_t = l = L_{-1}/Z$ for all $t = -1, 0, 1, \dots$ is given and popula-

tion density reads as $D = 2l$. Substituting (67) into (61), we obtain the long run rental rate of land as

$$\tilde{p}^Z = \frac{(1-\chi)(1-\gamma)}{1+\rho-2\rho(1-\chi)(1-\gamma)} \Omega \cdot A^{\frac{1}{\alpha}} \cdot D. \quad (70)$$

Using (68) and (70) into (59), in long run equilibrium,

$$\tilde{p}^H = \left(\frac{r + \delta^X}{\gamma \beta^\beta (1-\beta)^{1-\beta} \cdot B} \right)^\gamma \left(\frac{(1-\chi) \cdot D}{1+\rho-2\rho(1-\chi)(1-\gamma)} \right)^{1-\gamma} \Omega^{1-\gamma(1-\beta)} \cdot A^{\frac{1-\gamma(1-\beta)}{\alpha}}. \quad (71)$$

Using (70) and (71) in (41), we obtain

$$\tilde{p}^X = (r + \delta^X) \beta^{-\beta} (1-\beta)^{-(1-\beta)} \Omega^\beta \cdot \frac{A^{\frac{\beta}{\alpha}}}{B}. \quad (72)$$

Using (70) and (71) in (58), we obtain

$$\tilde{x} = \frac{\beta^\beta (1-\beta)^{1-\beta} \gamma (1-\chi)}{1+\rho-2\rho(1-\chi)(1-\gamma)} \frac{\Omega^{1-\beta}}{r + \delta^X} \cdot A^{\frac{1-\beta}{\alpha}} \cdot B \cdot D. \quad (73)$$

Moreover, according to (54) and (68),

$$\tilde{l}^X = \frac{\delta^X \tilde{x}}{B \left(\frac{1-\beta}{\beta} \Omega \cdot A^{\frac{1}{\alpha}} \right)^{1-\beta}} = \frac{\beta \gamma (1-\chi)}{1+\rho-2\rho(1-\chi)(1-\gamma)} \frac{\delta^X}{r + \delta^X} \cdot D, \quad (74)$$

where the latter follows after substituting (73).²⁵ Substituting (74) into (55), we find

$$\tilde{l}^Y = l - \tilde{l}^X = \left(1 - \frac{2\beta\gamma(1-\chi)}{1+\rho-2\rho(1-\chi)(1-\gamma)} \frac{\delta^X}{r + \delta^X} \right) \cdot \frac{D}{2}. \quad (75)$$

With these expressions, it is easy to confirm comparative-static results. ■

Proof of Proposition 2. With integrated labor markets, recalling $\Delta = 0$, equi-

²⁵For an interior long run equilibrium to exist, it must hold that $\tilde{\ell}^X(2l) < l$, i.e.

$$\frac{\beta\gamma(1-\chi)}{1+\rho-2\rho(1-\chi)(1-\gamma)} \frac{\delta^X}{r + \delta^X} < \frac{1}{2}.$$

librium condition (17) that governs migration holds, i.e.,

$$\log\left(\frac{w_t}{w^*}\right) = (1 - \chi) \cdot \frac{\log\left(\frac{p_t^H}{p^{H*}}\right) + \rho \log\left(\frac{p_{t+1}^H}{p^{H*}}\right)}{1 + \rho}, \quad (76)$$

according to (16), where w^* and p^{H*} are the wage rate and price for housing services in the foreign economy. Since the foreign economy is in steady state by assumption and differs from the domestic economy in productivity parameters (A^*, B^*) and population density D^* only. Thus, according to (67) and (71), we have

$$\frac{\tilde{w}}{w^*} = \left(\frac{A}{A^*}\right)^{\frac{1}{\alpha}}, \quad (77)$$

$$\frac{\tilde{p}^H}{p^{H*}} = \left(\frac{A}{A^*}\right)^{\frac{1-\gamma(1-\beta)}{\alpha}}, \quad (78)$$

respectively. Let us denote the long run population density with integrated labor markets by \hat{D} . Using (77) and (78) in (76), we obtain

$$\frac{\hat{D}}{D^*} = \frac{\left(\frac{A}{A^*}\right)^{\frac{\chi+\gamma(1-\chi)(1-\beta)}{\alpha(1-\gamma)(1-\chi)}}}{\left(\frac{B^*}{B}\right)^{\frac{\gamma}{1-\gamma}}}. \quad (79)$$

This confirms comparative-static results. ■

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Online Appendix – Reversal of Migration Flows: A Fresh Look at the German Reunification

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Abstract

This Online Appendix provides further details for the empirical evidence for East Germany in the paper (data sources, discussions of construction of the data, and robustness checks) as well as further numerical results. Section 1 relates to the migration data (Fig. 1 and Fig. 2 in the main text). Section 2 shows the evolution of variables in the model not displayed in Fig. 3 and 4 in the main text, based on the same experiments. Section 3 discusses the wage data (Fig. 5 in the main text). Section 4 gives details on the empirical rental rates for housing (Fig. 6 and 7 in the main text) and provides a number of additional Figures. They are based on different sample selections to check robustness. Moreover, we report the evolution of rental rates of housing according to city size in addition to "Bundesländer" (states) and East Germany as a whole.

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1 Migration Data

- Data sources

For the period 1991–1994: ‘Wanderungsdatenbank, Leibniz-Institut für Länderkunde’.

For the period 1995–2014: ‘Wanderungsstatistik - Statistische Ämter des Bundes und der Länder’, with the following exceptions where the data comes from the ‘Statistische Landesämter’: Brandenburg 1993 and 2014, Mecklenburg-Hither Pomerania 2014, Saxony 1994, Saxony-Anhalt 2007 and 2014, Thuringia 1991-1993 and 2007-2014.

- The migration data set used for **Fig. 1** and **Fig. 2** in the main text is based on net migration balances, taking into account all movements crossing the border of administrative districts. Administrative districts correspond to NUTS 3 units in the EUROSTAT typology for all five New Laender in Germany. The districts in the New Laender were subject to numerous border reforms between 1991 and 2014, reducing their number considerably. In order to be able to compare the data over a period from 1991 to 2014, one territorial status was chosen and reconstructed for the periods with differing district-borders. The longest period not marked by big territorial reforms lasted from 1995 to 2006. Thus, we selected the territorial boundaries valid at that time. For the periods before (1991-1994) and after (2007-2014), the municipalities (corresponding to LAU2 units) were assigned to the districts to whom they belonged during the referential period and their net migration balances were added up to reconstruct the data at the district-level.
- Two former districts of Saxony-Anhalt are not included in the analysis: Anhalt-Zerbst and Dessau. During the reforms of the districts’ borders in 2007 the urban municipality Dessau was merged with the urban municipality Roßlau. Unfortunately, there is no data available distinguishing between the former Dessau and the former Roßlau. It is therefore not possible to reconstruct the district of Dessau for the time before 1995 and after 2013. In the course of the reform, several municipalities from the newly formed district of Dessau-Roßlau were attributed to Anhalt-Zerbst, rendering it impossible to reconstruct this district as well. The municipalities which belonged to these two districts are therefore not shown in the data.

2 Complementing Numerical Results

In Fig. A.1 and Fig. A.2, we display for the same experiments the evolution of the variables in the model not displayed in **Fig. 3** and **Fig. 4** in the main text, respectively.

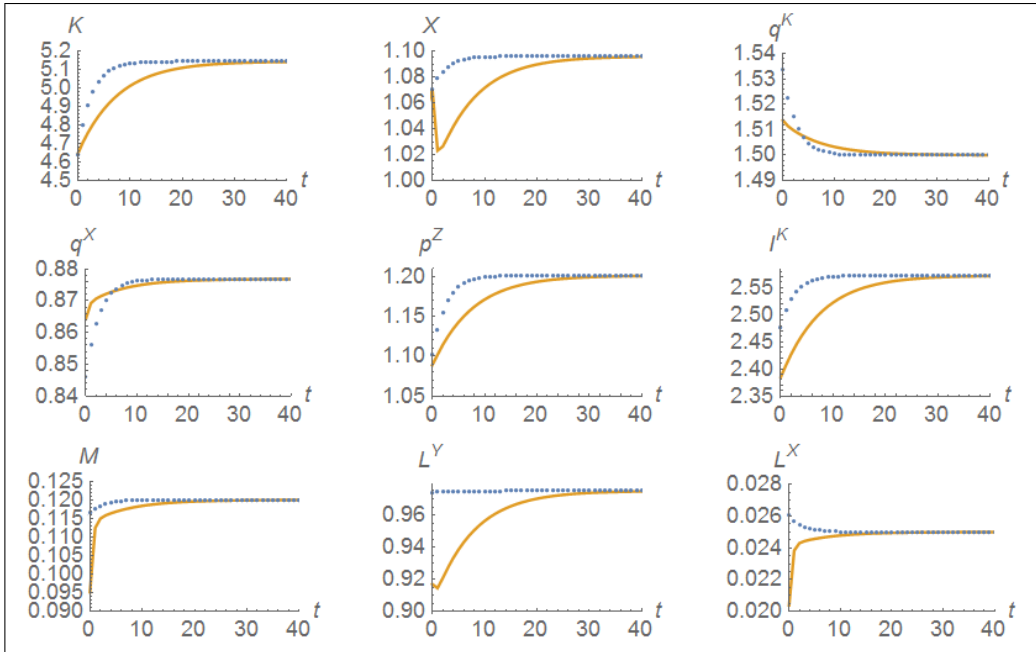


Figure A.1: Transitional dynamics for an initially capital-poor economy assuming labor market integration at $t=0$ (solid lines) and assuming that labor markets remain closed (dotted lines). Same parameter configuration as for Fig. 3 in the main text.

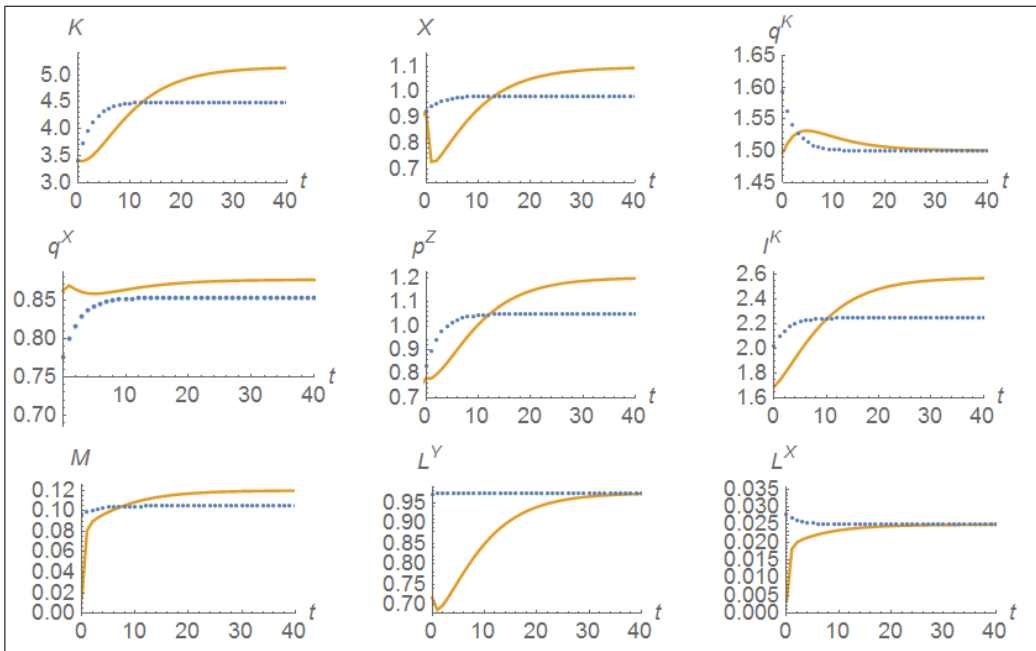


Figure A.2: Transitional dynamics for an economy that initially is capital-poor and has low TFP levels assuming labor market integration at $t=0$ (solid lines) and assuming that labor markets remain closed (dotted lines). Same parameter configuration as for Fig. 4 in the main text.

3 Wage Data

- Data source: “Entstehung, Verteilung und Verwendung des Bruttoinlandsprodukts in den Ländern der Bundesrepublik Deutschland 1991 bis 2015”, VGRdL (<http://www.vgrdl.de/VGRdL/tbls/>).
- The real wage time series employed in **Fig. 5** in the main text is based on gross wages (i.e. earnings before taxes, social contributions and payments in kind), nominal and real private household consumption and a consumption deflator.
- The consumption deflator was calculated from nominal private household consumption and real private household consumption. Real household consumption is derived from nominal private household consumption and a chain index. The current base year of the chain index is 2010. Nominal and real private household consumption is measured in million Euros.
- Gross wages are measured per employee, including civil servants, interns and trainees as well as part-time work in the main occupation.
- Fig. A.3 shows the evolution of real wages (in 2010 prices) in the five New Laender separately and for East Germany as a whole (without Berlin). There is a large increase in the 1990s that led to the (incomplete) convergence to the West German wage level shown in Fig. 5. Real wages in the New Laender as well as in West Germany changed little in the 2000s.

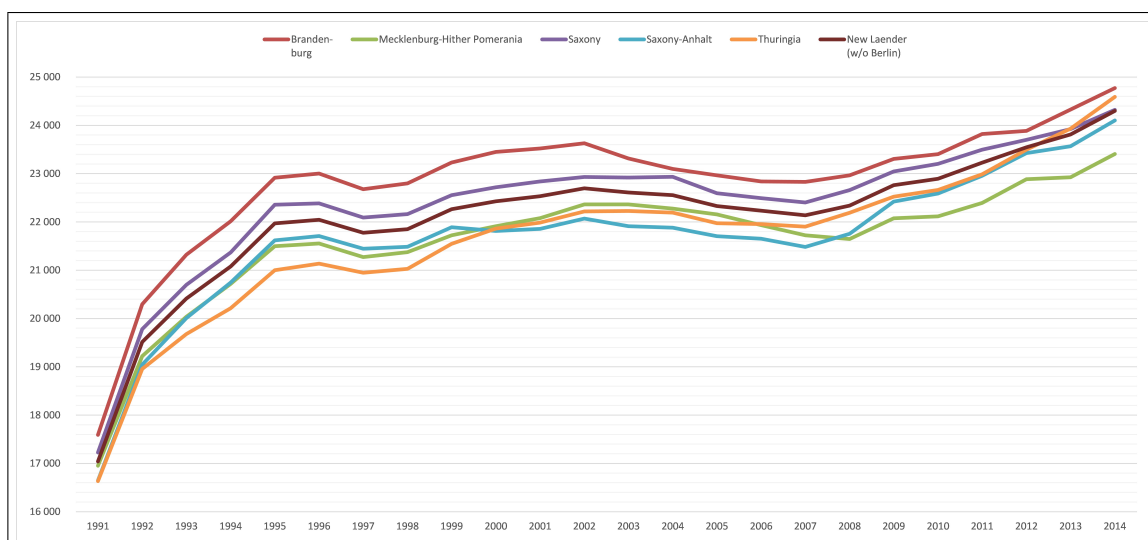


Figure A.3: Real wages per worker (in 2010 EUR) in the New Laender, 1991-2014.

4 Rental Rates of Housing

4.1 Data and Estimation Method

- Data source: German Socio-Economic Panel Study (SOEP) v31 (<http://dx.doi.org/10.5684/soep.v31>).¹
- SOEP is a representative annual household panel survey that offers detailed information on rental housing from the perspective of tenants. Because of the panel structure of the data, we are able to control for time-invariant confounders at the tenancy level. The final data set consists of 107,514 private households who live in rental apartments between 1984 and 2014 in West Germany and 34,248 private households who live in rental apartments between 1990 and 2014 in East Germany.
- To get robust estimations, we exclude the upper and the lower 1% of the unconditional rent and apartment size distribution. The final analysis is therefore restricted to apartments which

cost more than EUR 28,- (deflated) and less than EUR 1520,- (deflated), are not smaller than 26 sqm and not larger than 159 sqm.

- In addition to presenting descriptive evidence, we constructed price measures based on a standard hedonic pricing model that constructs a quality-adjusted measure of rental payments.
- Tab. A.1 describes the variables used to construct the empirical measures for the rental rates of housing. For categorical variables the reference category is printed in bold and excluded from the regression analyses.
- We specify and estimate the hedonic pricing model of rental unit i in year t by

$$(1) \quad p_{it}^H = \sum_{j=1}^k \beta_j \cdot x_{jit} + \sum_{R=1}^N \sum_{t=1}^T \gamma_{t,R} \cdot \mathbf{1}(i \in \mathcal{S}_R) \cdot \mathbf{1}(i \in \mathcal{S}_t) + \eta_i + u_{it},$$

where p_{it}^H denotes the rent (price for housing services) per square meter, x_{jit} are measures of apartment quality (see Tab A.1) that are indexed by $j \in \{1, \dots, k\}$, \mathcal{S}_R denotes the set of observations in region $R \in \{1, \dots, N\}$, $\mathbf{1}(i \in \mathcal{S}_R)$ is a dummy variable that equals one if rental unit i is located in region R , \mathcal{S}_t denotes the set of observations in period t , $\mathbf{1}(i \in \mathcal{S}_t)$ is a dummy variable that equals one if rental unit i is observed in period t , η_i is a fixed effect for rental unit i (included if and only if a rental unit is observed more than once), and u_{it} is the residual.

¹For background information on SOEP, see Wagner, Gert G., Joachim R. Frick, and Jürgen Schupp (2007). The German Socio-Economic Panel Study (SOEP): Scope, Evolution and Enhancements, *Schmollers Jahrbuch - Journal of Contextual Economics* 127, 139-169.

- The estimated coefficients of the interaction terms, $\gamma_{t,R}$, can be interpreted as the mean quality-adjusted price measure in region R and period $t \in \{1, \dots, T\}$.
- The unadjusted and quality-adjusted measure of rental payments are in addition rescaled to get an index with the average rent in East Germany in 1990 as base value (= 100).
- For each quality measure with missing values, except size, we replace missing values by zero and include an additional dummy variable coded one if the value of the original variable is imputed (and zero otherwise). Results presented under the label “Sample without rental units where not all quality indicators are available” exclude observations with missings in apartment characteristics.
- Results presented under the label “Sample without rental units that are observed only once” exclude tenancies with only one observation and control for fixed effects (η_i) in the hedonic pricing model. Using rental unit fixed effects addresses the possibility that unobserved and time-constant covariates are correlated with quality measures. In this case OLS estimators would be biased leading to residuals which are not correctly calculated. By including rental unit fixed effects, we are able to control for these unobserved time-invariant confounders. We implement the rental unit fixed effects by calculating mean values of each variable in the hedonic pricing model for each rental unit and calculate for each observation the difference between the values of the original variables and the mean values for each rental unit. Instead of the original variables, we then use these demeaned variables.

Table A.1: Variable List

Size

Size of an apartment measured in square meters.

Type of House

A categorical variable that identifies the type of building regarding the number of rental units. Each category is represented in the regression analysis by a dummy variable. The categories are

- **1-2 Family Detached House**
- 1-2 Family Nondetached House
- Apartment in 3-4 Unit Building
- Apartment in 5-8 Unit Building
- Apartment in 9+ Unit Building
- High-Rise Apartment Building
- Other Buildings

Residential Area

A categorical variable that identifies the type of residential area in which the apartment is located. Each category is represented in the regression analysis by a dummy variable. The categories are

- **Residential Area Old**
- Residential Area New
- Mixed Area
- Other Areas

Year of Construction

A categorical variable that identifies the year of construction. Each category is represented in the regression analysis by a dummy variable.

The categories are

- **Before 1918**
- 1918 to 1948
- 1949 to 1971
- 1972 to 1980
- 1981 to 1990
- 1991 to 2000
- Since 2001

Apartment Condition

A categorical variable that measures the subjective valuation of the apartment condition. Each category is represented in the regression analysis by a dummy variable. The categories are

- In Good Condition
- Partly in Need of Renovation
- **In Need of Complete Renovation**

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Table A.1: Variable List <continued>

Apartment Equipment

Each type of equipment is represented in the analysis by a dummy variable that indicates its existence. The various equipment we control for are

- Central Heating
- Basement
- Balcony or Terrace
- Garden

Reduced Payments

Two different types of reduced payments are identified in the regression analysis by dummy variables. First, whether the apartment is subsidized by the government and second, whether the apartment is offered by the landlord at a reduced price because the landlord is either the employer and thus the reduction in the rental price is an implicit earning or a relative of the tenant and thus the reduction in the rental price is a gift.

Elapsed Tenure

Elapsed tenure of a tenancy measured in years.

4.2 Sample Sizes and Results

- We present three sets of results for the evolution of rental rates for housing over time, distinguished by their level of aggregation to regional units.
 - West Germany vs. East Germany; see Tab. A.2 for sample sizes per year.
 - Fig. A.4 shows the unadjusted price index based on the full sample.
 - Fig. A.5 shows the hedonic price index based on the full sample.
 - Fig. A.6 shows the unadjusted price index based on the sample without rental units that are observed only once.
 - Fig. A.7 shows the hedonic price index based on the sample without rental units that are observed only once; the regression includes rental unit fixed effects.
 - Fig. A.8 shows the unadjusted price index based on the sample without rental units where not all quality indicators are available.

Fig. A.9 shows the hedonic price index based on the sample without rental units where not all quality indicators are available.

- The five New Laender in East Germany plus Berlin East; see Tab. A.3 for sample sizes per year.

Fig. A.10 shows the unadjusted price index based on the full sample.

Fig. A.11 shows the hedonic price index based on the full sample.

Fig. A.12 shows the unadjusted price index based on the sample without rental units that are observed only once.

Fig. A.13 shows the hedonic price index based on the sample without rental units that are observed only once; the regression includes rental unit fixed effects.

Fig. A.14 shows the unadjusted price index based on the sample without rental units where not all quality indicators are available.

Fig. A.15 shows the hedonic price index based on the sample without rental units where not all quality indicators are available.

- Cities according to four categories of population size: $< 20,000$ inhabitants ($< 20K$), $20,000$ - $100,000$ inhabitants ($20K$ to $100K$), $100,000$ - $500,000$ inhabitants ($100K$ to $500K$), $> 500,000$ inhabitants ($> 500K$); see Tab. A.4 for sample sizes per year.

Fig. A.16 shows the unadjusted price index based on the full sample.

Fig. A.17 shows the hedonic price index based on the full sample.

Fig. A.18 shows the unadjusted price index based on the sample without rental units that are observed only once.

Fig. A.19 shows the hedonic price index based on the sample without rental units that are observed only once; the regression includes rental unit fixed effects.

Fig. A.20 shows the unadjusted price index based on the sample without rental units where not all quality indicators are available.

Fig. A.21 shows the hedonic price index based on the sample without rental units where not all quality indicators are available.

- **Fig. 6** in the main text shows the rental rate of housing for the full sample without controlling for quality indicators of the apartment (i.e. Fig. 6 is purely descriptive). It corresponds to Fig. A.4.
- **Fig. 7** in the main text shows the quality-adjusted rents for the New Laender including rental unit fixed effects (“Sample without rental units that are observed only once”, i.e. tenancies with only one observation are excluded). It corresponds to Fig. A.13.
- All results on the evolution of rental payments in East German regional units basically suggest the same pattern. Rental payments per square meter were gradually increasing in the 1990s approximately by 500-600 percent and were quite stagnant thereafter.

4.2.1 Regional Unit: East and West Germany

Table A.2: Sample Size per Year

Survey Year	West Germany			East Germany		
	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings
1984	3624	2863	0	0	0	0
1985	3199	3101	0	0	0	0
1986	2992	2895	2677	0	0	0
1987	2946	2842	2596	0	0	0
1988	2797	2725	2474	0	0	0
1989	2726	2669	2390	0	0	0
1990	2656	2600	2286	606	508	5
1991	2669	2595	2373	497	475	33
1992	2692	2608	2366	1286	1187	93
1993	2693	2617	2362	1246	1223	79
1994	2652	2564	2330	1218	1195	157
1995	2833	2695	2421	1182	1152	347
1996	2755	2655	2453	1172	1133	431
1997	2669	2560	2356	1144	1101	490
1998	3014	2770	2828	1196	1135	1101
1999	2826	2710	2687	1162	1119	1089
2000	4795	4075	4511	1787	1559	1681
2001	4297	4115	4049	1624	1574	1531
2002	4182	3968	3904	1605	1539	1506
2003	3996	3825	3200	1572	1518	1296
2004	3891	3712	2806	1524	1480	1176
2005	3780	3581	2619	1468	1421	1121
2006	4083	3759	2790	1587	1503	1180
2007	3775	3591	2954	1492	1445	1228
2008	3483	3344	3193	1429	1383	1329
2009	3235	3085	2951	1351	1313	1261
2010	2969	2860	2690	1245	1212	1163
2011	3956	3480	3609	1577	1469	1465
2012	3989	3713	3654	1622	1547	1517

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Table A.2: Sample Size per Year <continued>

Survey Year	West Germany			East Germany		
	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings
2013	5416	4227	4856	1665	1548	1530
2014	5924	3636	4784	1991	1351	1638
Total	107514	98440	87169	34248	32090	24447

Note: The column labeled "Full" refers to the full sample. The columns labeled "W/o One-Obs.Tenancies" and "W/o Covariate Missings" refer to the samples without tenancies with only one observation and without covariate missings, respectively. Source: SOEP V31 and authors' calculations.

4.2.1.1 Full sample

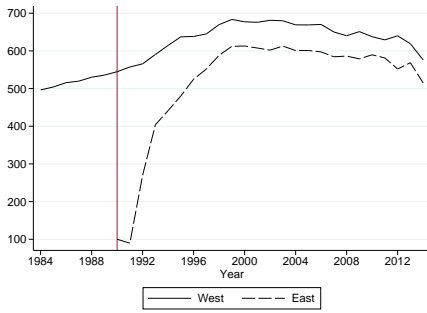


Figure A.4: Unadjusted Price Index

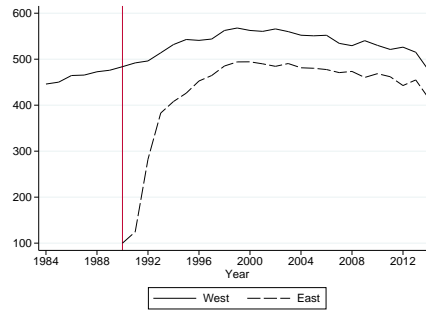


Figure A.5: Hedonic Price Index

4.2.1.2 Sample without rental units that are observed only once

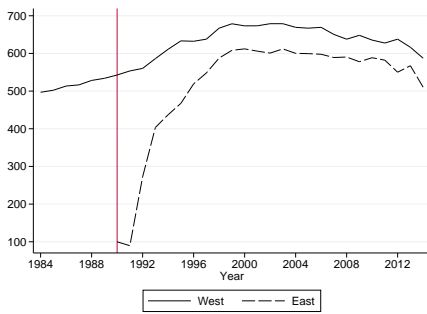


Figure A.6: Unadjusted Price Index

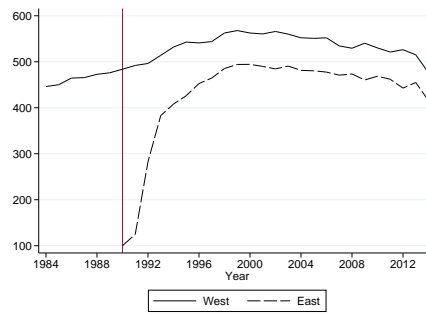


Figure A.7: Hedonic Price Index

4.2.1.3 Sample without rental units where not all quality indicators are available



Figure A.8: Unadjusted Price Index

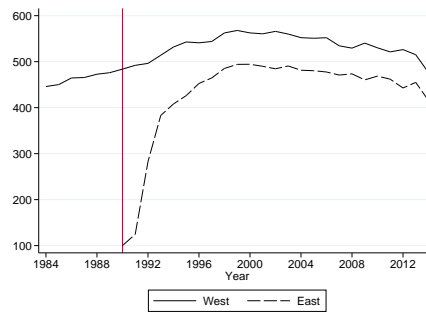


Figure A.9: Hedonic Price Index

4.2.2 Regional Unit: Federal States

Table A.3: Sample Size per Year

Survey Year	Berlin-East			Brandenburg			Mecklenburg-HP			Saxony			Saxony-Anhalt			Thuringia		
	Full	W/o One-Obs. Tenan-cities	W/o Covari-ate Miss-ings	Full	W/o One-Obs. Tenan-cities	W/o Covari-ate Miss-ings	Full	W/o One-Obs. Tenan-cities	W/o Covari-ate Miss-ings	Full	W/o One-Obs. Tenan-cities	W/o Covari-ate Miss-ings	Full	W/o One-Obs. Tenan-cities	W/o Covari-ate Miss-ings	Full	W/o One-Obs. Tenan-cities	W/o Covari-ate Miss-ings
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	104	84	1	90	77	1	47	41	0	167	135	2	112	101	0	86	70	1
1991	87	85	6	67	63	7	43	39	0	146	139	10	80	77	4	74	72	6
1992	138	129	7	193	175	18	137	123	5	407	378	42	237	220	7	174	162	14
1993	136	135	7	183	176	13	131	128	4	400	392	36	228	225	7	168	167	12
1994	133	131	10	179	175	27	134	132	15	383	378	54	216	209	26	173	170	25
1995	127	125	27	173	171	52	142	136	36	376	366	112	204	199	61	160	155	59
1996	127	125	32	181	174	73	138	132	50	364	357	131	200	192	76	162	153	69
1997	128	122	43	185	179	83	130	123	57	357	349	146	191	181	87	153	147	74
1998	126	120	111	191	176	178	128	120	124	377	365	344	213	203	196	161	151	148
1999	121	118	108	176	171	166	126	120	123	367	350	342	211	204	195	161	156	155
2000	210	185	191	303	265	285	190	159	181	558	489	526	286	258	267	240	203	231
2001	192	187	174	281	275	265	174	166	165	502	484	472	258	254	247	217	208	208
2002	194	188	174	289	271	271	162	159	156	490	470	458	254	245	242	216	206	205
2003	192	183	149	279	268	227	158	155	141	485	469	401	248	240	208	210	203	170
2004	186	177	136	264	258	196	157	154	130	467	459	372	238	229	185	212	203	157
2005	170	163	127	264	251	190	154	151	125	451	439	351	230	224	179	199	193	149
2006	175	168	129	297	279	219	157	149	120	495	472	365	247	232	188	216	203	159
2007	169	165	140	273	264	225	147	140	121	473	459	386	229	223	189	201	194	167

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Table A.3: Sample Size per Year <continued>

Survey Year	Berlin-East			Brandenburg			Mecklenburg-HP			Saxony			Saxony-Anhalt			Thuringia		
	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full Sample	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings
2008	165	164	149	257	249	236	143	139	135	457	438	422	213	207	203	194	186	184
2009	167	162	152	243	235	224	136	132	126	426	417	399	196	192	184	183	175	176
2010	144	138	131	218	212	203	129	127	118	388	382	360	193	186	183	173	167	168
2011	179	170	165	263	244	239	181	164	164	461	439	428	260	239	249	233	213	220
2012	188	182	175	246	235	227	190	182	178	502	479	462	260	244	250	236	225	225
2013	193	178	178	271	250	244	193	181	183	503	475	455	279	247	256	226	217	214
2014	230	153	190	337	221	283	231	152	188	583	412	473	329	221	270	281	192	234
Total	3981	3737	2712	5703	5314	4152	3658	3404	2645	10585	9992	7549	5612	5252	3959	4709	4391	3430

Note: The column labeled "Full" refers to the full sample. The columns labeled "W/o One-Obs.Tenancies" and "W/o Covariate Missings" refer to the samples without tenancies with only one observation and without covariate missings, respectively. Source: SOEP V31 and authors' calculations.

4.2.2.1 Full sample

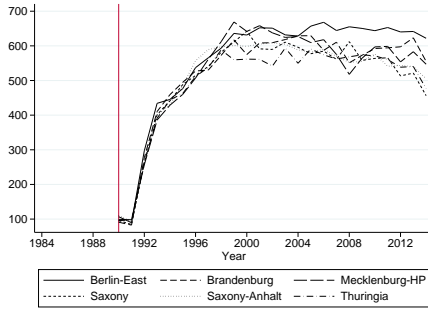


Figure A.10: Unadjusted Price Index

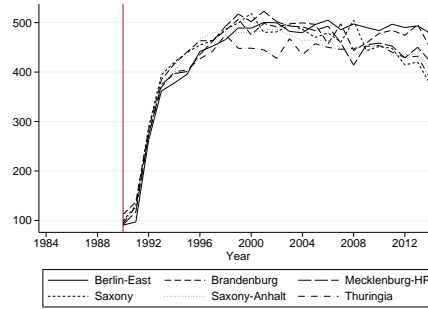


Figure A.11: Hedonic Price Index

4.2.2.2 Sample without rental units that are observed only once

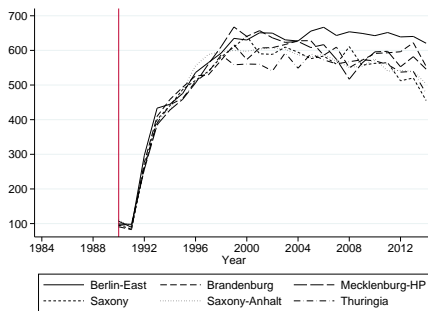


Figure A.12: Unadjusted Price Index

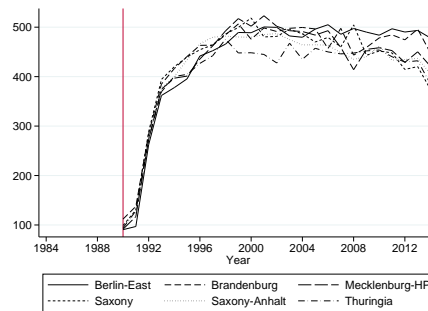


Figure A.13: Hedonic Price Index

4.2.2.3 Sample without rental units where not all quality indicators are available

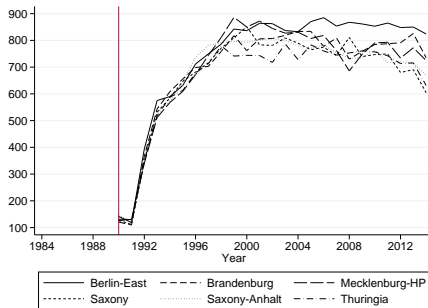


Figure A.14: Unadjusted Price Index

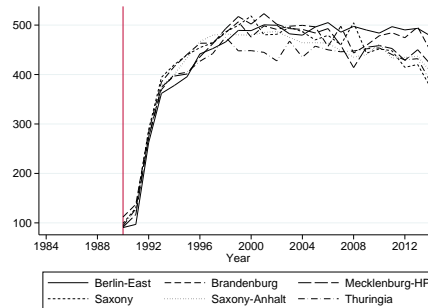


Figure A.15: Hedonic Price Index

4.2.3 Regional Unit: City Size

Table A.4: Sample Size per Year

Survey Year	≥ 500k			100k to 500k			20k to 100k			< 20k		
	Full	W/o One-Obs. Tenancies	W/o Co-variate Missings	Full	W/o One-Obs. Tenancies	W/o Co-variate Missings	Full	W/o One-Obs. Tenancies	W/o Co-variate Missings	Full	W/o One-Obs. Tenancies	W/o Co-variate Missings
1984	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	192	192	2	100	100	0	94	94	0	49	49	0
1991	188	188	16	88	88	4	70	70	2	60	60	2
1992	377	377	25	259	259	10	268	268	14	239	238	29
1993	405	402	25	270	267	10	296	291	13	275	263	31
1994	398	392	41	271	265	38	275	273	25	274	265	53
1995	393	384	102	260	254	71	268	260	72	260	253	101
1996	383	373	124	252	247	88	268	257	94	269	256	125
1997	342	329	131	298	288	124	251	240	109	253	244	126

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Table A.4: Sample Size per Year <continued>

Survey Year	≥ 500k			100k to 500k			20k to 100k			< 20k		
	Full	W/o One-Obs. Tenancies	W/o Co-variate Missings	Full	W/o One-Obs. Tenancies	W/o Co-variate Missings	Full	W/o One-Obs. Tenancies	W/o Co-variate Missings	Full	W/o One-Obs. Tenancies	W/o Co-variate Missings
1998	363	343	330	300	292	289	262	243	234	271	257	248
1999	355	344	330	301	292	290	253	241	233	253	242	236
2000	532	472	498	443	387	424	360	305	337	452	395	422
2001	497	481	461	406	400	386	315	297	302	406	396	382
2002	510	486	470	391	377	374	309	292	290	395	384	372
2003	523	501	416	368	360	316	286	275	234	395	382	330
2004	504	486	372	359	349	291	275	264	202	386	381	311
2005	418	400	304	429	423	332	452	438	359	169	160	126
2006	448	423	321	453	428	342	489	469	374	197	183	143
2007	435	422	350	417	408	360	456	440	372	184	175	146
2008	420	403	387	407	396	382	425	411	400	177	173	160
2009	397	383	372	388	382	361	396	386	371	170	162	157
2010	354	340	330	374	366	347	361	352	337	156	154	149
2011	420	401	390	483	443	454	463	428	421	211	197	200
2012	479	460	449	430	406	409	505	479	465	208	202	194
2013	512	473	467	447	414	421	515	476	464	191	185	178

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Table A.4: Sample Size per Year <continued>

Survey Year	≥ 500k			100k to 500k			20k to 100k			< 20k		
	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings	Full	W/o One-Obs. Tenancies	W/o Covariate Missings
2014	607	407	483	534	361	454	614	414	500	236	169	201
Total	10452	9862	7196	8728	8252	6577	8526	7963	6224	6136	5825	4422

Note: The column labeled "Full" refers to the full sample. The columns labeled "W/o One-Obs. Tenancies" and "W/o Covariate Missings" refer to the samples without tenancies with only one observation and without covariate missings, respectively. $k \doteq 1000$ inhabitants. Source: SOEP V31 and authors' calculations.

4.2.3.1 Full sample



Figure A.16: Unadjusted Price Index



Figure A.17: Hedonic Price Index

4.2.3.2 Sample without rental units that are observed only once

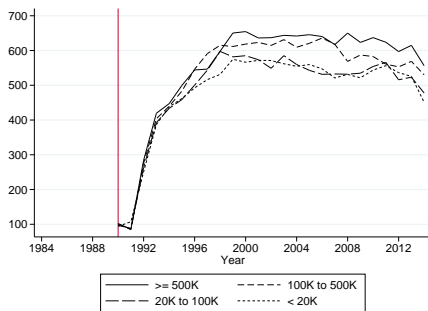


Figure A.18: Unadjusted Price Index



Figure A.19: Hedonic Price Index

4.2.3.3 Sample without rental units where not all quality indicators are available

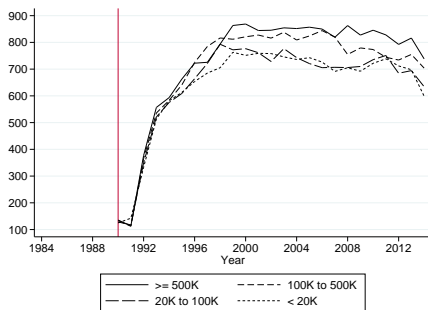


Figure A.20: Unadjusted Price Index



Figure A.21: Hedonic Price Index

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