To converge or not to converge: accounting for the German reunification

Daniel Fehrle, Vasilij Konysev

Angaben zur Veröffentlichung / Publication details:

Fehrle, Daniel, and Vasilij Konysev. 2025. "To converge or not to converge: accounting for the German reunification." Augsburg: Volkswirtschaftliches Institut, Universität Augsburg.

University of Augsburg
Institute of Economics

Daniel Fehrle, Vasilij Konysev

To converge or not to converge: Accounting for the German reunification

Economics Discussion Paper Series
No. 348, April 2025

University of Augsburg
Institute of Economics

To converge or not to converge: Accounting for the German reunification

Daniel Fehrle[a] and Vasilij Konysev[b]

[a]Kiel University, Department of Economics, Wilhelm-Seelig-Platz 1, 24118 Kiel, Germany, fehrle@economics.uni-kiel.de

[b]University of Augsburg, Department of Economics, Universitätsstraße 16, 86159 Augsburg, Germany, vasilij.konysev@uni-a.de

April 4, 2025

JEL classification: E13, E24, N14, O11, O47
Keywords: German reunification; Regional convergence; Wedge-growth accounting; Comparative inefficiencies

Abstract

German reunification in 1990 marked the first sudden integration of a socialist and capitalist economy. Despite East Germany's (EG) economic catch-up with West Germany (WG), the integration remains unfinished, as indicated by per capita output in EG still being about one-third lower. To study this unfinished regional convergence, we apply wedge-growth accounting using a human capital-augmented, two-sector, two-region model, incorporating labor supply constraints to capture key qualitative differences between EG and WG. Our findings show that sectoral labor and capital wedges are similar within regions and have significantly converged between regions, with EG initially overusing inputs. While productivity in the nontradable goods sector has fully converged, the tradable sector in EG remains less productive than in WG. Counterfactual analysis suggests that this productivity gap, together with persistent net inflows to EG, explains EG's lower economic activity. However, reducing the inflows would result in significant welfare losses in EG. Furthermore, we account for the reunification event, identifying a substantial productivity catch-up in EG between 1989 and 1991. Our findings offer clear policy insights, highlighting the trade-offs between economic activity and fiscal transfers.

Acknowledgment: We thank Kai Carstensen, Uwe Jensen, Thomas Lubik, and Alfred Maußner for their valuable comments. The paper significantly benefits from comments during the Seminar on Statistics and Econometrics at Kiel University.

1 INTRODUCTION

A third of a century after the German reunification in 1990, economic differences between the area of the former East and West Germany (EG and WG from here on)[1] are still present. For instance, the poorest state in terms of gross national income per capita in WG is still richer than the richest state in EG. Even more problematic, the catch-up process of EG decelerated widely, if not stalled, at two-thirds of WG's per capita output (70 % per working-age adult output). While the reasons for the lack of economic convergence are still under debate, it has become a political issue, linked to more extremist electoral behavior in EG. Moreover, the German reunification goes beyond its country-specific context. It was the first time in history that a socialist and a capitalist economy were suddenly unified, offering a unique opportunity to study the full integration of a planned economy into a developed market system. With minimal frictions—such as a shared language between regions—this case provides valuable insights for future economic integration.

We shed new light on the reunification process by measuring distortions—so-called wedges—in the resource allocation by reference to a structural model (Chari et al., 2007) for both regions of Germany separately from 1991 to 2019.[2] A comparison of these wedges between EG and WG highlights the segments and sectors where the allocation efficiency and productivity were already alike, are already converged, still converging, or convergence stalled. Further, to quantify the differences of the wedges in economic terms, we feed back wedges of one region or sector into their counterpart and examine the impact on both economic activity and welfare. The whole procedure quantifies through which channel the drivers of the economic differences account and helps to evaluate, which explanations in the literature align with our findings and where future research and policy have to focus.

For this purpose, we model the reunified economy by two integrated regions, representing EG and WG, each with two sectors, namely a tradable and nontradable goods sector. This way, we account for the insight of Boltho et al. (2018) and Burda and Severgnini

[1] In this paper, the area of the former of EG includes the "neue Bundesländer" Mecklenburg-Western Pomerania, Brandenburg, Saxony-Anhalt, Saxony, and Thuringia. However, we attribute East Berlin to WG, that includes throughout the "alte Bundesländer" Baden-Württemberg, Bavaria, Bremen, Hesse, Hamburg, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saarland, and Schleswig-Holstein plus whole Berlin.

[2] We end our analysis with the last year before COVID-19, 2019. This way, we avoid contamination of the comparison with this exogenous shock. Note that Corona rules like school and hospitality closures or mask mandates were set on the federal state level, with sizable differences between WG and EG states. Some rules lasted until 2023.

(2018) that EG's lower Gross Domestic Product (GDP) per capita is connected especially to the tradable goods sector. Furthermore, building on the work of Fernández-Villaverde et al. (2023), our two-sector model enables the differentiation of the value of trade and transfers between WG and EG.

From our model, we derive the optimal conditions for the input use of labor and capital in each sector and the optimal conditions for the household for aggregated labor and capital supply. The realized ratios of the optimality conditions between the sectors with respect to one input factor indicate the efficiency of the sectoral input allocation. Analogously, the ratio of the optimal conditions of leisure and labor and of consumption today and tomorrow's return on investment indicates the efficiency of the aggregated input allocation—the labor and capital wedges. We add a quantity constraint to labor supply to account for periods of high unemployment, which had been especially severe in EG. We map this constraint to a wedge between the desired marginal rate of substitution between labor and consumption and the realized, constrained one. Furthermore, we treat exogenous expenditure quantities—government consumption and net outflows—separately to account for continuing different signs in net outflows (resource wedges). We consider human capital due to a substantial, enduring interior migration of young educated from EG to WG (e.g. Fuchs-Schündeln and Schündeln (2009), Haußen and Übelmesser (2015), and Seegers and Knappe (2019)) and a superior initial human capital endowment in EG (see Fehrle and Konysev, 2025) which was general and usable in the reunified economy (Fuchs-Schündeln and Izem, 2012). We then measure human capital adjusted Total Factor Productivity (TFP) in each sector (productivity wedges). Lastly, differences in the regional intertemporal marginal rate of substitution enable us to account for the financial market efficiency (bond wedge).

We find that sectoral labor and capital wedges are similar within regions. Further, we find convergence between regions, resulting in minor differences between the regions in 2019 despite a comparatively substantial initial overuse of inputs in EG. Human capital and the quantity constraints on labor supply achieved nearly full convergence as well. Likewise, the bond wedge is balanced from the late-1990s onward. While productivity of the nontradable goods sector also converges completely, the productivity in the tradable goods sector in EG nearly stalls at three-quarters of WG's tradable goods sector productivity. Unlike the other wedges, the productivity measures depend on local prices. However, a back-of-the-envelope calculation suggests that this contributes little.[3] Regarding exoge-

[3]Additionally, our productivity measures are not affected by sociodemographic factors, as they are human-

nous demand components: first, net inflows to EG decline from nearly 75 % to 15 % of GDP within the first 20 years after reunification, where they have plateaued since due to a decelerating convergence where WG realizes positive net outflows over the whole period considered. Second, government consumption amounts constantly around 20 % of GDP in WG and falls from close to 40 % to 27 % in EG.

Counterfactual simulations indicate that balancing inflows in EG and closing the remaining gap in tradable goods sector efficiency would bring EG's economic activity to WG's level. Alternatively to closing the productivity gap, maintaining the initial gaps in the labor-related wedges between the regions could also close the difference in economic activity. However, such maintenance comes in our specification with significant welfare losses in EG. The realized convergence to the WG labor wedges has reduced these losses by about two-thirds compared to a hypothetical immediate alignment. While the productivity gap results in sizable welfare losses, amounting to one-third of consumption-equivalent welfare, the gains from the achieved productivity catch-up are of a similar magnitude. Inflows, while reducing economic activity significantly, provide welfare gains in this magnitude as well for EG.

In addition to the economic process after the actual reunification in 1990, we use the results from Fehrle and Konysev (2025), who conduct a wedge-growth accounting analysis for the segregated Germanies until 1989, and compare them with our findings for 1991. This way, we account implicitly for the reunification itself, which has been difficult to study so far due to data and valuation challenges. We find that EG experience an impressive productivity catch-up. TFP growth rates in EG surged. The relative TFP levels of EG to WG improve significantly between 1989 and 1991—across a broad spectrum of purchasing power conversion rates. The capital wedge in EG is similar to WG in the late 1980s, while in 1991 the capital wedge of EG spikes and returns until the mid-1990s. The WG capital wedge slightly decreases in the aftermath of the actual reunification. Before reunification, the labor wedge in EG is substantially higher than in WG. The wedges in both regions remain stable between 1989 and 1991. EG's labor wedge started to converge only after 1991.

We gain further insights by examining the role of demographics by differentiating between GDP growth, GDP per capita, and GDP per working-age adult following Fernández-Villaverde et al. (2023). We find minor differences between the regions. Further, we

capital adjusted and independent of the working-age-population ratio.

confirm the robustness of our human capital-adjusted TFP measure by comparing it with the traditional Solow residual approach.

Our findings have important policy implications. The welfare benefits from inflows make policy changes to increase economic activity—like halting transfers—politically challenging. Productivity improvements in the tradable sector seem politically more feasible and could create political conditions necessary to reduce transfers, yet concrete reforms are less obvious. We find that, comparatively, EG faces no lack of inputs, rather an excessive use. This input allocation, together with the balanced bond wedge from the late 1990s onward, indicates that continued inflows into EG cannot be justified by improvements in allocation efficiency. Similarly, excessive labor input challenges the goals of Keynesian unemployment policy in EG.

The approach to account for market distortions by employing wedges between optimal conditions and using them to calculate counterfactuals follows Chari et al. (2007). However, they focus on the business cycle frequency (business cycle accounting). Lu (2012) and del Río and Lores (2021) adapt the framework for a medium-run analysis—wedge-growth accounting. Additionally, in line with Lu (2012), we follow Hall and Jones (1999) to account for human capital. Fernández-Villaverde et al. (2023) apply a two-integrated-regions, tradable-and-nontradable-goods-sectors model to examine the non-convergence of wedges between North and South Italy within the wedge-accounting framework and quantify the impact of the wedges' average gaps between regions on economic activity.[4] In line with our findings, they emphasize the depressing impact of net inflows on economic activity in South Italy. In the spirit of a two integrated region model, Chodorow-Reich et al. (2023) integrate the Greek economy in the European Monetary Union to account for the Greek Depression from 2007 to 2017. Fehrle and Huber (2022) perform the wedge-accounting for the reunified Germany, yet they model a one-region, one-sector economy and focus on the Great Recession. Gourinchas and Jeanne (2013), Ohanian et al. (2018), and Rothert and Short (2023) apply bond wedges to account for distortions in international trade and between regional savings and investment. Cheremukhin et al. (2017), Cheremukhin et al. (2024), and Fehrle and Konysev (2025) use the wedge accounting framework with constraints on goods' quantities to account for economic development in command economies, namely Soviet Russia, mainland China, and the German Democratic Republic (GDR), respectively. Further, Fehrle and Konysev (2025) adapt the constrained

[4]In contrast, we account for time-dependent differences in the wedges' trajectories.

labor supply framework to account for unemployment in the Federal Republic of Germany.

The literature addresses the unfinished convergence in productivity and excessive unemployment observed in EG following reunification. Most similar to our study, Burda and Severgnini (2018) measure sectoral aggregated Solow residuals (not human capital adjusted TFP) for EG and WG from 1991–2015, and cross-sectoral labor productivity in the early 2010s. They also find that productivity convergence slowed down in the late 1990s and that the productivity gap was smaller in the nontradable sector. Mertens and Mueller (2022) confirm that regional price level differences do not account for the productivity gap, aligning with our results. Bachmann et al. (2022) attribute the gap to disincentives for productive firms to grow in EG, fearing the loss of monopsony power in the labor market by reaching a size threshold that triggers mandatory collective bargaining. Heise and Porzio (2022) find that spatial labor market frictions have only a limited effect on the productivity gap. Klodt (2000) and Sinn (2002), argue that subsidies can distort investment decisions, leading to capital misallocation and hindering productivity growth, echoing the detrimental effects of subsidies observed in the context of German reunification. Further, Sinn (2002) argues that the massive transfer payments from W,G to EG after reunification, akin to the Dutch Disease, inflated the EG economy, hindered the development of a competitive manufacturing sector, and ultimately slowed down economic convergence.

Regarding unemployment, Snower and Merkl (2006) attributes the high unemployment rates in the late 1990s and early 2000s to large inflows into EG. Akerlof et al. (1991), Sinn and Sinn (1992), and Sinn (2002) argue that excessively high wages in the former GDR contributed significantly to unemployment. Uhlig (2006, 2008) highlights a mechanism for the observed lower productivity and higher unemployment in EG. He demonstrates that a combination of labor search frictions and network externalities can lead to an equilibrium where one region (EG) experiences high unemployment, low productivity, and persistent emigration and one region has low unemployment, high productivity, and no emigration (WG).

Beyond unfinished convergence and unemployment, Burda (2008) emphasizes the significant adjustment costs associated with the integration process. Boltho et al. (2018) compare the convergence experiences of EG and Southern Italy, highlighting EG's superior performance comparatively. In contrast to the findings of Fuchs-Schündeln and Izem (2012) that GDR human capital was generally usable in the reunified Germany, Canova and Ravn (2000) argue that German reunification can be modeled as a mass immigration of low-skilled workers. They argue that the presence of a generous welfare state can exacerbate economic challenges, leading to prolonged recessions and low investment. Fuchs-Schündeln et al. (2010) analyzes income inequality within EG and WG, respectively: while initial income variance was lower in EG, it became larger than in WG in the early 2000s.

The effects of reunification on WG have received less attention. Abadie et al. (2015), later revisited by Klößner et al. (2018) and Abadie (2021), apply the synthetic control method to construct a counterfactual scenario for WG without reunification. Their findings indicate a significant negative impact on WG's economic activity, accumulating to 8 % of GDP per capita in 1990 over the period from 1990 to 2003.

The remainder of the paper is organized as follows. First, we briefly discuss our data processing and explore the resulting data descriptively. Afterward, we introduce the two-sector two-region general equilibrium model and continue with the quantitative exercises, i.e., measuring the wedges and analyzing their impact via counterfactual experiments. We discuss our findings in light of the literature and political implications. Finally, the paper concludes. An appendix provides details about our data, model solution, and results.

2 Data

Here, we first outline the data sources and processing, while we discuss the details in the Appendix A. Afterward, the section provides a descriptive data analysis, focusing on key features and convergence that will guide the model-based analysis in the subsequent sections.

2.1 Data definitions, sources, and processing

Our definition of tradable and nontradable goods follows Fernández-Villaverde et al. (2023): services are nontradable, and all other goods are tradable.[5]

Our main source is the Federal Statistical Office of Germany and the statistical offices of the German states. Arbeitskreis "Volkswirtschaftliche Gesamtrechnungen der Länder" (2023) (AVGRL) reports the System of National Accounts (SNA) (ESA 2010) on the German state level and for former EG and WG (both with and without Berlin). For our purposes, we have to process the data for several reasons.

[5] A more granular distinction between tradable and nontradable goods as, e.g., in Chodorow-Reich et al. (2023) is impossible due to a lack of more sectoral disaggregated regional data on investments and depreciation rates.

First, note that the residuum between the AVGRL regional GDP—the sum of regional sectoral output—and regional absorption (C+I+G) is of interest as the residuum represents net outflows. More precisely, the residuum consists of the trade balance with the other region and the rest of the world, governmental transfers between the regions, and net inter-regional traveling expenses—spatial net outflows—and the change of inventories—net outflows in time (Arbeitskreis "Volkswirtschaftliche Gesamtrechnungen der Länder", 2021). However, by default, the sectoral output is reported as value-added, i.e., at production costs, and absorption in market prices. Thus, a correction to the same prices is necessary. To translate the sectoral output from production costs to market prices, we use the report of Statistisches Bundesamt (2022) on taxes and subsidies on goods on the sectoral level.

Second, we aggregate the sectoral and regional human capital data from microdata using the German Socio-Economic Panel by Liebig et al. (2019) (SOEP).[6] Third, we have to construct data on sectoral hours worked before 2000 which are missing so far, where we also make use of the SOEP. Lastly, the denominator of regional unemployment rates does not include self-employed persons before 1994, which we also correct.

We consider the quality losses due to the necessary corrections as minor, and report the detailed measures and discussion that lead to this conclusion in Appendix A.4.

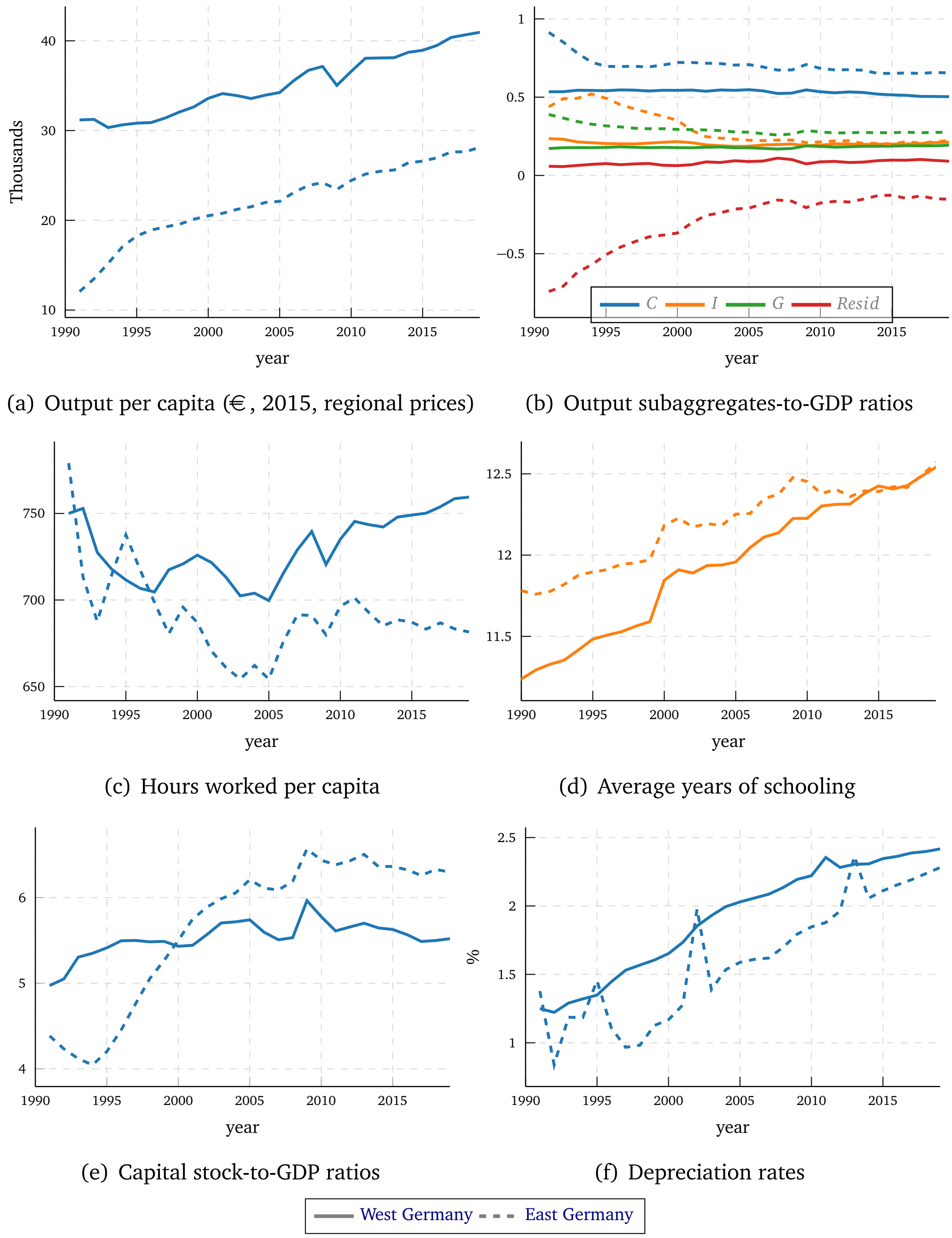
2.2 Data exploration

Figure 1 illustrates the aggregated regional data for the reunified Germany from 1991 until 2019, and Figure 3 illustrates the sectoral regional data. Prices are regional and from 2015. For a rough translation into purchase power parity on one's own, EG consumption prices are around 96 % of the WG price in 2015.[7] Panel (a) of Figure 1 displays the GDP per capita for both regions. GDP per capita was more than twice as high in WG than in EG right after the reunification. The EG GDP per capita catches up in the 1990s with a loss of velocity in the late 1990s and converges only slowly toward the WG GDP per capita since then. As a result of the slow convergence, the GDP per capita is nearly 45 % higher in WG than in EG at the advent of the COVID-19 pandemic.

[6]The SOEP is a representative survey and includes information on sectoral work, hours worked, and years of education.

[7]We calculate the population-weighted average of the county-level consumption price indices 2016 from Weinand and von Auer (2020) and translate them to 2015 with our regional GDP deflator. Heise and Porzio (2022) report 94 % for the period 2009–2015.

Figure 1: Data for the two reunified Germanies



(a) Output per capita (€, 2015, regional prices)

(b) Output subaggregates-to-GDP ratios

(c) Hours worked per capita

(d) Average years of schooling

(e) Capital stock-to-GDP ratios

(f) Depreciation rates

Panel (b) of Figure 1 plots the subaggregates private consumption (C), investments (I), government consumption (G), and the net outflows ($Resid$) relative to GDP. In both regions, private consumption accounts for the biggest share of GDP ($\geq 50\,\%$). The share in GDP in the early 1990s in EG is exceptionally high, with values higher than 90 %. The fractions of investment converged to each other at roughly 20 %. However, while the investment share in GDP is around 20 % over the whole period in WG, this share is close to 50 % in the early 1990s in EG and converges to the WG share between 1995 and 2005. The share of government consumption in GDP is somewhat lower than 20 % over the whole period in WG. In EG, the share is close to 40 % in 1991, shrinks after, and plateaus to 27 % since 2005. Lastly, concerning the residuum, we observe large net inflows (around 75 % of GDP) in 1991 in EG. This share decreases quickly and plateaus somewhat above 15 % of GDP. In WG, the share of the residuum (net outflows) increases slightly from approximately 5 % in 1991 to 10 % in 2019.

Panel (c) of Figure 1 plots the hours worked per capita in both regions, and Panel (d) the average number of years enrolled in school. Average hours worked decline in the 1990s with a turning point in the early 2000s and increase from there on. However, the drop in hours worked is more severe for EG while the recovery is weaker. The EG years enrolled in school have an advance of around one year until the mid-2010s, compared to WG. In both regions, years in school increase. Yet, the years enrolled in school increase faster in WG, and slumps slightly in the early 2010s in EG—resulting in catching up of WG.

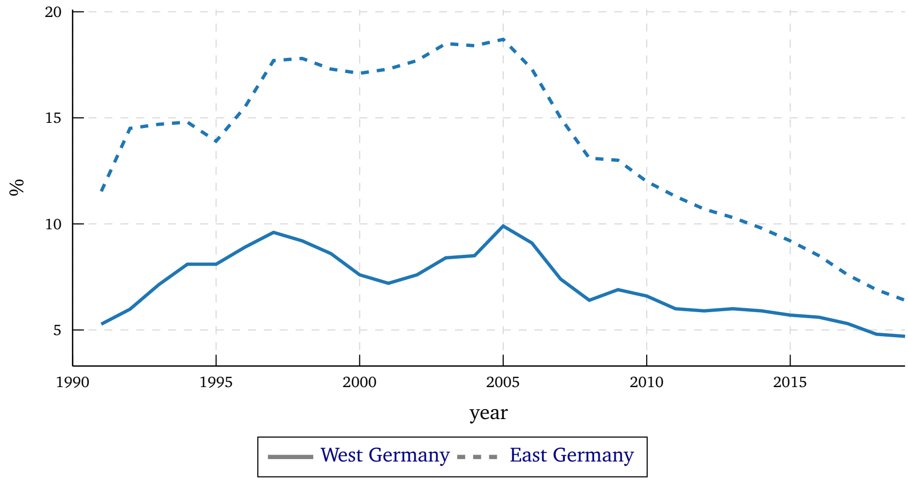
Panel (e) of Figure 1 displays the gross-capital-to-GDP ratios and Panel (f) the respective depreciation rates or, more accurately, disposal rates.[8] The capital-to-GDP ratio in WG increases slightly in the 1990s from 5 to around 5.5 and levels off afterward. In EG, the capital-to-GDP increases from slightly above 4 to above 6 in the early 2000s. The spike in 2009 is driven by a drop in GDP (the denominator) during the Great Recession. The depreciation rates in EG fluctuated around 1 % in the early 1990s, increasing over 2 % in the early 2010s. There are two eye-catching peaks in 2002 and 2013 beyond structural turmoil immediately after the reunification. Both peaks are due to floods in EG destroying sizable fractions of the capital stock (see Gühler and Schmalwasser, 2020). In WG, the depreciation rates increase slightly from a minimum of 1.3 % in 1991 to a maximum close

[8] Gühler and Schmalwasser (2020), members of the German national accounting office, highly recommend the usage of the gross capital stock (and corresponding disposal) instead of net capital stock (and the corresponding deprecation) as the latter only expresses the present value, while the former represents the total value of the usable capital. Accordingly, major maintenance operations on existing capital are treated as part of gross investments. However, due to common use, we stick to the term depreciation.

to 2.5 % in 2019. A small peak in 2011 is due to an early disconnection of 8 nuclear power plants (see Gühler and Schmalwasser, 2020). The depreciation rates in WG are generally higher than in EG. However, the gap narrows over time.

Figure 2 plots the unemployment rates in EG and WG. Initially, the unemployment rate was slightly above 10 % in EG and 5 % in WG. The unemployment rates increase in both regions during the 1990s and early 2000s, peaking in 2005 at 19 % and 10 % in EG and WG, respectively. The rates fall drastically from there on, ending slightly above 6 % in EG and below 5 % in WG in 2019.

Figure 2: Unemployment rates

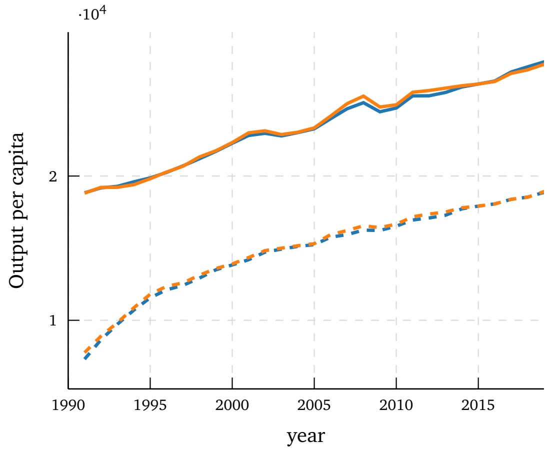


Complementary, we plot output, capital, hours worked, and years enrolled in school disaggregated for the nontradable (left-hand side) and tradable (right-hand side) sectors in Figure 3. In the first row, the panels display sectoral output in GDP-deflated values and in real terms, i.e., deflated by the sector-specific price index. Nontradable output evolves similarly to GDP. Two things concerning the tradable sector become apparent in both regions: i) the sector is more prone to business cycles, and ii) relative prices fall over time.

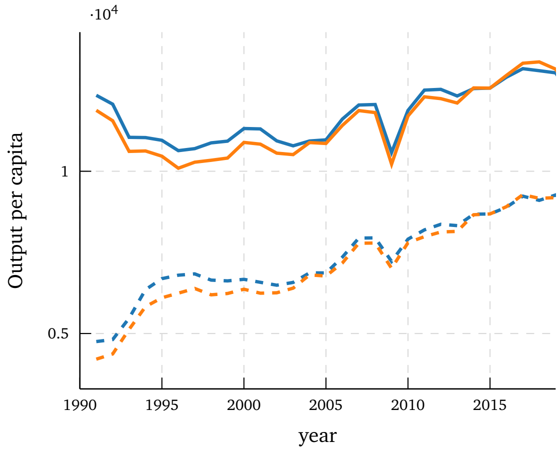
In the second row, we present data on labor input, i.e., hours worked (blue) and years of schooling (orange). Hours worked increased in the nontradable sector and decreased in the tradable sector. While the decrease in EG and WG is similar, the increase is higher in the WG, especially in the 2010s. Concerning years in school, WG catches up entirely in both sectors. In both regions, the average worker in the nontradable sector was longer enrolled in school than in the tradable sector, with approximately one year from the late 2000s on.

The last row displays the capital input in the sectors. While the nontradable goods sector's capital-to-sectoral output ratios increase from below 3 to over 4 in EG, in WG, it plateaus slightly below 4. Regarding the tradable goods sectors in EG, the ratio depresses in the early 1990s, increases from below 1.5 to above 2, and levels off. In WG, the ratio increases from slightly above one to 1.5 in the early 2010s and decreases slightly since.

Figure 3: Sectoral data for the two reunified Germanies

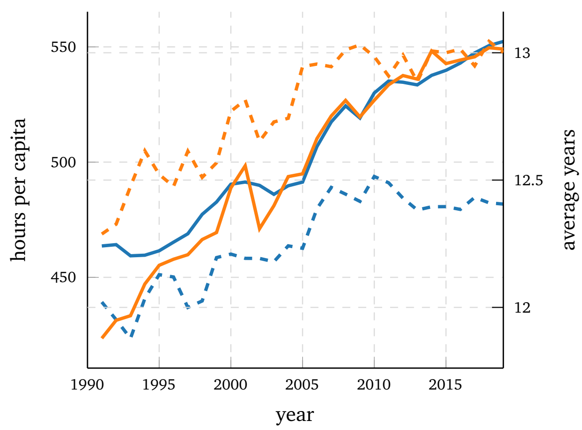


(a) Output per capita nontradable (€, 2015, regional price)

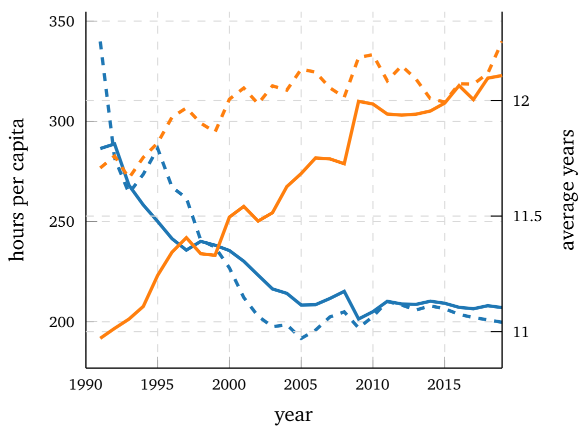


(b) Output per capita tradable (€, 2015, regional prices)

GDP deflated — Real terms

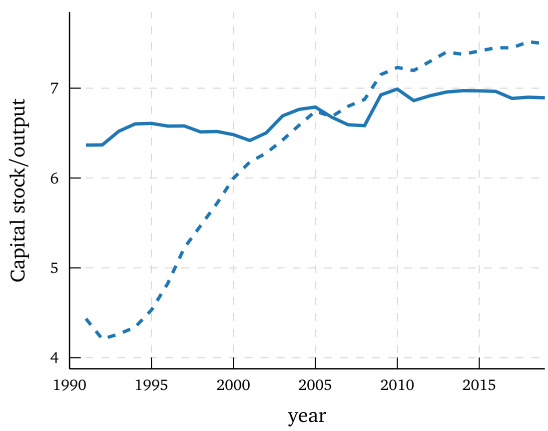


(c) Labor nontradable sector

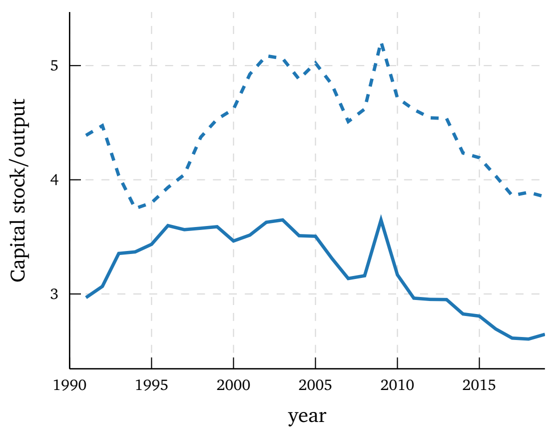


(d) Labor tradable sector

Quantity (hours) — Quality (years of schooling)



(e) Capital nontradable sector



(f) Capital tradable sector

West Germany - - - East Germany

3 THEORETICAL FRAMEWORK

3.1 Model structure and agents

We deploy a two-region two-sector model of a small open economy representing Germany. The two regions in turn represent EG and WG, indexed by $i \in \{E, W\}$. The two sectors are in an intermediate production stage and represent a tradable and a nontradable good-producing sector, indexed by $j \in \{T, NT\}$. The model features various types of frictions represented in a reduced form—the wedges. Specifically, capital and labor wedges capture distortions in the aggregated and sectoral allocation of labor and capital. Regional bond wedges capture distortions in financial flows between regions. Resource wedges portray distortions between private absorption and value added. Productivity wedges capture inefficiencies in input utilization.

In our model, in each region i and sector j, a representative firm operates in a competitive environment using labor and capital as inputs. A final good producer assembles intermediate goods for absorption in a competitive environment. Each region is inhabited by a representative household that consumes, supplies labor, and saves in interest-bearing deposits and bonds. Labor is distributed across sectors by a regional labor organization. More specifically, concerning savings, households contribute to the financial system by lending to regional banks and trading bonds with a global financial agent. The regional banks provide loans to firms in the intermediate production stage. Meanwhile, the global financial agent facilitates transactions between regions and the rest of the world by enabling imbalances in trade and between regional savings and investments. Regional governments raise taxes to finance regional government consumption, while a federal government facilitates resource transfers between regions.

In the following, we describe our model. A detailed derivation leading to the equation system describing the economy's dynamics entirely at the end of the section can be found in Appendix C.

The regional population level N_{it} evolves according to a time-varying growth factor g_{Nit+1}. We denote aggregate quantities with capital letters, while prices and per-capita quantities are represented with lowercase letters. Time is discrete, infinite, and t represents one year. There is no uncertainty.

Financial and labor market intermediaries Within each region, a labor organization and a regional bank act as intermediaries between households and firms in the intermediate production stage.[9] The labor organization allocates hours worked between the tradable L_{iTt} and nontradable L_{iNTt} sectors, while the bank allocates funds V_{ijt} between the sectors. These intermediaries create a wedge between buyer and seller prices: sector-specific labor costs w_{ijt} may differ from the wages households receive w_{it}, and the interest rates on the firm's loans in each sector ρ_{ijt} may not equal the deposit rates ρ_{it} offered to households. The labor organization's decisions result additionally in a regional labor constraint, denoted by $L^C_{it} \geq L_{iTt} + L_{iNTt}$, which limits the total labor supply that is allocated across sectors. Profits or losses from regional intermediation

$$\Sigma_{it} = \sum_{j\in\{T,NT\}} \left(w_{ijt} - w_{it}\right) L_{ijt} + \left(\rho_{ijt} - \rho_{it}\right) V_{ijt} \tag{1}$$

accrue to households within the specific region.

Beyond regional intermediaries, a global financial agent operates in international bond markets, buying and selling bonds for each region at a region-specific price q_{it}. Here, a wedge between the bond prices in the two regions can arise. The repayment value of a bond in period $t+1$ is equivalent to one unit of the issuing region's numéraire in $t+1$. The global financial agent is based abroad. Thus, any profits or losses from these transactions remain abroad—outside the domestic economy.

The behavior of intermediaries—serving as a source of friction within the economy—is not explicitly derived from underlying objectives. Instead, their actions are treated as a black box, i.e., these frictions are analyzed later using the wedges. Specifically, we derive labor, capital, and bond market wedges by examining discrepancies between buyer and seller prices and regional price differentials.

Intermediate goods firms The representative firm in each sector j in each region i produces output X_{ijt} according to the technology

$$X_{ijt} = A_{ijt} f_{ij}(K_{ijt}, h_{ijt}, L_{ijt}), \tag{2}$$

with diminishing positive marginal returns ($\partial f_{ij}(\cdot)/\partial\Upsilon > 0$, $\partial f^2_{ij}(\cdot)/\partial\Upsilon^2 < 0$, for $\Upsilon \in \{K_{ijt}, h_{ijt}, L_{ijt}\}$) and constant returns to scale ($\zeta A_{ijt} f(K_{ijt}, h_{ijt}, L_{ijt}) = A_{ijt} f(\zeta K_{ijt}, h_{ijt}, \zeta L_{ijt})$). Beyond sec-

[9]Note that firms in Germany traditionally finance themselves predominantly through loans. Additionally, the German banking sector is highly regional, characterized by the significant presence of local savings banks ("Sparkassen") and cooperative banks ("Genossenschaftsbanken"), which prioritize relationship-based banking.

toral hours worked L_{ijt}, A_{ijt} is Hicks-neutral sectoral TFP, K_{ijt} sectoral physical capital stock, and h_{ijt} sectoral human capital in region i at time t.

The intermediate firms' per-period cash flow

$$\pi_{ijt} = p_{ijt}X_{ijt} - w_{ijt}L_{ijt} - d_{it}(I_{ijt} - \Delta K_{ijt}) - \rho_{ijt}V_{ijt} - \Delta V_{ijt} \tag{3}$$

consist of revenues $p_{ijt}X_{ijt}$ net of total labor costs $w_{ijt}L_{ijt}$, total expenditures for newly installed and traded capital $d_{it}(I_{ijt}-\Delta K_{ijt})$, and total debt services plus redemption $\rho_{ijt}V_{ijt}+\Delta V_{ijt}$. Here, p_{ijt} are the sectoral intermediate goods' prices, and d_{it} are the regional prices of newly installed capital I_{ijt} and intersectorally traded capital ΔK_{ijt}.[10] Debt V_{ijt} is required to finance capital $\left(V_{ijt+1} \geq d_{it}K_{ijt+1}\right)$ and is constrained by the firm's physical capital stock $\left(V_{ijt+1} \leq d_{it}K_{ijt+1}\right)$, reflecting a borrowing limit tied to the value of the firm's assets. Firms can only access regional banks within their region.

Intermediate goods firms choose L_{ijt}, K_{ijt+1}, ΔK_{ijt}, I_{ijt}, and V_{ijt+1} to maximize the firm's net present value $\Xi_{ij0} = \sum_{t=0}^{\infty} R_{ij0,t}\pi_{ijt}$ subject to the production function (2), the law of accumulation of the sectoral capital stock, debt, and the financial market enforced equality between the value of the capital stock and the outstanding debt

$$K_{ijt+1} = (1-\delta_{it})K_{ijt} + I_{ijt} - \Delta K_{ijt}, \tag{4}$$

$$V_{ijt+1} = V_{ijt} - \Delta V_{ijt}, \tag{5}$$

$$V_{ijt+1} = d_{it}K_{ijt+1}, \tag{6}$$

where $R_{ij0,t}$ is the discount factor of the firm's manager regarding period t. The optimality conditions imply that in each period t, sector j and region i specific wages and gross debt services equal the values of the marginal products of labor and capital plus the value of the left-over capital, respectively:

$$w_{ijt} = p_{ijt}A_{ijt}\frac{\partial f_{ij}}{\partial L_{ijt}}, \tag{7}$$

$$1 + \rho_{ijt+1} = \frac{1}{d_{it}}\left(p_{ijt+1}A_{ijt+1}\frac{\partial f_{ij}}{\partial K_{ijt+1}} + (1-\delta_{it+1})d_{it+1}\right). \tag{8}$$

[10] We stick to the assumption of non-sector-specific capital as the Arbeitskreis "Volkswirtschaftliche Gesamtrechnungen der Länder" (2023) does not report sectoral investment on a regional level because investment includes selling and buying goods between sectors, which is why they do not account for on a regional level. Thus, sector-specific investment can not be reported as at least some capital goods are inter-sectoral usable, or in other words, capital is not sector-specific in the national accounts framework.

Additionally, the transversality condition $\lim_{t\to\infty} R_{ij0,t} d_{it} K_{ijt+1} = 0$ holds. Together with equation (6), this condition rules out Ponzi schemes associated with debt V_{ijt}.

In the Keynesian scenario of underemployment, labor supply constraints depress demand, restricting the supply of goods (see e.g., Barro and Grossman, 1971). However, with constant returns to scale, the realized and the desired marginal productivity remain equal as the optimal marginal productivity is independent of the output level with constant returns to scale and, consequently, the optimal input usage.

Final goods firm In each region i exists a time-varying technology transforming tradable and nontradable intermediate goods to the final good

$$Y_{it}^{D} = Z_{it} F_{it}(M_{iNTt}, M_{iTt}), \tag{9}$$

with diminishing marginal returns ($\partial F_{it}(\cdot)/\partial \Upsilon > 0$, $\partial F_{it}^{2}(\cdot)/\partial \Upsilon^{2} < 0$, for $\Upsilon \in \{M_{iTt}, M_{iNTt}\}$) and constant returns to scale ($\zeta Z_{it} F_{it}(M_{iTt}, M_{iNTt}) = Z_{ijt} F_{it}(\zeta M_{iTt}, \zeta M_{iNTt})$), where Z_{it} is Hicks-neutral region-specific TFP. The firm's per-period profits are $\Pi_{it} = p_{it} Y_{it}^{D} - p_{iTt} M_{iTt} - p_{iNTt} M_{iNTt}$, where p_{it} denote regional final goods' price. We define the final good as the numéraire ($p_{it} = 1 \forall t$) and, hence, p_{ijt} reflects the relative price of good j in region i. The time-varying technology, combined with TFP Z_{it}, provides the necessary degrees of freedom to match the relative prices p_{ijt} observed.

Final goods firms choose M_{ijt} to maximize Π_{ijt} subject to the production function (9). Their optimality conditions result in the rule that sectoral good prices equal the marginal products of intermediate inputs:

$$p_{ijt} = Z_{it} \frac{\partial F_{it}}{\partial M_{ijt}}. \tag{10}$$

The final good producers sell the good for private and government consumption purposes (C_{it} and G_{it}) as well as for investment I_{it}. However, transforming the final good into capital costs $d_{it} - 1$ units, which is why d_{it} represents the relative price of investment. We give in Appendix B a detailed explanation and reasons for investment-specific prices. Further, see Rothert and Short (2023) and Fehrle and Huber (2022) for already existing applications of relative investment prices within the wedge-growth and business cycle accounting framework.

Again, in the Keynesian scenario of underemployment, the realized and the desired marginal productivity are always equal as the optimal marginal productivity is independent of the output level with constant returns to scale.

Households The representative household in region i receives utility from per-capita shares of private and government consumption (c_{it} and g_{it}), and leisure $\bar{l}-l_{it}$.[11] Leisure is the residual between the household's time endowment $\bar{l}$ and time spent for work l_{it}. Hence, the per-period utility is $u_i(c_{it}, g_{it}, \bar{l}-l_{it})$, with diminishing positive marginal utility ($\partial u_i(\cdot)/\partial \Upsilon = u_\Upsilon > 0$, $\partial u_i^2(\cdot)/\partial \Upsilon^2 = u_{\Upsilon\Upsilon} < 0$, for $\Upsilon \in \{c_{it}, g_{it}, \bar{l}-l_{it}\}$). The household receives income from labor $w_{it}L_{it}$, the interest on deposits $\rho_{it}V_{it}$, transfers $p_{iTt}Tr_{it}$, and the profits and losses from the intermediation Σ_{it}. Household income is spent on consumption C_t and to pay net lump sum taxes Tax_{it}. Further, the household can place deposits denoted by V_{it+1} at a local bank and hold bonds from international capital markets, with bonds purchased in t denoted in the final good as $p_{iTt}B_{it+1}$. Note that bonds, as well as transfers, are traded interregional and thus, the payments are tradable goods at price p_{iTt}. Hence, the household pays for the bonds $q_{it}p_{iTt}B_{it+1}$ at t and receives $p_{iTt+1}B_{it+1}$ at time $t+1$. Accordingly, the household's per-period budget constraint in the value of final goods' prices reads

$$C_{it} + V_{it+1} + q_{it}p_{iTt}B_{it+1} + Tax_{it} \leq w_{it}L_{it} + (1+\rho_{it})V_{it} + p_{iTt}Tr_{it} + p_{iTt}B_{it} + \Sigma_{it}. \quad (11)$$

Note that bonds B_{it} and transfers Tr_{it} can be negative. Further, the labor supply and income is constrained by L_{it}^C, thus $w_{it}L_{it} \leq w_{it}L_{it}^C$.

The household discounts future utility with the discount factor $\beta_i \in (0,1)$ and maximizes its lifetime utility

$$U_{i0} = \sum_{t=0}^{\infty} \beta_i^t N_{it} u_i(c_{it}, g_{it}, \bar{l}-l_{it}).$$

by choosing the per-capita amount of consumption c_{it}, hours worked l_{it}, deposits v_{it+1},

[11] In the wedge-growth accounting literature, government consumption is treated as a rival good (see e.g., Fernández-Villaverde et al., 2023). Alternatively, it can be viewed as non-rival goods that augment the utility function by an amount equivalent to one N_t-th of the rival goods of government consumption.

and bonds b_{it+1} for all t. The corresponding intertemporal optimality conditions are

$$\frac{u_{c_{it}}}{\beta_i u_{c_{it+1}}} = 1 + \rho_{it+1}, \tag{12}$$

$$\frac{p_{iTt} u_{c_{it}}}{\beta_i p_{iTt+1} u_{c_{it+1}}} = \frac{1}{q_{it}}. \tag{13}$$

Further, taking the quantity constraint on labor supply into consideration, the optimality condition on labor supply reads

$$u_{\bar{l}-l_{it}} = w_{it} u_{c_{it}} \left(1 + \frac{\phi_{it}}{u_{c_{it}}}\right), \tag{14}$$

where ϕ_{it} denotes the Kuhn-Tucker multiplier ($\phi_{it} < 0$) for the demand-induced constraint on labor supply in terms of w_{it}.[12]

Lastly, the transversality condition holds for deposits ($\lim_{t\to\infty} \beta_i^t u_{c_{it}} v_{it+1} = 0$) and a no Ponzi-scheme condition applies to bonds ($\lim_{t\to\infty} \beta_i^t u_{c_{it}} q_{it} p_{iTt} b_{it+1} = 0$).

Government Regional governments use their revenues Tax_{it} to finance government consumption G_{it}. Adhering to a balanced budget policy,[13] the per-period government budget constraint is given by:

$$Tax_{it} = G_{it}. \tag{15}$$

At the federal level, resource transfers occur between the regions. Ensuring the overall balance of federal resource allocation across both regions nets to zero, the federal government's interregional transfer constraint is

$$\sum_{i \in \{E,W\}} Tr_{it} = 0.$$

Similar to intermediaries, the government's behavior is not explicitly derived from underlying objectives; instead, its actions are treated as a black box and are captured in wedges defined below.

[12] The definition of a negative Kuhn-Tucker multiplier aligns with Howard (1977). Furthermore, note that labor harms utility.

[13] Note that a lot of German states have zero-debt fiscal rules. This means that expenditures must be fully covered by taxes there.

Trade balances Tradable goods can be transferred between regions and countries. The difference between the production of tradable goods X_{iTt} and the domestic demand for tradable goods M_{iTt} is defined as

$$NM_{it} = X_{iTt} - M_{iTt}, \tag{16}$$

where NM_{it} represents the net outflows (or net inflows, if negative) of tradable goods expressed in units of tradable goods.

The net outflows NM_{it} are further decomposed as:

$$NM_{it} = q_t B_{it+1} - B_{it} - Tr_{it}. \tag{17}$$

Thus, NM_{it} captures both the payment for bonds $q_t B_{it+1} - B_{it}$ and payments for transfers $-Tr_{it}$. Due to data limitations, we cannot distinguish between bond payments and transfers at the regional level. As a result, we combine these drivers below into one wedge in the first place. We then discuss that whether NM_{it} is considered as transfer payments (received) or actual claims (liabilities) does not notably affect our results.[14]

The national trade balance, TB_t expressed in units of EG's tradable good, is given by $TB_t = NM_{Et} + \frac{p_{WTt}}{p_{ETt}} NM_{Wt}$.

Market clearing Except for the aggregate labor supply, markets clear, i.e., between sectors and between the intermediate and final goods production in each region. Thus, the following market-clearing conditions hold

$$\sum_{j \in \{T,NT\}} \Delta K_{ijt} = 0, \tag{18}$$

$$K_{it} = K_{iTt} + K_{iNTt}, \tag{19}$$

$$V_{it} = V_{iTt} + V_{iNTt}, \tag{20}$$

$$V_{ijt} = d_{it-1} K_{ijt}, \tag{21}$$

$$L^C_{it} = L_{iTt} + L_{iNTt}, \tag{22}$$

$$X_{iNTt} = M_{iNTt}. \tag{23}$$

[14]As a result, it does neither matter whether transfers from the federal government are financed through taxes or debt.

3.2 Wedges

Wedges capture the frictions within our model in reduced form. Productivity disparities are measured using TFP (A_{ijt}, Z_{it}), while resource wedges capture disparities in the absorption of resources by private agents versus the entire regional economy (government consumption wedge), as well as differences between regional absorption and regional value added (residual wedge). Quantity constraint wedges reflect gaps between desired and realized outcomes. Additionally, labor, capital, and bond wedges represent deviations from optimal supply and demand conditions, arising from differences in buyer and seller prices or regional price disparities, respectively. Notably, our derivation of the latter three types of wedges differs from the benchmark business cycle accounting approach (see Chari et al., 2007), where they are modeled as taxes. However, the results are equivalent,[15] and the interpretation remains the same: differences between optimal supply and demand conditions reflect distortions, as equality indicates a Pareto optimum.

Labor-related wedges Recall the first-order condition subject to the constrained labor supply (14). Denoting the unconstrained counterpart with superscript UC, dividing the constraint result by the unconstrained counterpart, and rearranging yields

$$w_{it} = \frac{u_{\bar{l}-l_{it}^{UC}}}{u_{c_{it}^{UC}}} = \frac{1}{1+\phi_{it}/u_{c_{it}}} \frac{u_{\bar{l}-l_{it}}}{u_{c_{it}}}, \tag{24}$$

where the term $1/1+\frac{\phi_{it}}{u_{c_{it}}}$ in condition (14) acts like a wedge between the optimal—desired—marginal rate of substitution and the realized one for a given wage w_{it}. Hence, we define the quantity-constraint-on-labor wedge ω_{it}^{QL} by

$$\omega_{it}^{QL} = \frac{1}{1+\phi_{it}/u_{c_{it}}} = \frac{u_{\bar{l}-l_{it}^{UC}}/u_{c_{it}^{UC}}}{u_{\bar{l}-l_{it}}/u_{c_{it}}}. \tag{25}$$

We use the difference between labor costs and wages to define the sector-specific labor wedges. From this definition, and using optimality conditions (24) and (7), the labor

[15] Wedges are typically represented as proportional taxes, which directly affect the government balance sheet. We deviate from this conventional assumption by introducing intermediaries in the input and bond markets. However, one can think of these intermediaries as paying the proportional taxes, which would be reflected in the wedge. In this case, the profit or losses of the intermediaries would change. However, the lump-sum tax would adjust by the same amount (with the opposite sign), leaving no net change to the household balance sheet or the overall economic equilibrium. Therefore, our approach effectively yields the same results as the traditional tax-based framework.

wedge ω^L_{ijt} in sector j and region i reads

$$\omega^L_{ijt} = \frac{w_{it}}{w_{ijt}} = \omega^{QL}_{it} \frac{u_{\bar{l}-l_{it}}/u_{c_{it}}}{p_{ijt}A_{ijt}\frac{\partial f_{ij}}{\partial L_{ijt}}}. \tag{26}$$

Note that the ratio of the two labor-related wedges $\omega^L_{ijt}/\omega^{QL}_{it}$ is equivalent to the standard (sectoral) labor wedges commonly used in the literature (e.g., Chari et al. (2007), Kersting (2008), Lama (2011), Karabarbounis (2014), Ohanian et al. (2018), and Fernández-Villaverde et al. (2023)).

Capital wedges Similarly to the labor wedge, we use the difference between the firms' debt and households' deposit interest rates to define the capital wedge. Thus, using the optimality conditions (8) and (12), the capital wedge ω^K_{ijt+1} in sector j and region i reads

$$\omega^K_{ijt+1} = \frac{1+\rho_{it+1}}{1+\rho_{ijt+1}} = \frac{u_{c_{it}}/\left(\beta_i u_{c_{it+1}}\right)}{\left(p_{ijt+1}A_{ijt+1}\frac{\partial f_{ij}}{\partial K_{ijt+1}} + (1-\delta_{it+1})d_{it+1}\right)/d_{it}}. \tag{27}$$

Bond wedges Differences in regional bond prices q_{it} on international capital markets serve as our bond wedge measure. Using the optimality conditions (13) of EG's household by those of WG, the national bond wedge ω^B_{t+1} can be expressed as

$$\omega^B_{t+1} = \frac{q_{Wt}}{q_{Et}} = \frac{u_{c_{Et}p_{ETt}}/\left(\beta_E u_{c_{Et+1}} p_{ETt+1}\right)}{u_{c_{Wt}} p_{WTt}/\left(\beta_W u_{C_{Wt+1}} p_{WTt+1}\right)}. \tag{28}$$

Productivity wedges We treat intermediate firms' TFPs A_{ijt} as wedges, representing the sectoral productivity wedges ω^e_{ijt} in sector j. Rearranging (2) leads to

$$\omega^e_{ijt} = A_{ijt} = \frac{X_{ijt}}{f_{ij}(K_{ijt}, h_{ijt}, L_{ijt})}. \tag{29}$$

Analogously, inverting the production function (9), final goods productivity wedge ω^Z_{it} is given by

$$\omega^Z_{it} = Z_{it} = \frac{Y^D_{it}}{F_{it}(M_{iTt}, M_{iNTt})}. \tag{30}$$

Resource wedges The residual wedge captures the disparity between absorbed goods and value added. Using the tradable market clearing condition (17), we define the residual wedge ω_{it}^{D} as the share of tradable goods not used within the region i by

$$\omega_{it}^{D} = \frac{NM_{it}}{X_{iTt}}. \tag{31}$$

Similar to the residual wedge, we define the government consumption wedge ω_{it}^{G} by the share of regional government spending to total absorption, i.e.,

$$\omega_{it}^{G} = \frac{G_{it}}{Y_{it}^{D}}. \tag{32}$$

3.3 General equilibrium

Given that households and firms follow their optimality conditions, the behavior of intermediaries, government, and trade is captured by the wedges, and the market-clearing conditions hold, it is straightforward to show that the national accounting expenditure and value-added identities hold on the regional level. They read in terms of final goods

$$Y_{it} = C_{it} + d_{it}I_{it} + \omega_{it}^{G}Y_{it}^{D} + p_{iTt}\omega_{it}^{D}X_{iTt}, \tag{33}$$

$$Y_{it} = p_{iNTt}X_{iNTt} + p_{iTt}X_{iTt}, \tag{34}$$

where Y_{it} corresponds to GDP.

3.4 Functional forms

The parametrization of the utility function follows Fernández-Villaverde et al. (2023) and reads $u = \ln(c_{it} + g_{it}) + \theta_i \ln(\bar{l} - l_{it})$. Fernández-Villaverde et al. (2023) argue that perfect substitutability between private and government consumption prevents excessive large income effects of government consumption on labor supply. Furthermore, Jarosch et al. (2025) find no time trends in hours worked for full-time workers in Germany between 1985 and 2021, validating the assumption that the income and substitution effects on leisure cancel each other out. In line with Jones and Sahu (2017), the technologies to produce the final good read: $Y_{it} = Z_{it}M_{iTt}^{\eta_{it}}M_{iNTt}^{1-\eta_{it}}$, where, $\eta_{it} \in (0,1)$ is the time-varying elasticity of final goods to intermediate inputs. The technologies to produce intermediate goods are Cobb-Douglas style with fixed parameters: $X_{ijt} = A_{ijt}K_{ijt}^{\alpha_{ij}}(h_{ijt}L_{ijt})^{1-\alpha_{ij}}$, where

$\alpha_{ij} \in (0,1)$ denotes sector-specific output elasticity of capital. Following Hall and Jones (1999), the quality of labor captured in the human capital factor translates from sector-specific years of schooling s_{ijt} according to a function $h_{ijt} = h(s_{ijt}) = e^{\chi(s_{ijt})}$. For $\chi(s_{ijt})$, we use their step function as $4\gamma_1 + (s_{ijt} - 4)\gamma_2$ for $4 < s_{ijt} < 8$ and $4\gamma_1 + 4\gamma_2 + (s_{ijt} - 8)\gamma_3$ for $s_{ijt} > 8$, with $\gamma_1, \gamma_2, \gamma_3 > 0$.

3.5 Dynamic equilibrium with wedges

Finally, we present the full analytic framework as nonlinear equation system in per-capita terms derived from the presented model in Appendix C. The parameterized nonlinear equation system governs the dynamics of the set of the 35 endogenous variables

$$\left\{y_{it},\, y_{it}^D,\, x_{ijt},\, m_{ijt},\, c_{it},\, g_{it},\, i_{it},\, l_{ijt},\, l_{it},\, k_{ijt},\, k_{it+1},\, p_{ijt},\, \omega_{t+1}^B\right\}_{t=0}^{\infty}, \tag{35}$$

given the set of the 34 deterministic exogenous variables and time-varying parameters

$$\{\omega_{it}^{QL},\, \omega_{ijt}^{L},\, \omega_{ijt+1}^{K},\, \omega_{it}^{D},\, \omega_{it}^{G},\, \omega_{ijt}^{e},\, \omega_{it}^{Z},\, s_{ijt},\, d_{it},\, g_{Nit+1},\, \delta_{it},\, \eta_{it}\}_{t=0}^{\infty}, \tag{36}$$

the set of parameters $\{\beta_i,\, \theta_i,\, \bar{l},\, \alpha_{ij},\, \gamma_1,\, \gamma_2,\, \gamma_3\}$, the initial capital stock k_{i0}, and the transversality condition $\lim_{t\to\infty} \beta_i^t \frac{k_{it+1}}{g_{it}+c_{it}} = 0$. The nonlinear system for $t = 0, 1, \ldots$ reads

$$\omega_{it}^{QL} \frac{\theta(c_{it} + g_{it})}{\bar{l} - l_{it}} = \omega_{ijt}^{L}(1 - \alpha_{ij}) \frac{p_{ijt} x_{ijt}}{l_{ijt}}, \tag{37a}$$

$$\frac{c_{it+1} + g_{it+1}}{\beta_i (c_{it} + g_{it})} = \omega_{ijt+1}^{K} \frac{1}{d_{it}} \left(p_{ijt+1} \alpha_{ij} \frac{x_{ijt+1}}{k_{ijt+1}} + (1 - \delta_{it+1}) d_{it+1} \right), \tag{37b}$$

$$\frac{(c_{Et+1} + g_{Et+1}) p_{ETt}}{\beta_E (c_{Et} + g_{Et}) p_{ETt+1}} = \omega_{t+1}^{B} \frac{(c_{Wt+1} + g_{Wt+1}) p_{WTt}}{\beta_W (c_{Wt} + g_{Wt}) p_{WTt+1}}, \tag{37c}$$

$$x_{ijt} = \omega_{ijt}^{e} k_{ijt}^{\alpha_{ij}} (e^{\chi(s_{ijt})} l_{ijt})^{1-\alpha_{ij}}, \tag{37d}$$

$$y_{it}^D = c_{it} + g_{it} + d_{it} i_{it}, \tag{37e}$$

$$y_{it} = y_{it}^D + p_{iTt} \omega_{it}^D x_{iTt}, \tag{37f}$$

$$g_{it} = \omega_{it}^G y_{it}^D, \tag{37g}$$

$$m_{iTt} = (1 - \omega_{it}^D) x_{iTt}, \tag{37h}$$

$$m_{iNTt} = x_{iNTt}, \tag{37i}$$

$$p_{iTt} = \eta_{it} \frac{y_{it}^D}{m_{iTt}}, \tag{37j}$$

$$p_{iNTt} = (1-\eta_{it})\frac{y_{it}^D}{m_{iNTt}}, \tag{37k}$$

$$y_{it}^D = \omega_{it}^Z m_{iTt}^{\eta_{it}} (m_{iNTt})^{1-\eta_{it}}, \tag{37l}$$

$$g_{Nit+1} k_{it+1} = (1-\delta_{it}) k_{it} + i_{it}, \tag{37m}$$

$$k_{it} = k_{iTt} + k_{iNTt}, \tag{37n}$$

$$l_{it} = l_{iTt} + l_{iNTt}. \tag{37o}$$

4 Quantitative analysis

We build on the model presented in section 3 and the data discussed in section 2 to conduct our quantitative analysis, which consists of two parts. First, we evaluate the magnitude of the wedges from our model. Second, we perform counterfactual exercises to quantify the role of the wedges in German economic convergence. A prerequisite for both steps is to pin down the values of the constant model parameters through a calibration exercise.

Constant parameters Table 1 presents our choices for the set of parameter values $\{\beta_i, \theta_i, \bar{l}, \alpha_{ij}, \gamma_1, \gamma_2, \gamma_3\}$. Concerning the parameters determining the household's preferences, we follow the conclusion on homogeneous preferences between EG and WG from Burda and Hunt (2001), Burda (2008), Dohmen et al. (2011), and Fehrle and Konysev (2025). Specifically, we adopt the values from Fehrle and Konysev (2025) for the former separated Germany, where $\{\beta_i,\ \theta_i,\ \bar{l}\} = \{0.976,\ 6,\ 5760\}$ for all i, which follows the calibration exercise described by Heer and Maussner (2009, Ch. 1.5.2).

The calibration from Fehrle and Konysev (2025) relies on time series averages of economic variables and ratios for WG from 1975 to 1989. These averages capture the long-term behavior of singular equations of our model. As Ohanian et al. (2018) demonstrate and Fehrle and Konysev (2025) further discuss, such calibration exercises generally do not allow for a clear distinction between preference parameters and labor and capital wedges. However, given preference homogeneity, the preference parameters only rescale the wedges but do not alter the relative differences between regions (see Fernández-Villaverde et al., 2023). Thus, any differences in relative wedges and their evolution must arise from different regional distortions. Consequently, despite the inability to clearly distinguish between the preference parameters and labor and capital wedges, our primary objective—analyzing the convergence of wedges—remains unaffected. Additionally, the calibration strategy for β_i incorporates the household's first-order condition for bond purchases (eq. (13)). This strategy reflects the marginal rate of intertemporal substitution, independent of wedges. As a result, β_i does not pose a concern for the capital wedge (see Fehrle and Konysev, 2025).

For production elasticities in the intermediate sectors, we account for differences in elasticity across regions and sectors. We follow again Heer and Maussner (2009, Ch. 1.5.2) by utilizing the parameterized first-order condition with respect to labor of the intermediate firms: we deduce the labor elasticity of output $1-\alpha_{ij}$ from the average share of sectoral compensation of employee, i.e., total labor costs, in sectoral value added.[16] As a result, the complementary capital elasticities α_{ij} read as follows: $\{\alpha_{ET}, \alpha_{WT}, \alpha_{ENT}, \alpha_{WNT}\} = \{0.303, 0.304, 0.336, 0.391\}$. For comparison, Heer and Maussner (2024, Ch. 1.6.2) find a sectoral and regional aggregated capital share equal to 0.36 for the reunified Germany from 1991–2019. Fehrle and Konysev (2025) apply the aggregated capital shares for the regions of EG and WG during 1960–1989 from Glitz and Meyersson (2020), who find a higher capital share in EG of 0.399 compared to 0.282 in WG, indicating a loss of capital intensive production during the reunification in EG.

Finally, we utilize the parameter values that characterize the evolution of human capital, i.e. $\gamma_1 = 0.134$, $\gamma_2 = 0.101$, and $\gamma_3 = 0.068$, from Hall and Jones (1999). These values align with the wedge-growth accounting exercise in Lu (2012).

Table 1: Constant model parameters

Parameter	Value (East)	Value (West)	Description
β	0.976		Discount factor
θ	6		Preference for leisure
$\bar{l}$	5760		Time endowment (hours/year per capita)
α_{NT}	0.336	0.391	Capital share in nontradable good production
α_T	0.303	0.304	Capital share in tradable good production
γ_1	0.134		Mincerian return on primary educ. (1-4 years)
γ_2	0.101		Mincerian return on secondary educ. (5-8 years)
γ_3	0.068		Mincerian return on tertiary educ. (>8 years)

[16] As there is no data on self-employed persons on the sectoral and regional levels combined, those parameter estimates are not corrected for the wage income of this group.

4.1 Measuring the wedges

In this section, we first measure the wedges of our two-sector, two-region growth model for the period 1991 to 2019 and discuss the results. We then examine how these wedges evolved during the German reunification shock 1990 and conclude by inferring the dynamics of wedge convergence over time.

To measure the wedges, we begin by deriving the quantity-constraint-on-labor wedges $\{\omega_{it}^{QL}\}_{t=0}^{T}$, where $t = 0$ corresponds to 1991 and $t = T$ to 2019. Using these results, we can deduce all other latent variables and time-varying parameters, including the remaining wedges. We utilize the realizations of observables $\{y_{it},\ c_{it},\ g_{it},\ i_{it},\ x_{ijt},\ l_{ijt},\ l_{it},\ k_{ijt},\ p_{ijt},\ d_{it},\ s_{ijt},\ \delta_{it}\}_{t=0}^{T}$ and the calibrated parameters to solve equations (37a)–(37j), and (37l) for $\{\omega_{ijt}^{L},\ \omega_{ijt}^{K},\ \omega_{ijt}^{e},\ \omega_{it}^{D},\ y_{it}^{D},\ \omega_{it}^{G},\ m_{iTt},\ m_{iNTt},\ \eta_{it},\ \omega_{it}^{Z}\}_{t=0}^{T}$ and $\{\omega_{ijt+1}^{K},\ \omega_{it+1}^{B}\}_{t=0}^{T-1}$, respectively. While equations (37k), (37m)–(37o) are redundant in this solution, they are consistent with the realizations of observables k_{i0} and $\{i_{it},\ l_{ijt},\ l_{it},\ k_{ijt},\ k_{it+1},\ \delta_{it},\ g_{iNt+1}\}_{t=0}^{T}$.[17]

Labor quantity constraint wedge To quantify the quantity-constraint-on-labor wedges ω_{it}^{QL}, we use three auxiliary assumptions. First, we assume that a labor supply-constrained household member desires to work the same number of hours as the average working population. Second, we assume that the fraction of labor supply-constrained household members equals the fraction of registered job-seekers in the economy, denoted uq_{it}.[18] Third, we assume a constant average marginal propensity to consume, χ_i, from the hypothetical additional labor income earned by unemployed household members. Given these assumptions, the additional desired hours worked read $l_{it}^{a} = l_{it}\left(\frac{uq_{it}}{1-uq_{it}}\right)$ and the corresponding additional desired consumption $c_{it}^{a} = \chi_i w_{it} l_{it}^{a}$. Note that equation (26) implies equality between the regional wage w_{it} and the product of the sectoral labor wedge and the value of the marginal product of labor $\omega_{ijt}^{L} p_{ijt} \omega_{ijt}^{e} \frac{\partial f_{ij}}{\partial l_{ijt}}$ for all sectors. By equation (24), this equality extends to the unconstrained, desired marginal rate of substitution between leisure and consumption $\theta \frac{c_{it}+g_{it}+c_{it}^{a}}{\bar{l}-l_{it}-l_{it}^{a}}$. Thus, we have $\theta \frac{c_{it}+g_{it}+c_{it}^{a}}{\bar{l}-l_{it}-l_{it}^{a}} = w_{it} = \omega_{ijt}^{L} p_{ijt} \omega_{ijt}^{e} \frac{\partial f_{ij}}{\partial l_{ijt}}$.

[17] Note that we use data for $\{k_{it}\}_{t=0}^{T+1}$, which includes the initial per-capita capital stocks k_{i0} in 1991 and the terminal per-capita capital stock k_{iT+1} in 2020. Regarding the population growth rate, we use its realization in 2020 g_{iNT+1}.

[18] Assuming all registered job-seekers are involuntary unemployed creates an upper bound for our measure.

Inserting c_{it}^a and l_{it}^a, and rearranging yields

$$\omega_{it}^{QL} = \left(1 - \frac{l_{it}}{\bar{l} - l_{it}} \frac{uq_{it}}{1 - uq_{it}} (1 + \chi_i \theta_i)\right)^{-1}. \tag{38}$$

This approach is in line with Fehrle and Konysev (2025). The only unknown parameter of the right-hand side of formula (38) is the average marginal propensity to consume χ_i. The Continuous Household Budget Surveys (LWR) of the Federal Statistical Office of Germany (Statistisches Bundesamt, 2012) reports the monthly consumption expenditures and income of unemployed, blue-collar, white-collar, and/or all employees separately for EG and WG for the years 2000–2012.[19] Table 2 presents the average values for the ratio of the difference in consumption and income between a representative unemployed and a representative of each of the three mentioned employment types—the average marginal propensities to consume. Given that the unemployment rate is higher for blue-collar workers than for white-collar workers, and that the average marginal propensity to consume for blue-collar workers is equal to that of all employees, we choose average marginal propensities of $\chi_E = 0.61$ and $\chi_W = 0.58$. Note that the higher values for EG need not be from preference heterogeneity but rather from a smaller change in income out of unemployment.

Table 2: Average marginal propensities to consume out of unemployment

	Region	Blue-collar	White-collar	All employees
$\overline{\left(\frac{\Delta c}{\Delta y}\right)}$	EG	0.61	0.59	0.61
	WG	0.58	0.55	0.58

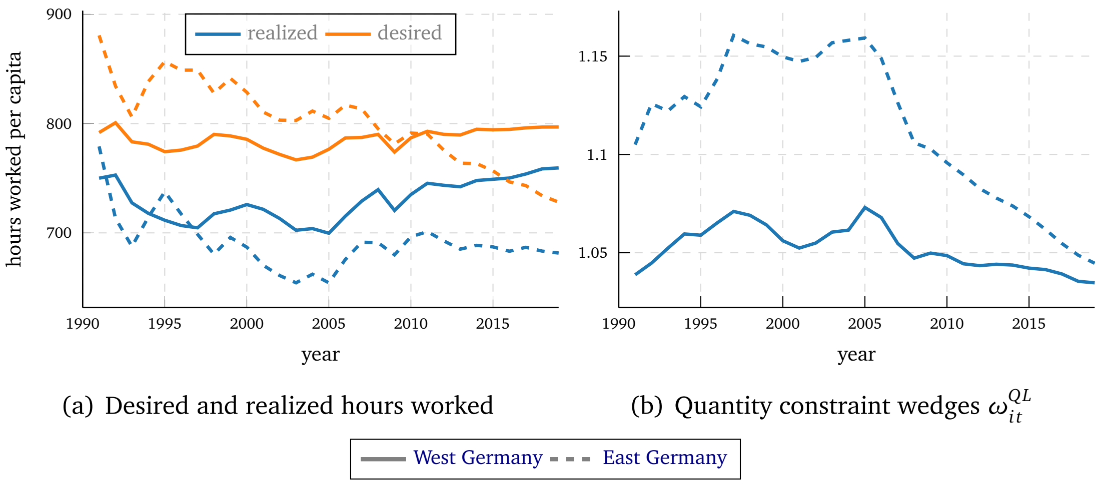
Source: Statistisches Bundesamt (2012), own calculations. $\overline{\left(\frac{\Delta c}{\Delta y}\right)}$ represents the average distance in consumption over the average distance in disposal income of unemployment and the three types of workers.

Figure 4 presents, in Panel (a), the desired hours worked compared to the realized hours. While in WG the desired hours worked are stable over time and the gap between realized and desired narrows due to increasing realized hours worked, in EG the gap narrows especially due to declining desired hours worked. Nevertheless, the desired hours worked are larger in EG compared to WG until 2010. Panel (b) of Figure 4 plots the resulting

[19] The information on blue/white-collar workers is missing for 2004, 2005, 2008, 2011, and 2012, for all employees for 2001 and 2008.

labor quantity constraint wedges. The labor quantity constraint wedge follows the above-presented unemployment rates. More to the point, the EG wedge converges from being closely 10 % larger in the early 2000s to the WG wedge being only 1 % larger in 2019.

Figure 4: Labor market quantity constraints

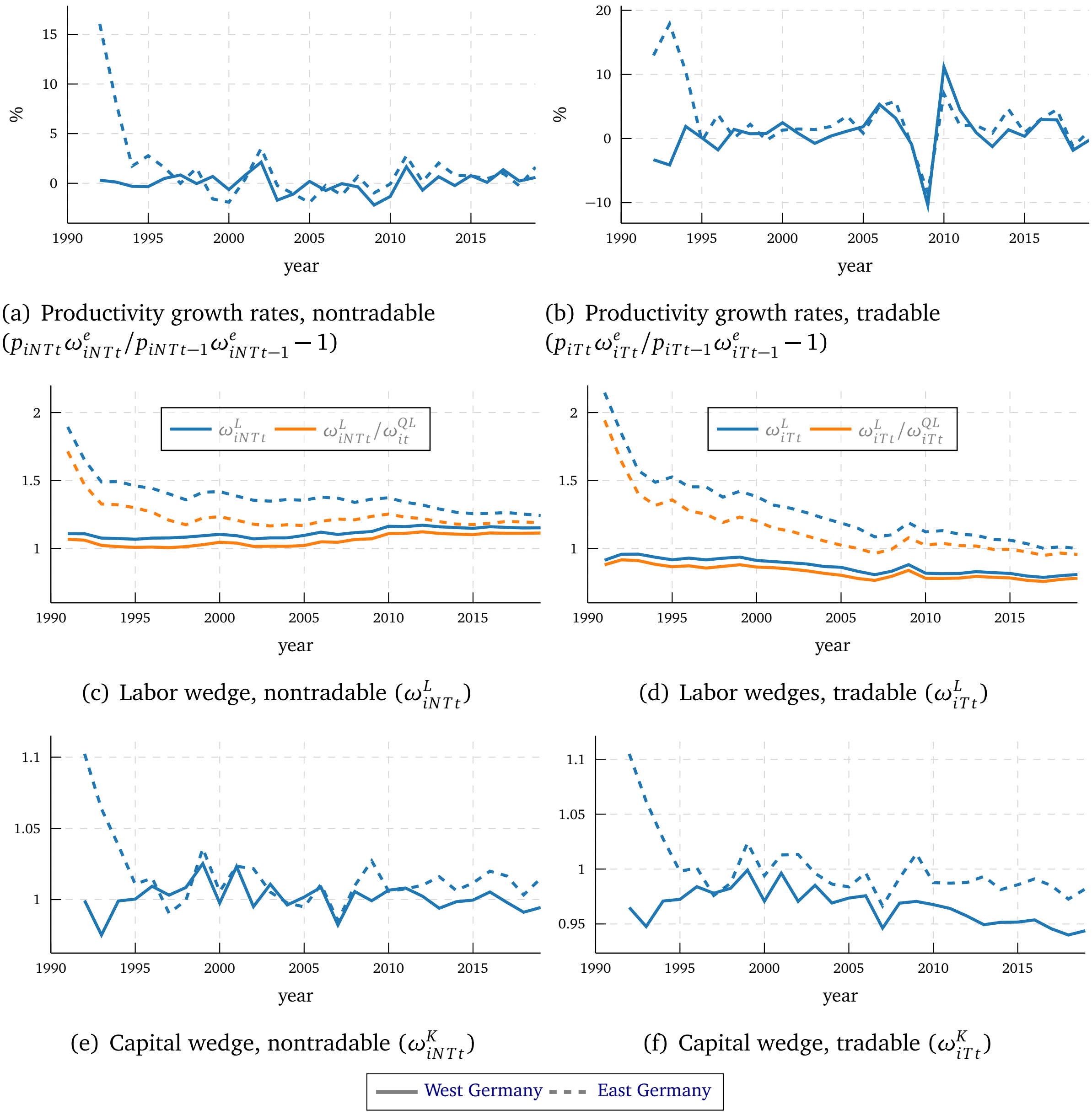


(a) Desired and realized hours worked (b) Quantity constraint wedges ω_{it}^{QL}

Sectoral productivity wedges We continue by presenting the wedges related to the sectoral efficiency ω_{ijt}^{e}, derived from equation (37d). The first row of Figure 5 displays the growth rates of TFP in both sectors, expressed in terms of the final good—the numéraire. On the one hand, we observe very high productivity growth in EG in the early 1990s. On the other hand, the sectoral productivity growth rates exhibit similar patterns across regions since the late 1990s. The productivity in the tradable goods sectors grows faster than in the nontradable goods sectors—on geometric average, 2.8 % and 1.2 % in EG and 0.7 % and 0.0 % in WG. Figure 6 plots the ratio of EG's to WG's sectoral productivity levels for two different purchasing power exchange rates—one and 1.04. The latter equals the reciprocal of 0.96 which is our estimate for the price level ratio of EG with WG.[20] We find that the initial EG productivity level was only 40 % of the WG level in the tradable and about 75 % in the nontradable goods sector. In both sectors, faster productivity growth in EG stalled around the mid-1990s. However, while the productivity in the nontradable goods sector in EG catches up with the WG's one, the productivity in the tradable goods sector in EG stalled at two-thirds to three-quarters of the WG's one.

[20] Note that the conversion follows $\frac{\omega_{Ejt}^{e} e^{R(1-\alpha_{Ej})}}{\omega_{Wjt}^{e}}$, $e^R \in \{1, 1.04\}$.

Figure 5: Productivities and wedges



(a) Productivity growth rates, nontradable ($p_{iNTt}\omega^e_{iNTt}/p_{iNTt-1}\omega^e_{iNTt-1} - 1$)

(b) Productivity growth rates, tradable ($p_{iTt}\omega^e_{iTt}/p_{iTt-1}\omega^e_{iTt-1} - 1$)

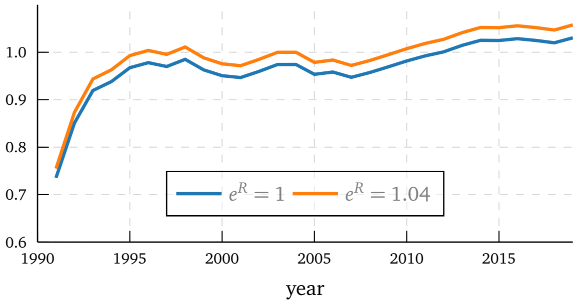
(c) Labor wedge, nontradable (ω^L_{iNTt})

(d) Labor wedges, tradable (ω^L_{iTt})

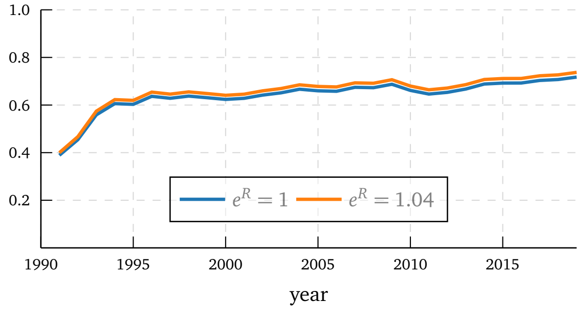
(e) Capital wedge, nontradable (ω^K_{iNTt})

(f) Capital wedge, tradable (ω^K_{iTt})

Figure 6: Relative productivities, EG to WG



(a) Nontradable ($p_{ETt}\omega^e_{ENTt}/p_{WNTt}\omega^e_{WNTt}$)



(b) Tradable ($p_{ETt}\omega^e_{ETt}/p_{WTt}\omega^e_{WTt}$)

Sectoral labor wedges The second row of Figure 5 plots the labor wedges ω^L_{ijt} for the nontradable goods sector in Panel (c) and the tradable goods sector in Panel (d), computed using equation (37a). Blue lines indicate our labor wedge measure and orange lines the labor wedge measured at the realized marginal rate of substitution between consumption and leisure, i.e., $\omega^L_{ijt}/\omega^{QL}_{it}$. Comparing the wedges' differences, for both sectors and measures, the labor wedges are permanently higher in EG than in WG. The disparities in labor wedges between WG and EG diminish over time, narrowing a significant initial gap that is bigger in the tradable goods than in the nontradable goods sector. More specifically, in the nontradable sector, the labor wedge gap decreased from 70 % of the WG wedge to less than 8 %, and in the tradable sector, it dropped from over 135 % to under 24 %.

Regarding an efficient allocation, given our calibration, the labor wedge in the nontradable goods sector is closer to one in WG than in EG over the entire period. However, in the tradable goods sector, the allocation in EG becomes more efficient with the onset of the COVID-19 pandemic.

Sectoral capital wedges The last row of Figure 5 plots the sectoral capital wedges ω^K_{ijt+1}, derived from equation (37b). Regarding the regional convergence of the sectoral capital wedges, the initial gaps between WG and the EG are nearly 10 % in the nontradable sector and 15 % in the tradable in terms of the WG wedges. However, these gaps closed until the mid-1990s, reflecting a period of fast convergence. Beginning in the early-2010s, the gaps start to widen again and persist through 2019, indicating a renewed divergence in sectoral capital allocations across regions in the later years of our sample; although, in a smaller magnitude. Between 1991 and 2019 capital wedges in WG shrank by 0.1 % in the tradable goods sector versus almost no growth in the nontradable on average. In EG, they decreased at rates of 0.2 % and 0.1 %, respectively.

Within the same region, the capital wedges in the tradable goods sectors are smaller than those in the nontradable goods sector. Further, the capital wedge's levels in EG are nearly always higher than in WG and closer to one from the mid-1990s on, indicating a more efficient capital allocation in EG in this period.

Remaining wedges and further variables Figure 1 Panel (b) presents already the government consumption and the residual wedge as they correspond to the share of government consumption and the residual on GDP, so we refrain from presenting them again here. In our model, the bond wedge is an endogenous variable according to equation (37c), so we focus on how other wedges affect it. For this reason, we present and discuss the bond wedge in the counterfactuals section (Figure 8, Panel (b)). The remaining measures $\{\eta_{it}, d_{it}, Z_{it}\}_{t=0}^{T}$ are reported in Appendix E Figure E.3, as they primarily determine relative prices, which are generally quite similar. A relatively high price for capital goods in EG during the early 1990s, when the share of investment on GDP was elevated, is worth noting. This difference in investment prices highlights the importance of accounting for relative investment prices. Figure E.4 in Appendix E compares the capital wedges with those from a model that does not account for such prices. In that case, the EG wedges are much closer to one and to WG capital wedges during the early 1990s.

Sectoral aggregation and reunification shocks Fehrle and Konysev (2025) describe the economic situation of the former GDR compared to the former Federal Republic of Germany (FRG) within the standard one-sector wedge-accounting framework until 1989. Building on their quantitative results, we can analyze the immediate impact of the German reunification through the lens of wedges and productivities. For the sake of comparability to the one-sector model of Fehrle and Konysev (2025) and, generally, to the standard, we aggregate the value of the sectoral TFP with the respective sectoral good's shares on value added as weights by $\omega_{it}^{e} = \sum_{j\in\{T,NT\}} \frac{p_{ijt}x_{ijt}}{y_{it}} p_{ijt}\omega_{ijt}^{e}$. Further, the aggregated regional labor ω_{it}^{L} and capital wedge ω_{it}^{K} read

$$\omega_{it}^{L} = \omega_{it}^{QL} \frac{u_{\bar{l}-l_{it}}/u_{c_{it}}}{\frac{\partial y_{it}}{\partial l_{it}}}, \ \omega_{ijt+1}^{K} = \frac{u_{c_{it}}/\left(\beta_i u_{c_{it+1}}\right)}{\left((1-\delta_{it+1})d_{it+1} + \frac{\partial y_{it+1}}{\partial k_{it+1}}\right)/d_{it}}.$$

From sectoral market clearing (37h), the tradable price condition (37j), and the value added-absorption (37f), we write the regional value added

$$y_{it} = y_{it}^{D}\left(1 + \eta_{it}\frac{\omega_{it}^{D}}{1 - \omega_{it}^{D}}\right).$$

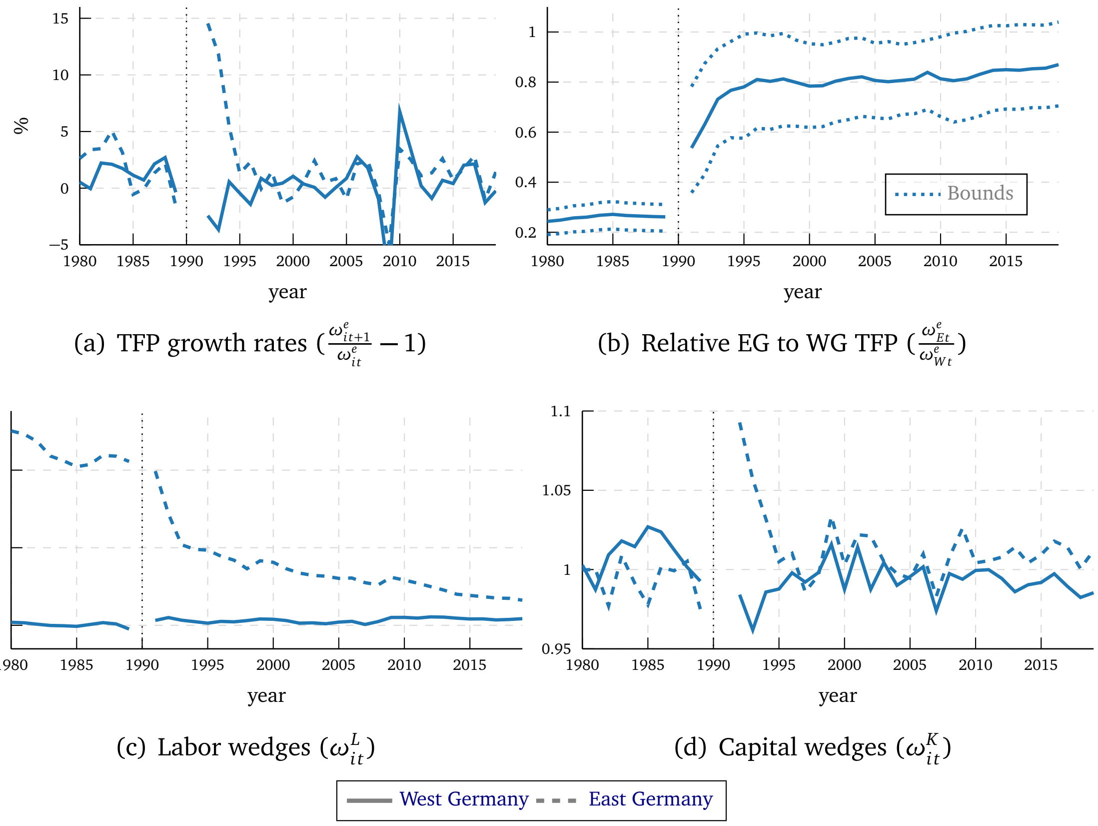
Further, the aggregated marginal productivities $\frac{\partial y_{it}}{\partial l_{it}}$ and $\frac{\partial y_{it}}{\partial k_{it}}$ follow

$$\frac{\partial y_{it}}{\partial l_{it}} = \sum_{j\in\{T,NT\}} \frac{\partial y_{it}}{\partial y_{it}^{D}} \frac{\partial y_{it}^{D}}{\partial m_{ijt}} \frac{\partial m_{ijt}}{\partial x_{ijt}} \frac{\partial x_{ijt}}{\partial l_{ijt}} \frac{\partial l_{ijt}}{\partial l_{it}},$$
$$\frac{\partial y_{it}}{\partial k_{it}} = \sum_{j\in\{T,NT\}} \frac{\partial y_{it}}{\partial y_{it}^{D}} \frac{\partial y_{it}^{D}}{\partial m_{ijt}} \frac{\partial m_{ijt}}{\partial x_{ijt}} \frac{\partial x_{ijt}}{\partial k_{ijt}} \frac{\partial k_{ijt}}{\partial k_{it}},$$

whereby the equations (37a), (37b), (37n), and (37o) determine the allocation of the sectoral inputs, i.e., the marginal change in the sectoral input factors when the aggregated input factor changes by $\frac{\partial l_{ijt}}{\partial l_{it}}$ and $\frac{\partial k_{ijt}}{\partial k_{it}}$.

Figure 7 illustrates regional aggregated productivities and labor and capital wedges from the early-1980s until 2019. Before German reunification in 1990, we plot the wedges from Fehrle and Konysev (2025). Note that identical assumptions regarding households' preferences apply in time and space, while the production side is period- and region-dependent. Further, Fehrle and Konysev (2025) also account for labor supply constraints in the FRG and, complementary, for consumption demand constraints in the GDR. Thus, the wedge measures from both studies are fully consistent regarding quantity constraints. The labor supply constraints in WG are similar (around 1.04) before and after reunification. The consumption demand constraints in the GDR impact the marginal rate of substitution between consumption and leisure equivalent to a labor supply constraint wedge of 1.33, where the labor supply constraints wedge is around 1.11 in EG in 1991. Additionally, consumption demand constraints diminish marginal utility, while in our setting unemployment causes no direct disutility.

Figure 7: Aggregated productivities and wedges



(a) TFP growth rates ($\frac{\omega^e_{it+1}}{\omega^e_{it}} - 1$)

(b) Relative EG to WG TFP ($\frac{\omega^e_{Et}}{\omega^e_{Wt}}$)

(c) Labor wedges (ω^L_{it})

(d) Capital wedges (ω^K_{it})

Figure 7 Panel (a) shows aggregated TFP growth rates. Focusing directly on the reunification, we observe an impressive increase in TFP growth rates in EG, especially when compared to the preceding decade, while WG's productivity growth became negative.

We plot EG's regional TFP levels relative to WG's regional TFP levels in Panel (b). Solid lines represent the ratio of our regional TFP estimates, while dotted lines denote the upper and lower bounds for relative TFP values. The bounds for the TFP ratio between the GDR and the FRG are due to uncertainty about the purchasing power parity exchange rates and represent real exchange rates between 0.5 and 1 with the solid line equal 0.75.[21] After reunification, we use ratios of TFPs in the tradable goods sector as the lower bound for regional ratios and the one of TFPs in the nontradable goods sector as the upper bounds, as our measure is only exact for zero-net-inflows.

Despite these mentioned methodological challenges, it is undoubted that the productiv-

[21]Note that the productivity wedge growth rates as well as the labor and capital wedges are unitless and are without such valuation problems.

ity catch-up in EG between 1989 and 1991 was impressively large, and likely even larger than the high growth rates discussed for 1991 and following.[22]

Panel (c) of Figure 7 displays the aggregated regional labor wedges. The labor wedges demonstrate a convergence pattern similar to that of sectoral labor wedges, narrowing from an initial gap nearly as large as the WG wedge to about 10 %. The regional wedges from 1991 correspond to the findings for the last two decades of the two Germanies by Fehrle and Konysev (2025), where the wedge in EG was above but close to two, while in WG it was close to one. This alignment suggests a minor immediate influence on the labor wedges by the actual reunification shock.

Panel (d) of Figure 7 illustrates aggregated regional capital wedges. The capital wedges largely mirror the average behavior of sectoral capital wedges within each region. Initially, there were notable differences between WG and EG, with EG capital wedges exceeding those in WG by 10 %. These differences rapidly diminished during the convergence phase up to the mid-1990s. However, in the analysis of Fehrle and Konysev (2025) aggregated capital wedges in both WG and EG converged to similar levels, settling close to one by 1980. This illustrates an immediate shock to the capital allocation efficiency across the two regions, triggered by reunification—an impact on the capital wedge of a magnitude that had not been observed in any of both regions between 1960 and 2019.

Convergence Here, we quantify and infer from our descriptive analysis of the wedges' differences. Specifically, we test whether the wedges between the regions were initially alike, have already converged, are still converging, or if convergence has stalled. To achieve this, we first test for initial differences, and if such differences exist, we proceed to test for convergence.

For this purpose, we first test the hypothesis that the relative distance between the wedges, $R_t = {}^{(\omega^{\upsilon}_{Ejt} - \omega^{\upsilon}_{Wjt})}/_{\omega^{\upsilon}_{Wjt}}$, with $\Upsilon \in \{L, K, e, QL, D\}$ and $j \in \{T, NT\} \cup \{\emptyset\}$, is zero at $t = 0$. This hypothesis is tested via an intercept α^{Υ}_j significance test of the trend regression

$$R_t = \alpha^{\Upsilon}_j + \beta^{\Upsilon}_j t + \epsilon^{\Upsilon}_{1jt}, \quad t = 0, 1, \ldots, T. \tag{39}$$

In the case that the test rejects the hypothesis of wedge equality, we subsequently test the hypothesis that the exponential decay rate λ^{Υ}_j is not positive. This is tested by a regression

[22]Note that WG experienced positive GDP growth in 1990.

on the log-absolute transformation of the exponential decay model, i.e.,

$$\ln(|R_t|) = \gamma_j^{\Upsilon} - \lambda_j^{\Upsilon} t + \epsilon_{2jt}^{\Upsilon}, \quad t = 0, 1, \ldots, T. \tag{40}$$

To verify equality between the wedges at later time points—indicating finished convergence—we conduct this procedure not only for the full period (1991 – 2019) but also for each decade separately, i.e., the periods 1991 – 1999, 2000 – 2009, and 2010 – 2019.

Table 3 presents the estimates for α_j^{Υ} and λ_j^{Υ}, summarizing the results of this exercise. Statistical significance is indicated by stars: one (*) for p-values below 0.1, two (**) for p-values below 0.01, and three (***) for p-values below 0.001. The Tables E.4 and E.5 in Appendix E report all parameters estimates and the corresponding p-values.

Regarding the nontradable efficiency, we observe an initial significant gap in the 1990s, followed by fast convergence, which slows down in the 2000s. However, convergence completes in the 2000s, as indicated by a non-significant gap in the 2010s. The patterns for the tradable efficiencies are similar. However, the initial gap in the 1990s is larger, and the convergence rates are lower, resulting in incomplete convergence until the end of the period under consideration. The aggregated efficiency difference can be described as the average of the behavior of the nontradable and tradable efficiency differences.

Regarding the quantity labor wedge, there was quantitative divergence in the 1990s. Since then, statistical convergence has occurred, with decay rates of 7 % in the 2000s and 16 % in the 2010s. As a result, the initial gap in 2010 diminished to one-fifth by the end of the decade. The sectoral and aggregated labor wedges exhibit the fastest statistically significant convergence in the 1990s. Since then, they have experienced a stable rate of convergence, with a slight acceleration in the 2010s. While not fully converged yet, the gap has narrowed substantially but remains statistically significant in 2010. Given the decay rates in the 2010s, the gap has halved at least since then.

For the nontradable capital wedges, there is a significant gap at the beginning, followed by convergence in the 1990s. Convergence is complete within the decade, as indicated by a non-significant gap, close to zero, from 2000 onward. Looking at the entire period, the results suggest that the gap in the early 1990s is more of an outlier than a structural gap, as the initial gap exists but is not statistically significant. The pattern for the tradable capital wedge is similar in the 1990s, although a small, significant gap remains, and convergence stalls or even divergence occurs from the 2000s onward. Looking at the full period, the result on whether the gap in the early 1990s is an outlier or a structural gap is borderline, with a p-value around 0.08. The aggregated capital wedge behaves similarly to the nontradable wedge.

For residual demand, there are significant gaps in all cases, along with significant convergence rates. However, the convergence rates decrease remarkably over time.

Table 3: Tests for initial gaps and subsequent convergence

Wedge		1991-1999	2000-2009	2010-2019	full period
Nontradable efficiency	α	-0.18^{**}	-0.05^{***}	-0.01	-0.11^{***}
	λ	0.22^{**}	0.05^{*}	–	0.06^{**}
Tradable efficiency	α	-0.55^{***}	-0.37^{***}	-0.36^{***}	-0.46^{***}
	λ	0.05^{***}	0.01^{***}	0.02^{***}	0.02^{***}
Aggregate efficiency	α	-0.39^{***}	-0.21^{***}	-0.20^{***}	-0.29^{***}
	λ	0.08^{***}	0.02^{***}	0.04^{***}	0.03^{***}
Quantity labor	α	0.06^{***}	0.10^{***}	0.05^{***}	0.10^{***}
	λ	-0.03	0.07^{***}	0.16^{***}	0.06^{***}
Nontradable labor	α	0.59^{***}	0.29^{***}	0.17^{***}	0.47^{***}
	λ	0.09^{***}	0.04^{***}	0.09^{***}	0.07^{***}
Tradable labor	α	1.06^{***}	0.50^{***}	0.39^{***}	0.79^{***}
	λ	0.09^{***}	0.04^{***}	0.05^{***}	0.04^{***}
Aggregate labor	α	0.75^{***}	0.35^{***}	0.23^{***}	0.57^{***}
	λ	0.09^{***}	0.04^{***}	0.07^{***}	0.06^{***}
Nontradable capital	α	0.09^{***}	0.00	0.00	0.03
	λ	0.32^{***}	–	–	–
Tradable capital	α	0.12^{***}	0.02^{***}	0.02^{***}	0.05^{*}
	λ	0.33^{**}	-0.03	-0.06	-0.01
Aggregate capital	α	0.10^{***}	0.01^{*}	0.01	0.04
	λ	0.34^{**}	-0.01	–	–
Residual	α	-14.56^{***}	-5.86^{***}	-3.08^{***}	-10.63^{***}
	λ	0.10^{***}	0.08^{***}	0.03^{***}	0.06^{***}

Notes: α and λ are OLS estimates from $R_t = \alpha_j^{\Upsilon} + \beta_j^{\Upsilon} t + \epsilon_{1jt}^{\Upsilon}, \quad t = 0, 1, \ldots, T.$ and $\ln(|R_t|) = \gamma_j^{\Upsilon} - \lambda_j^{\Upsilon} t + \epsilon_{2jt}^{\Upsilon}, \quad t = 0, 1, \ldots, T.$ *, **, and *** denote HAC-robust p-values of < 0.1, < 0.01, and < 0.001, respectively, for the null hypotheses $H_0 : \alpha = 0$ and $H_0 : \lambda \leq 0$.

4.2 Counterfactual analysis

The realized wedges analyzed in the previous section provide insights into the channels that influence regional allocations across various segments and sectors, and how these allocations have evolved over time. However, they do not allow us to assess the relative contribution of each wedge to the convergence of EG's economic activity toward that of

WG and the contribution of the remaining gaps in the wedges to the persisting gap in economic activity.

To assess these contributions, we conduct counterfactual experiments by modifying the values of the wedges and evaluating their impact on EG's model economy. A natural candidate for such counterfactuals is a scenario with no distortions. Given our focus on economic convergence within a single nation using a sectorally disaggregated framework, another reasonable approach is to swap the corresponding wedges from the respective region or sector. Since the choice of meaningful counterfactuals is case-dependent, we discuss our strategy for each wedge during its respective counterfactual analysis. Before that, we outline the computational implementation of our approach.

4.2.1 Computational implementation

We describe in Appendix D our computational implementation in detail. In brief, solving the model represented by system (37) for a set of exogenous variables is a two-point boundary value problem. While the initial condition k_{i0} is observable, the terminal condition must be inferred as the trajectory for $t > T$ is unobserved, however, under perfect foresight, the agents' decisions for $t = 0, ..., T$ base on knowledge of the trajectories after T. We solve this problem with the approach of del Río and Lores (2021). i) We calibrate a sufficient number of steady-state values to determine a unique fixed point, from which we derive all steady-state values of both endogenous and exogenous variables. ii) We compute a hypothetical trajectory for the observables as they converge toward the fixed point and deduce the latent variables again using system (37). After, we can solve system (37) from the initial condition to the fixed point—the terminal condition—with the counterfactual trajectories of exogenous variables from $t = 0$ toward a steady state. Thus, terminal conditions change with counterfactual exogenous variables' steady states as they change the fixed point, but the initial condition remains as observed.

Regarding the convergence path (ii)), we assume exponential convergence at a rate of 3 % toward the steady state per period and simulate this process over 1,000 periods, at which point the steady state is assumed to be reached. We specify the model's fixed point (i)) to align with long-term observed data for each German region, respectively. Specifically, we pin down the consumption-to-domestic GDP ratios $\frac{c_i}{y_i^D}$, investment-to-domestic GDP ratios $\frac{i_i}{y_i^D}$, sectoral labor shares $\frac{l_{ij}}{l_i}$, sectoral capital shares $\frac{k_{ij}}{k_i}$, regional levels of hours l_i, levels of average years of schooling s_{ij}, sectoral prices p_{ij}, regional investment prices d_i

and the sectoral output levels x_{ij} to their empirical average counterparts in 2010 – 2019. We report their values in Appendix D.1, Table D.2. The chosen period is based on the fact that most wedges exhibit near-stability, suggesting a tendency toward long-run behavior. Further, using these values, the trajectory as well as the steady-state values of the model match recent data for EG and WG in 2024.[23]

4.2.2 Results

We begin our analysis by examining the role of net inflows, establishing a new benchmark at zero net inflows to ensure an interior solution for the subsequent counterfactual experiments. Without this combination, the counterfactual trajectories of some endogenous variables reach their zero lower bounds due to the large inflows to EG in the early 1990s. We find interpreting the effects within an interior solution more fruitful, even if it comes at the cost of a counterfactual benchmark case. After, we analyze the efficiency, capital, and labor-related wedges. Our analysis focuses first on the wedge's impact on economic activity, measured by GDP per capita. Subsequently, we conduct a welfare analysis using a consumption-equivalent measure. For simplicity of notation, we define the growth factors of sectoral TFPs and wedges as $g^{\Upsilon}_{ijt+1} = \frac{\omega^{\Upsilon}_{ijt+1}}{\omega^{\Upsilon}_{ijt}}$, where $\Upsilon \in \{e, K, L, QL, D\}$, and denote the counterfactual trajectories of TFPs, wedges, and investment prices with upper bars.

The role of net inflows and the benchmark First, we conduct a zero-net-inflows counterfactual, formally $\bar{\omega}^{D}_{Et} = 0$ for all t. The goal is to confront EG's economy with the disappearance of the large inflows in all years, most pronounced from the early 1990s until the mid-2000s. We present the results in Figure 8. The straight blue line displays the counterfactual GDP in EG. The straight black line in Panel (a) displays EG's real GDP per capita data and the dashed line, the complementary time series for WG. All values are in log-distance to the counterfactual GDP in 1991 given zero net inflows. The zero-net-inflows counterfactual increases economic activity sizably, especially in the 1990s. In this period, the level of GDP increases by nearly 40 %. Generally, the gap in economic activity narrows between EG and WG by roughly one-third in the counterfactual.

From here on, the zero-net-inflows counterfactual becomes our already mentioned new benchmark, i.e., we assess the impact of efficiency, capital, and labor-related wedges in

[23] We ignore growth in the long run due to similar economic activity in 2017 and 2024, as well as similar forecasted conditions for the coming years. Ignoring growth in the long run due to a stagnant economic period aligns with the wedge-growth accounting study for Italy by Fernández-Villaverde et al. (2023).

combination with net-zero inflows. To understand the implications that come with this counterfactual benchmark, we plot in addition to GDP the realized and benchmark counterfactual time paths of the bond wedge, consumption, and labor.

In Panel (b) we plot the endogenous bond wedges. The straight black line represents the implicit bond wedge from the data, and the straight blue line represents the bond wedge from the zero-net-inflows counterfactual. The differences in the 1990s indicate that the inflows helped to smooth consumption in fact in EG. However, the continuing inflows barely affect the bond wedge from the late 2000s onward. Panel (c) plots the consumption paths in EG and WG. Due to a positive income effect generated by the net inflows, the counterfactual consumption in EG decreases and substantially widens the gap to WG. As can be seen in Panel (d), this negative income effect increases counterfactual hours worked considerably.

The role of productivity differences Here, we evaluate the role of productivity differences between EG and WG. Figure 9 displays various counterfactuals for EG's GDP. In Panel (a), we display the counterfactual of WG's TFP levels in EG's nontradable and tradable goods sectors, respectively ($\bar{\omega}^e_{ENTt} = \omega^e_{WNTt} \vee \bar{\omega}^e_{ETt} = \omega^e_{WTt}$ for all t), in addition to the WG data and the EG zero-net-inflows benchmark. It turns out that the differences between WG and EG are small in the nontradable goods sector, unlike the differences in the tradable goods sector. Regarding the latter, EG's economic activity would be larger until the mid-2000s or similar from the mid-2000s to WG (together with zero net-inflows).

Figure 8: Zero net inflows in EG counterfactual

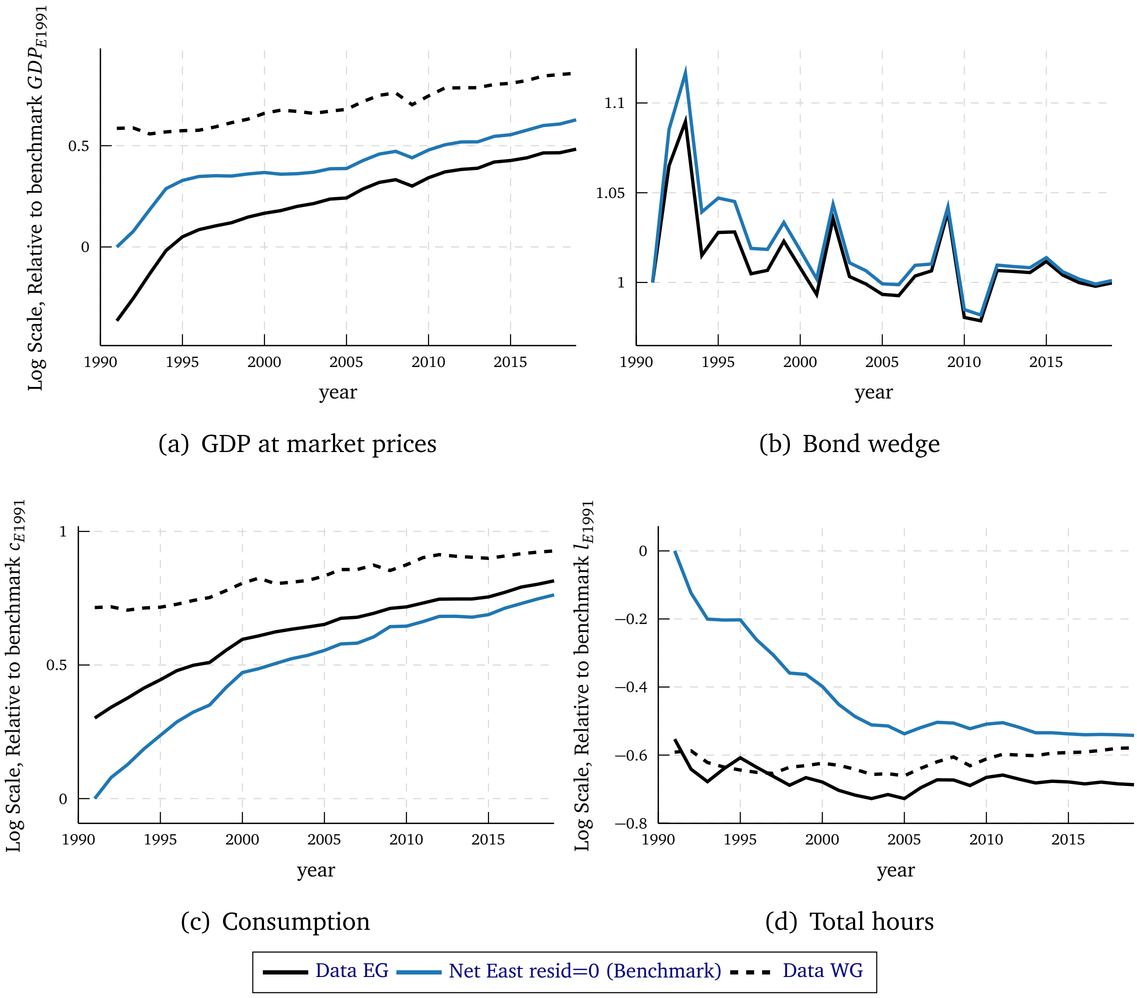
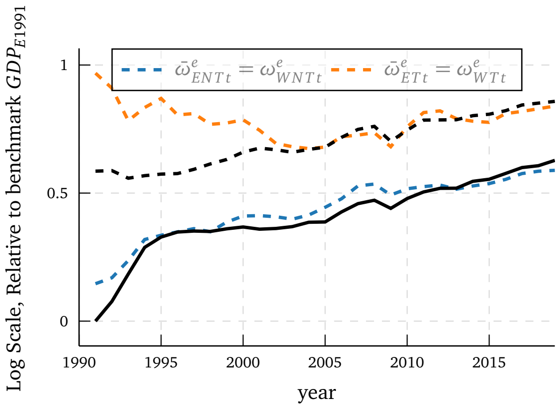
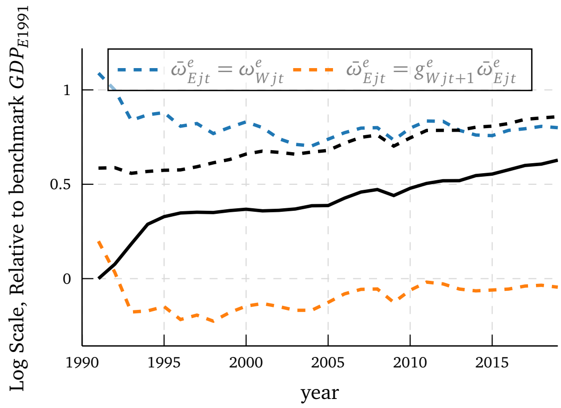


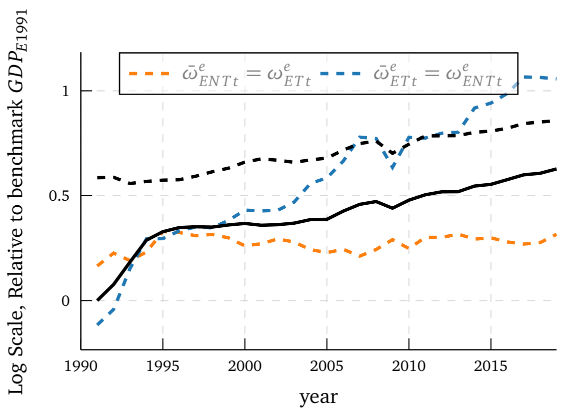
Figure 9: TFP-related counterfactuals in EG



(a) GDP with sectoral WG TFP levels



(b) GDP with immediately and no convergence in TFP



(c) GDP with swapped EG sectoral TFP levels

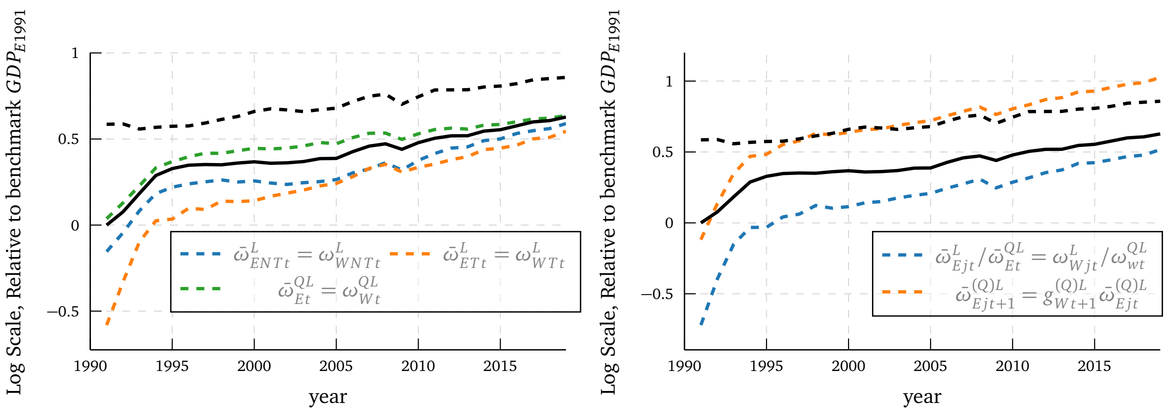
Benchmark - - - West Germany

In Panel (b), we simulate the counterfactual where the TFP levels in both sectors of EG are set to those of WG simultaneously, i.e., $\bar{\omega}^e_{ENTt} = \omega^e_{WNTt}$ and $\bar{\omega}^e_{ETt} = \omega^e_{WTt}$. This counterfactual assumes an immediate convergence of EG's to WG's overall productivity. Further, we simulate the opposite: a no-convergence counterfactual. In this case, the initial productivity gaps between WG and EG persist over time, formally expressed as $\bar{\omega}^e_{Ejt+1} = g^e_{Wjt+1}\bar{\omega}^e_{Ejt}$ and $\bar{\omega}^e_{Ej1991} = \omega^e_{Ej1991}$. Again, an immediate convergence of TFP implies that EG's economic activity would be larger or equal to WG's (together with zero net inflows). The second counterfactual—no catch-up in productivity—depresses economic activity heavily, indicating the large effects of the catching-up process of productivity in EG. Mind that we observe a jump in the productivity gap between the segregated and reunified Germany. This happened before our no-convergence counterfactual quantification, meaning that economic activity would have been depressed even more, assuming a constant productivity gap since 1989.

To emphasize the difference between the productivity catch-up in the tradable and nontradable sectors, we present in Panel (c) counterfactuals, where we exchange the TFP levels between the sectors within EG ($\bar{\omega}^e_{ENTt} = \omega^e_{ETt} \vee \bar{\omega}^e_{ETt} = \omega^e_{ENTt}$). The counterfactual, where both sectors are endowed with the nontradable sectorâs TFP (blue dashed line), implies that economic activity in EG would catch up to WG's in the late 2000s and overtake from the early 2010s on (together with zero net inflows). Conversely, the counterfactual, where both sectors are endowed with the tradable sectorâs TFP (orange dashed line), indicates stagnation from 1995 onward.

Labor-related wedges In this paragraph, we assess the impact on economic activity of labor wedge differences between EG and WG. Panel (a) in Figure 10 displays a counterfactual with WG's sectoral wedges and, additionally, the quantity constraint wedge individually. Panel (b) displays EG's counterfactual, with immediate and no convergence in the labor market to WG. The term labor-related wedges refers here to the sectoral labor wedges and the labor quantity constraint wedge. As we consider the sectoral labor wedge differences within EG minor, we refrain from a within-region analysis of the sectoral differences here.

Figure 10: Labor-related wedges counterfactuals in EG



(a) GDP with sectoral WG labor wedges

(b) GDP with immediately and no labor wedge convergence

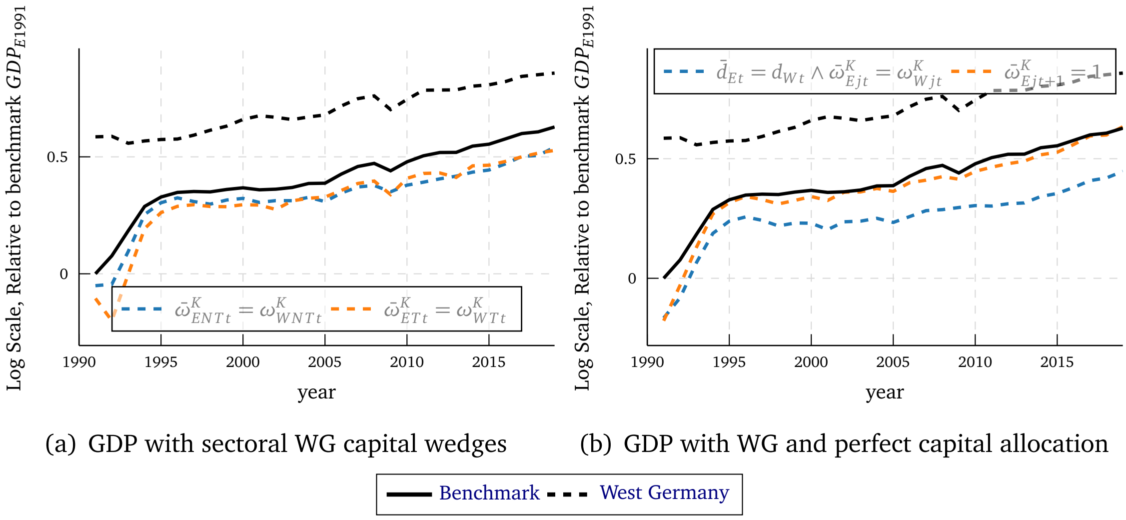
Benchmark — West Germany

EG's economic activity would decrease substantially with the sectoral labor wedges, especially in the early 1990s. Economic activity increases with the more slack labor quantity constraint from WG. However, the effect is comparatively small. Consequently, economic activity is depressed in the counterfactual, where all labor-related wedges from WG operate. Further, with no-convergence of the labor-related wedges, economic activity in EG would catch up WG's in the 1990s (together with zero net inflows).

Capital-related wedges Lastly, we conduct the counterfactuals for the capital-related wedges. Figure 11 presents the counterfactuals for EG's GDP. As for the productivity wedges, Panel (a) displays the counterfactual of the WG capital wedges in EG's nontradable and tradable sectors, respectively $\bar{\omega}^K_{ENTt} = \omega^K_{WNTt} \vee \bar{\omega}^K_{ETt} = \omega^K_{WTt}$. In Panel (b), we depict the capital wedge equality between EG and WG in both sectors in blue. Additionally, we assume equality in relative capital prices d_{it}, as the capital wedge gap is reflected in the relative price gap between EG and WG (see Appendix E, Figure E.3, Panel (c)), suggesting a dependency. Formally, this implies $\bar{d}_{Et} = d_{Wt} \wedge \bar{\omega}^K_{ENTt} = \omega^K_{WNTt} \wedge \bar{\omega}^e_{ETt} = \omega^e_{WTt}$. Further, we plot in Panel (b) a no-distortion counterfactual, where $\bar{\omega}^K_{Ejt+1} = 1$ for all t. A no-convergence counterfactual is not meaningful because the capital wedges in the early 1990s do not reflect a simple rollover of the GDR structure nor a persistent structural pattern. This is evident from the capital wedges from Fehrle and Konysev (2025) and the convergence analysis, respectively. In line with the labor-wedges analysis, we refrain from a within-region analysis of the sectoral differences, as the differences are minor.

The results show that the realized allocation in EG is mostly superior in terms of economic activity compared to the counterfactuals, including the no-capital-market-distortion counterfactual. However, the effect of the no-capital-market-distortion counterfactual is minor, especially compared to the medium-size impact of the WG counterfactual.

Figure 11: Capital wedge counterfactuals in EG



(a) GDP with sectoral WG capital wedges (b) GDP with WG and perfect capital allocation

4.3 Impact on welfare and summary measures

While GDP per capita is often the main subject of public debates on the differences between EG and WG, our framework allows a welfare analysis by comparing differences in the levels of utility augmenting quantities, i.e., consumption and leisure, and their allocation over time. Instead of discussing the ambiguous effects of counterfactual outcomes of these quantities, we plot their paths in Appendix E and assess their impact on welfare by calculating a consumption-equivalent welfare measure Δc_i. The measure Δc_i is the solution of

$$\sum_{t=0}^{T} \beta_i^t N_{it} u(c_{it}^f, g_{it}^f, l_{it}^f, \Delta c_i) \stackrel{!}{=} \sum_{t=0}^{T} \beta_i^t N_{it} u(c_{it}^c, g_{it}^c, l_{it}^c), \tag{41}$$

where the superscripts c denote the counterfactual and superscripts f as the zero-net-inflows benchmark or the EG realizations, and per-period utilities write $u(c_{it}, g_{it}, l_{it}, \Delta c_i) = \ln((c_{it} + g_{it})(1 + \Delta c_i)) + \theta \ln(\bar{l} - l_{it})$. This measure quantifies the percentage change in the consumption path required to make a household indifferent between benchmark and counterfactual scenarios. Therefore, a positive consumption-equivalent welfare value signifies a gain, while a negative value indicates a loss. Note that it captures solely the observation period of 29 years from 1991 until 2019. This has implications for the capital wedge and net flows, as investments in capital or bonds with payoffs after 2019 account here as welfare losses and debt as gains.

In addition to the welfare measure, we report the average relative distance Δz of the counterfactual GDP per capita paths by

$$\Delta z_f^c = \frac{1}{T+1} \sum_{t=0}^{T} \frac{y_t^c}{y_t^f} - 1, \tag{42}$$

where c represents a counterfactual and f the benchmark (BM) or the WG realization (WG). This measure summarizes our visual inspection of counterfactual GDP trajectories in the previous section. More importantly, it helps to capture the contrasts between superior outcomes in economic activity and welfare.

Table 4 summarizes the discussed measures for various counterfactual scenarios. The first row documents both measures for the WG per capita realization of GDP, consumption, and leisure in EG. The second row presents the results for the zero-net-inflows counterfactual. Rows three through eight cover the counterfactuals from the respective Panel (b) of Figures 9, 10, and 11. Note that in the first two cases—the WG realization and the zero-net-inflows counterfactual—the benchmark (BM) is the actual EG realization. For all other counterfactuals, the benchmark is the zero-net-inflows counterfactual, as previously discussed.

The first row of Table 4 shows that despite, on average, 63 % higher economic activity in WG, the consumption-equivalent welfare gain is only 13 %. The second row indicates that zero net inflows result in a welfare loss equivalent to 34 % of total consumption, despite a sizable increase in economic activity by more than 20 % on average. The third row shows a welfare loss equivalent to 32 % of total consumption if there is no convergence in sectoral productivities (TFP). In contrast, immediate convergence in productivity yields a substantial welfare gain, with an increase equivalent to 34 % of consumption, alongside more than 50 % higher economic activity. Note that in this case, EG economic activity would exceed WG economic activity by nearly 13 %.

Regarding the labor-related wedges, rows five and six indicate that the absence of convergence results in a welfare loss of 17 %, whereas average economic activity increases to WG levels. Immediate convergence with WG increases welfare by an equivalent of 8 %, despite a 20 % lower economic activity on average. Lastly, for capital wedges in rows seven and eight, the absence of distortions results in a small welfare gain of 3 % of consumption, while equivalence in wedges and prices yields higher welfare benefits equivalent to 8 % of consumption, despite lower economic activity.

Table 4: Welfare and economic activity gap measures for EG in %

Counterfactual	Δc_E	Δz^{CF}_{BM}	Δz^{CF}_{WG}
WG per capita realizations	13.0	63.2	0.0
Zero net inflows (Benchmark *BM* after)	−33.8	22.0	-25.1
No TFP convergence	−31.7	−38.5	−54.6
Immediate TFP convergence	33.5	52.8	12.6
No labor-related wedges convergence	−17.0	33.6	0.6
Immediate labor-related wedges from WG	7.7	−20.1	−39.8
No capital market distortion	3.0	−3.1	−27.3
Immediate capital wedges and prices from WG	8.3	−14.5	−36.0

Notes: This table reports discounted consumption equivalent welfare measured by equation (41) and average relative GDP distance in % measured by equation (42) for the observation period 1991 until 2019 in various counterfactual simulations. Columns 1 and 2: The WG per capita realization in EG and the zero-net-inflows case in row 1 and 2 use EG's observed consumption, hours worked and GDP paths as a benchmark. All other cases in rows 3 until 8 use the paths of the zero net residual counterfactual as their benchmark. For further reference, we document the welfare and distance measures for the complete set of counterfactuals in Table E.6 in Appendix E.

5 Discussion, policy implications, and further results

In this section, we first discuss our results in light of the literature and their policy implications. Subsequently, we examine the impact of demographics on economic activity in the two regions, emphasizing the differences in GDP per capita and per working-age adult. This is important as it seems the declining unemployment in EG comes with a lower labor supply (desired hours worked) instead of higher realized hours worked, which in turn can be driven from a higher share of retirees. Lastly, we check the robustness of our human-capital-adjusted efficiency measure by comparing it with the standard Solow residuals.

Main results in light of the literature and policy implications To summarize our results, all initial differences between the regions in the wedges vanish in the sense that their impact on recent economic activity is minor, except for the inflows and the productivity of the tradable goods sector. Closing these two remaining gaps would bring economic activity in EG to WG's level. While the productivity gap comes with substantial welfare losses, the realized productivity gains increase welfare by a similar amount. This is a notable achievement, especially concerning the catch-up of productivity in the nontradable sector. The realized convergence in the sectoral labor wedges hinders economic activity convergence but led to sizable welfare gains with our calibration. This realized convergence has closed roughly two-thirds of these sizable losses compared to an immediate convergence—a clear success. Realized capital-related wedges slightly increase economic activity convergence but lead to modest welfare losses.

Regarding inflows, although they reduce economic activity and both the realized and the net-zero inflows counterfactual bond wedge have been close to one since the late 1990s, they provide substantial welfare benefits for EG. Lastly, regarding unemployment, we conclude that the excess unemployment in EG is more likely due to Classical causes (excessive supply) than Keynesian ones (demand scarcity). This grounds that labor wedges in EG, measured at the realized marginal rate of substitution between leisure and consumption, are consistently greater than 1 and, more important, higher than those in WG, regardless of the measure used.

Evidence for Classical causes aligns with the literature emphasizing excessively high wages in EG (Akerlof et al., 1991; Sinn and Sinn, 1992; Sinn, 2002). Our findings of depressed hours worked due to inflows towards the EG support the link between excessive unemployment and transfers established by Snower and Merkl (2006). However, we observe that the quantity labor wedge converges most at times where changes in the inflow-to-GDP ratios decelerated, indicating a temporal disconnection between the two phenomena.

The coincidence of net-inflow and tradable sector productivity convergence supports the notion of a net-inflow-driven depressed manufacturing sector, as suggested by Sinn (2002). However, the literature also highlights the opposite effect in other countries, where net-inflows can depress the nontradable sector via capital misallocation (e.g., Reis, 2013).

The lower productivity observed in EG's tradable sector aligns with the argument of Bachmann et al. (2022) that manufacturing firms avoid growth to escape collective bargaining wages. This reluctance of productive firms in the tradable sector to grow leads to an overallocation of input factors to less productive firms. This within-sector misallocation reduces the tradable sector's TFP by shifting production toward less productive firms. Such within-sector misallocation could explain the selective impact of general capital misallocation, as discussed by Klodt (2000) and Sinn (2002), in the tradable sector. Similarly, the growth reluctance in the tradable sector may also explain why the network externalities proposed by Uhlig (2006) and Uhlig (2008) are reflected exclusively in the tradable sector. However, the idea of monopsony power in the EG labor market does not align with the idea of excessively high wages causing unemployment in EG.

Canova and Ravn (2000) address potential skill mismatches due to structural change following reunification in EG as a threat for convergence. However, it cannot explain the exclusive impact on the tradable sector. Further, this explanation seems less plausible for the lower productivity and the slow convergence after three decades. Moreover, Fuchs-Schündeln and Izem (2012) argue that human capital was transferable from EG to the reunified Germany, further questioning the significance of skill mismatches as a primary driver of the observed productivity gap.

Our findings not only corroborate prior theories on the factors hindering full convergence but also provide significant policy implications. Classical unemployment, together with the spiking capital wedges in EG and the depressed ones in WG in the early 1990s, indicates an overuse of inputs in EG after reunification. The excessive use of inputs in EG, along with balanced bond wedges since the late 1990s, suggests that further transfers—whether for investment or consumption—are not justified from an allocation efficiency perspective. Likewise, Keynesian, demand-driven labor market policies lacks justification. However, the welfare benefits from net inflows toward the EG make policy changes—like reducing transfers from WG to EG—politically challenging. Hence, emphasizing productivity improvements in the tradable sector seems politically more realizable. However, well-defined policy interventions targeting the productivity gap in the tradable sector are less evident or inherently part of a vicious cycle when driven by net inflows.

Our analysis does not distinguish between non-entitlement transfers and liabilities and claims resulting from in- and outflows. However, the effects due to the extrapolation beyond 2019, where potentially a net payback realizes, are minor, given we cut our welfare measure in 2019. Thus, it is minor for our results whether they are entitlement or non-entitlement in- and outflows.

The role of demographics We attend to the argument of Fernández-Villaverde et al. (2023) that GDP growth per capita and GDP growth per working-age adult becomes different due to population aging. As the interior migration from EG to WG is done by the young educated, and we already account for the education, we want to briefly consider the effect of the migration of the young by differentiating between GDP growth, GDP growth per capita, and GDP growth per working-age adult. Note that our productivity measures are population-independent; thus, we not only account for the brain drain but also implicitly for the youth drain. Nevertheless, we want to account explicitly for the effect of the youth drain for GDP. Table 5 presents the average GDP growth, GDP growth per capita, and GDP growth per working-age adult rates for WG, EG, and Germany in total in percent. Additionally, the last column of Table 5 reports the difference between EG and WG in percentage points. It becomes apparent that the working-age population in EG shrinks faster than the population (-0.83 % vs. -0.52 %). In contrast, both the total population and the working-age population in WG grow. Albeit, the former grows faster than the latter (0.26 % vs. 0.05 %). The larger difference in the growth rates between population and working-age population in EG indeed increases the GDP per working-age adult growth rates more than in WG in absolute terms. As a result, the average GDP per capita growth rate in WG amounts to 1 % while in EG to 2.94 %—a difference of 1.94 percentage points. The average GDP per working-age adult growth rate in WG amounts to 1.21 % while in EG to 3.26 %—a difference of 2.05 percentage points. Thus, while the difference in GDP per capita and per working-age adult is significant at the national level, the growth gap between regions remains similar across these measures.

Table 5: Average growth rates in % 1991 – 2019

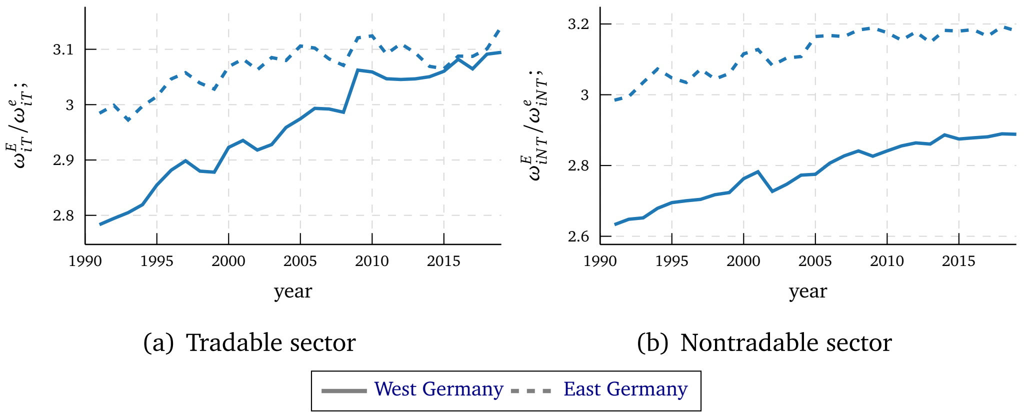
Measure	WG	EG	GER	EG minus WG
GDP	1.25	2.40	1.23	1.15
GDP per capita	1.00	2.94	1.10	1.94
Population	0.26	−0.52	0.13	−0.78
GDP per working-age adult	1.21	3.26	1.32	2.05
Working-age adults	0.05	−0.83	−0.09	−0.88

Solow residuals Here, we check the effect of our human capital productivity specification for robustness. For this reason, we compare our human capital adjusted TFP measures ω^e_{ijt} with the usual TFPs ω^E_{ijt} (Solow residuals). In line with Fehrle and Konysev (2025), we convert the latter into the former by

$$\omega^E_{ijt} = \omega^e_{ijt} h^{1-\alpha_{ij}}_{ijt}.\text{[24]} \tag{43}$$

Figure 12 illustrates the impact of human capital accumulation on sectoral TFP levels, plotting the ratios of usual-to-adjusted TFP levels. Furthermore, Table 6 shows the corresponding average growth rates of the sectoral and regional TFPs levels.

Figure 12: Usual to adjusted TFP ratios



(a) Tradable sector (b) Nontradable sector

Mechanically, increasing human capital leads to lower average productivity growth rates compared to Solow residuals. It matters the most in the productivity growth of WG's tradable goods sector and the least in the productivity growth of EG's tradable goods sector from the mid-2000s. This analysis indicates that the relative Solow residual in the nontradable sector of EG over WG would be ca. 7 % higher in 1991 and similar in the late 2010s than our measure, i.e., without accounting for human capital in the nontradable sector, productivity growth is underestimated. In the same manner, the relative Solow residual in the tradable sector of EG over WG would be ca. 13 % higher than our measure. The relative difference is stable.

[24]This follows directly from our efficiency measure $\omega^e_{ijt} = \frac{y_{ijt}}{k^{\alpha_{ij}}_{ijt}(h_{ijt}l_{ijt})^{1-\alpha_{ij}}}$ and the measure implied by a usual production function – $\omega^E_{ijt} = \frac{y_{it}}{k^{\alpha_{ij}}_{it}(l_{it})^{1-\alpha_{ij}}}$. Note that TFP level differences between ω^e_{ijt} and ω^E_{ijt} should be interpreted with caution, as they are highly dependent on also the scaling of the human capital function $h_{ij}(s_{ij})$.

Table 6: Average TFP growth rates 1991-2019

TFP measure	East Germany		West Germany	
	tradable	nontradable	tradable	nontradable
Usual	2.54	0.64	1.53	0.30
Adjusted	2.40	0.42	1.15	- 0.04

Notes: Average growth rate in % estimated from a linear time trend.

6 Conclusion

This study provides new insights into the unfinished convergence between East Germany (EG) and West Germany (WG) since reunification in 1990 by applying the wedge-growth accounting framework. Through this approach, we measure wedges in the allocation of goods and inputs across sectors, regions, and time, allowing us to assess their impact on economic activity and welfare through various counterfactual exercises.

Our analysis reveals that the largest welfare gains in EG result from productivity catch-up and substantial net inflows. While these inflows help to reduce disparities in the marginal rate of intertemporal substitution in the 1990s between the regions, their comparative impact on the intertemporal marginal rate is neutral since then. On the contrary, a lag in productivity in EG's tradable goods sector and the large net inflows together account for the one-third lower economic activity in EG. Regarding the labor and capital wedges, sectoral differences are small within regions, and large initial regional differences vanish due to convergence, especially regarding capital wedges. Thus, despite a comparative overuse of labor and capital in EG, especially in the early 1990s, differences in the labor and capital wedges have minor effects on welfare when considered over the entire period. The overuse of labor suggests that the excessive unemployment in EG stems from Classical rather than Keynesian causes.

Our welfare measure highlights that focusing solely on GDP per capita overlooks important implications. In EG, lower GDP is associated with contemporary welfare gains, which stem from increased voluntary leisure—driven by a declining, converging labor wedge—and permanent positive net inflows.

Our results have important policy implications: the continued inflows to EG cannot be justified on the grounds of equalizing allocation efficiency. They require a broader rationale, such as a preference for inter-regional welfare equality. Additionally, our findings contradict the objectives of Keynesian unemployment policy for EG. Moving forward, future research and policy should focus on addressing the remaining productivity gap in EG's tradable goods sector to accelerate convergence between the regions and simultaneously create the political conditions necessary to reduce transfers.

REFERENCES

Abadie, A. (2021). Using synthetic controls: Feasibility, data requirements, and methodological aspects. *Journal of economic literature 59*(2), 391–425.

Abadie, A., A. Diamond, and J. Hainmueller (2015). Comparative politics and the synthetic control method. *American Journal of Political Science 59*(2), 495–510.

Akerlof, G. A., A. K. Rose, J. L. Yellen, H. Hessenius, R. Dornbusch, and M. Guitian (1991). East germany in from the cold: the economic aftermath of currency union. *Brookings Papers on Economic Activity 1991*(1), 1–105.

Arbeitskreis "Volkswirtschaftliche Gesamtrechnungen der Länder" (2021). Methodenbeschreibung ESVG 2010/Revision 2019. Technical report, Statistische Ämter der 16 Bundesländer, Statistisches Bundesamtes und Statistisches Amt Wirtschaft und Kultur der Landeshauptstadt Stuttgart.

Arbeitskreis "Volkswirtschaftliche Gesamtrechnungen der Länder" (2023). Volkswirtschaftliche Gesamtrechnung der Länder. Technical report, Statistische Ämter der 16 Bundesländer, Statistisches Bundesamtes und Statistisches Amt Wirtschaft und Kultur der Landeshauptstadt Stuttgart.

Bachmann, R., C. Bayer, H. Stüber, and F. Wellschmied (2022). Monopsony makes firms not only small but also unproductive: Why east germany has not converged.

Barro, R. J. and H. I. Grossman (1971). A general disequilibrium model of income and employment. *The American Economic Review 61*(1), 82–93.

Barro, R. J. and J. W. Lee (2013). A new data set of educational attainment in the world, 1950–2010. *Journal of Development Economics 104*, 184–198.

Barro, R. J. and X. Sala-i-Martin (1995). *Economic Growth* (1 ed.). New York: McGraw-Hill.

Boltho, A., W. Carlin, and P. Scaramozzino (2018). Why east germany did not become a new mezzogiorno. *Journal of Comparative Economics 46*(1), 308–325.

Bundesamt, S. (2024). GENESIS table: 13211-0001. Technical report.

Burda, M. C. (2008). What kind of shock was it? regional integration and structural change in germany after unification. *Journal of Comparative Economics 36*(4), 557–567. Special Symposium on East Germany.

Burda, M. C. and J. Hunt (2001). From reunification to economic integration: Productivity and the labor market in eastern germany. *Brookings papers on economic activity 2001*(2), 1–92.

Burda, M. C. and B. Severgnini (2018). Total factor productivity convergence in german states since reunification: Evidence and explanations. *Journal of Comparative Economics 46*(1), 192–211.

Canova, F. and M. O. Ravn (2000). The macroeconomic effects of german unification: Real adjustments and the welfare state. *Review of Economic Dynamics 3*(3), 423–460.

Chari, V. V., P. J. Kehoe, and E. R. McGrattan (2007). Business cycle accounting. *Econometrica 75*(3), 781–836.

Cheremukhin, A., M. Golosov, S. Guriev, and A. Tsyvinski (2017). The industrialization and economic development of russia through the lens of a neoclassical growth model. *The Review of Economic Studies 84*(2), 613–649.

Cheremukhin, A., M. Golosov, S. Guriev, and A. Tsyvinski (2024, April). The political development cycle: The right and the left in people's republic of china from 1953. *American Economic Review 114*(4), 1107–39.

Chodorow-Reich, G., L. Karabarbounis, and R. Kekre (2023). The macroeconomics of the greek depression. *American Economic Review 113*(9), 2411–2457.

del Río, F. and F.-X. Lores (2021). Accounting for us economic growth 1954–2017. *Economic Modelling 101*, 105529.

del Río, F. and F.-X. Lores (2023). Accounting for spanish economic development 1850–2019. *Economic Modelling 121*, 106200.

Dohmen, T., A. Falk, D. Huffman, U. Sunde, J. Schupp, and G. G. Wagner (2011, 06). Individual risk attitudes: Measurement, determinants, and behavioral consequences. *Journal of the European Economic Association 9*(3), 522–550.

Fehrle, D. and J. Huber (2022). Hone the neoclassical lens and zoom in on germany's fiscal stimulus program 2008-2009.

Fehrle, D. and V. Konysev (2025). A "marginal" tale of two germanies: Accounting for the systemic divide. Discussion Paper Series 347, Universitaet Augsburg, Institute for Economics.

Fernández-Villaverde, J., D. Laudati, L. Ohanian, and V. Quadrini (2023). Accounting for the duality of the italian economy. *Review of Economic Dynamics*.

Fernández-Villaverde, J., G. Ventura, and W. Yao (2023). The wealth of working nations. Technical report, National Bureau of Economic Research.

Fuchs-Schündeln, N. and R. Izem (2012). Explaining the low labor productivity in east germany–a spatial analysis. *Journal of Comparative Economics 40*(1), 1–21.

Fuchs-Schündeln, N., D. Krueger, and M. Sommer (2010). Inequality trends for germany in the last two decades: A tale of two countries. *Review of Economic Dynamics 13*(1), 103–132.

Fuchs-Schündeln, N. and M. Schündeln (2009). Who stays, who goes, who returns? east–west migration within germany since reunification 1. *Economics of Transition 17*(4), 703–738.

Glitz, A. and E. Meyersson (2020, April). Industrial espionage and productivity. *American Economic Review 110*(4), 1055–1103.

Gourinchas, P.-O. and O. Jeanne (2013). Capital flows to developing countries: The allocation puzzle. *Review of Economic Studies 80*(4), 1484–1515.

Gühler, N. and O. Schmalwasser (2020). Anlagevermögen, Abschreibungen und Abgänge in den volkswirtschaftlichen Gesamtrechnungen. *WISTA-Wirtschaft und Statistik 72*(3), 76–88.

Hall, R. E. and C. I. Jones (1999, 02). Why do Some Countries Produce So Much More Output Per Worker than Others?*. *The Quarterly Journal of Economics 114*(1), 83–116.

Haußen, T. and S. Übelmesser (2015). Mobilität von Hochschulabsolventen in Deutschland. *ifo Dresden berichtet 22*(2), 42–50.

Heer, B. and A. Maussner (2009). *Dynamic general equilibrium modeling: computational methods and applications* (2nd ed.). Springer Science & Business Media.

Heer, B. and A. Maussner (2024). *Dynamic general equilibrium modeling: computational methods and applications* (3nd ed.). Springer Science & Business Media.

Heise, S. and T. Porzio (2022). Labor misallocation across firms and regions. Technical report, National Bureau of Economic Research.

Howard, D. H. (1977). Rationing, quantity constraints, and consumption theory. *Econometrica 45*(2), 399–412.

Jarosch, G., L. Pilossoph, and A. Swaminathan (2025). Should friday be the new saturday? hours worked and hours wanted. Technical report, National Bureau of Economic Research.

Jones, J. B. and S. Sahu (2017, November). Transition accounting for India in a multi-sector dynamic general equilibrium model. *Economic Change and Restructuring 50*(4), 299–339.

Karabarbounis, L. (2014). The labor wedge: MRS vs. MPN. *Review of Economic Dynamics 17*(2), 206–223.

Kersting, E. K. (2008, jan). The 1980s recession in the UK: A business cycle accounting perspective. *Review of Economic Dynamics 11*(1), 179–191.

Klodt, H. (2000). Industrial policy and the east german productivity puzzle. *German Economic Review 1*(3), 315–333.

Klößner, S., A. Kaul, G. Pfeifer, and M. Schieler (2018). Comparative politics and the synthetic control method revisited: A note on Abadie et al.(2015). *Swiss journal of economics and statistics 154*, 1–11.

Lama, R. (2011). Accounting for output drops in latin america. *Review of Economic Dynamics 14*(2), 295–316.

Liebig, S., J. Goebel, C. Schröder, M. Grabka, D. Richter, J. Schupp, C. Bartels, A. Fedorets, A. Franken, J. Jacobsen, S. Kara, P. Krause, H. Kröger, M. Kroh, M. Metzing, J. Nebelin, D. Schacht, P. Schmelzer, C. Schmitt, D. Schnitzlein, R. Siegers, K. Wenzig,

S. Zimmermann, and Deutsches Institut für Wirtschaftsforschung (DIW Berlin) (2019). Sozio-oekonomisches panel (SOEP), Daten der Jahre 1984-2018.

Lu, S.-S. (2012). East asian growth experience revisited from the perspective of a neoclassical model. *Review of Economic Dynamics 15*(3), 359–376.

Mertens, M. and S. Mueller (2022). The East-West German gap in revenue productivity:Just a tale of output prices? *Journal of Comparative Economics 50*(3), 815–831.

Ohanian, L. E., P. Restrepo-Echavarria, and M. L. J. Wright (2018, December). Bad investments and missed opportunities? postwar capital flows to asia and latin america. *American Economic Review 108*(12), 3541â82.

Reis, R. (2013). The portuguese slump and crash and the euro crisis. *Brookings Papers on Economic Activity*.

Rothert, J. and J. Short (2023). Non-traded goods, factor market frictions, and international capital flows. *Review of Economic Dynamics 48*, 158–177.

Seegers, P. and A. Knappe (2019). *Studentische Wanderungsbewegungen innerhalb Deutschlands zwischen Schule, Studium und Beruf. Sonderauswertung der Studienreihe "Fachkraft 2030"*. Köln; Maastricht.

Sinn, G. and H.-W. Sinn (1992). *Jumpstart: The economic unification of Germany*. MIT Press.

Sinn, H.-W. (2002). Germany's economic unification: An assessment after ten years. *Review of international Economics 10*(1), 113–128.

Snower, D. J. and C. Merkl (2006). The caring hand that cripples: The east german labor market after reunification. *American Economic Review 96*(2), 375–382.

Statistisches Bundesamt (2000–2012). Fachserie / 15 / 1 / jährlich, laufende Wirtschaftsrechnungen, Einkommen, Einnahmen und Ausgaben privater Haushalte. Technical report, Statistisches Bundesamt.

Statistisches Bundesamt (2003–2022). Produktions- und Importabgaben sowie Subventionen: Gliederung nach Wirtschaftsbereichen. *Volkswirtschaftliche Gesamtrechnungen (VGR) 1-20*.

Statistisches Bundesamt (2023). Inlandsproduktberechnung lange Reihen ab 1970. *Volkswirtschaftliche Gesamtrechnungen Fachserie 18 Reihe 1.5*.

Uhlig, H. (2006, May). Regional labor markets, network externalities and migration: The case of german reunification. *American Economic Review 96*(2), 383–387.

Uhlig, H. (2008). The slow decline of east germany. *Journal of Comparative Economics 36*(4), 517–541. Special Symposium on East Germany.

Weinand, S. and L. von Auer (2020). Anatomy of regional price differentials: evidence from micro-price data. *Spatial Economic Analysis 15*(4), 413–440.

A Data appendix

A.1 Data definitions and sources

Our definition of tradable and nontradable goods follows Fernández-Villaverde et al. (2023): services are nontradable, and all other goods are tradable.[25]

We aggregate the sectoral and regional human capital data from microdata, more to the point, the SOEP.[26] Additionally, we use the SOEP to interpolate missing data on sectoral hours worked before 2000.

The remaining data is from the Federal Statistical Office of Germany and the statistical offices of the German states. AVGRL reports the SNA (ESA 2010) on the German state level and for former East and WG (both with and without Berlin). To translate the sectoral output from production costs to market prices, we use the report of Statistisches Bundesamt (2022) on taxes and subsidies on goods on the sectoral level. Bundesamt (2024) provides the data on unemployment.

A.2 Compilation of human capital data

Common databases for human capital proxies (e.g., average years enrolled in a school based on Barro and Lee (2013)) do neither report on the regional level nor the sectoral. Thus, we must create a disaggregated human capital measure to differentiate human capital in our two regions-two sectors framework. The SOEP's cross-national equivalent file contains the variable number of years of education with which we can measure a proxy for human capital for Germany, the former eastern and western sovereign parts, and the employees in the tradable and nontradable sectors. For the whole SOEP Panel period (1984–2020), there are 709,843 valid and 356,703 invalid observations. We assume that the invalid observations occur randomly, making the (weighted) valid ones representative. Regarding the sectoral and regional level, the lowest number of observations is 623 for the tradable sector in the region of former EG in 1996, representing 1.8 million employees. Table A.1 in the Appendix A lists the numbers of observations for each subaggregate and year. We aggregate and average with the SOEP cross-national equivalent file's cross-sectional

[25] A more granular distinction between tradable and nontradable goods as, e.g., in Chodorow-Reich et al. (2023) is impossible due to a lack of more sectoral disaggregated regional data on investments and depreciation rates.

[26] The SOEP is a representative survey and includes information on sectoral work, hours worked, and years of education.

weights (all samples) relative to the aggregated weight of the respective subgroup.

Using the SOEP as well, Fuchs-Schündeln and Izem (2012) show that the accumulated human capital in the German Democratic Republic was general and transferable to the reunified economy.

A.3 Data processing

To translate sectoral output from production costs to market prices we use the data on sectoral value added from AVGRL sectoral net taxes of goods on the federal level from 1995 onward (Statistisches Bundesamt, 2022). Note that the AVGRL follows the ESVG advice to split the federal net taxes of goods into the states' net taxes proportional to the states' value added to transform value added to output in market prices—GDP (see Arbeitskreis "Volkswirtschaftliche Gesamtrechnungen der Länder", 2021). Hence, we proceed in the same way. We split the final goods' value-added tax likewise proportional to the regional and sectoral value-added, and add the import taxes to the tradable goods taxes. Lastly, we split the residuum of our regional GDP measures and the AVGRL ones to the sectors again proportional to the sectoral value added. We proceed the same way for the years 1991–1994 with an interpolation of the sectoral net good taxes share on the total net good taxes. AVGRL reports the latter for the whole period.

Regarding the missing data on sectoral hours worked, we use the SOEP to measure the regional share of average hours worked in the respective sectors from 1991–1999, adjusted to equal the SNA data in 2000. We then use sectoral hours worked on the federal level from Statistisches Bundesamt (2023) to calculate the missing hours. Note that Statistisches Bundesamt (2023) is consistent with AVGRL data.

Lastly, we predict the regional unemployment rates including self-employed persons in the denominator by regressing regional unemployment rates including self-employed persons on national unemployment rates including self-employed persons, and the regional number of unemployed persons. We then predict the missing data using the predictors for the years pre-1994. However, for 1991, the national unemployment rate including self-employed persons is reported neither. We predict this using a regression of unemployment rates excluding self-employed persons, which is reported for 1991, on unemployment rates including self-employed persons.

A.4 Data quality

Concerning the translation from producer to market prices, the difference between output valued at producer and market prices averages around 10 % of value added. We can assign one-third of this difference directly to the sectors. The remaining part is vaguer as there is no sectoral information for the value-added tax. However, in the worst, highly improbable, case that value added tax is only raised entirely on one sectoral good, the error would be around 3 %. However, the error is expected to be much smaller because, e.g., the tradable goods share on consumption was in 2019 40 %. Additionally, the tax changes between sectoral goods over time should be even more minor. We eliminate inconsistencies of different accounting procedures (ESVG 1995, ESVG 2010) in the net tax data by using only relative measures and multiplying them with the total net tax of ESVG 2010 (the sectoral ESVG 2010 is only available from 2010 onward). The correction between the two measures is also small. Figure A.1 reports the percent of the residual of our constructed and the AVGRL nominal GDP for both regions and in total before we correct this error proportionally to the sectors. The error is smaller than two permille for EG, except in 1991 (there, <1 %), for WG the error is smaller than one permille. Further, national GDP is identical, which validates a consistent manipulation.

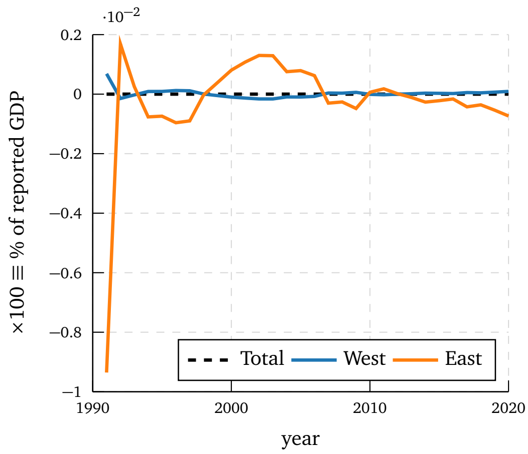
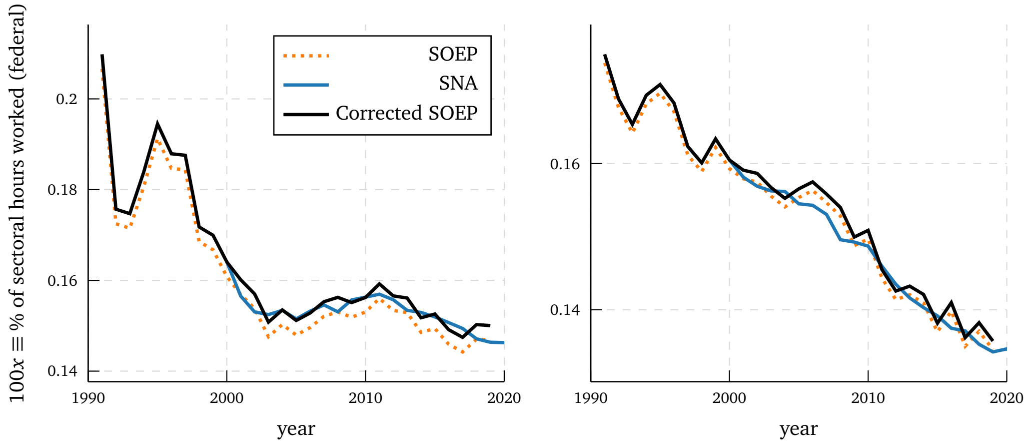


Figure A.1: % residuum of GDP (pre correction)

We plot in Figure A.2 EG's hours worked share on total sectoral hours worked. The SOEP and the SNA data move similarly over time. However, there is a small shift along the intercept. Once we correct this for this difference in the reference year 2000, the differences are minor. We use the SNA data from 2000 onward and the corrected SOEP from 1991 to 1999.



(a) Tradable (b) Nontradable

Figure A.2: EG hours worked share on total sectoral hours worked

Regarding the estimations for the unemployment rates including self-employed persons in the denominator, the adjusted coefficient of determination (adjusted R^2) is greater than 0.98 in all regressions.

Table A.1: # Observations years of education

Year	N						
	FRG	West			East		
	age 15 – 64	age 15 – 64	tradable	nontrad.	age 15 – 64	tradable	nontrad.
1984	10593	10593	3460	2982	0	0	0
1985	9529	9529	2885	2580	0	0	0
1986	9144	9144	2627	2345	0	0	0
1987	8975	8975	2575	2339	0	0	0
1988	8526	8526	2421	2288	0	0	0
1989	8232	8232	2854	2669	0	0	0
1990	11928	8263	2713	2509	3665	1508	1228
1991	11661	8211	2701	2805	3450	1170	1219
1992	11342	8098	2521	2646	3244	845	1184
1993	11098	8008	2522	2779	3090	746	1138
1994	11166	8157	2191	2540	3009	666	1058
1995	11398	8481	2144	2774	2917	701	1147
1996	11117	8220	1957	2535	2896	623	1063
1997	10838	7994	1997	2661	2843	629	1102
1998	11623	8650	2049	2990	2973	658	1087
1999	11357	8429	1885	2854	2928	628	1063
2000	20047	15573	3690	6362	4474	1004	1784
2001	17880	13829	3088	5473	4051	855	1573
2002	19013	14961	3030	5475	4052	794	1559
2003	17563	13725	2637	4964	3838	679	1398
2004	16834	13147	3063	6440	3687	760	1721
2005	15788	12298	2738	5787	3490	674	1529
2006	16596	12948	2764	5895	3648	660	1575
2007	15327	11939	2838	6157	3388	711	1679
2008	14158	11000	2518	5549	3158	669	1509
2009	14827	11543	2725	6194	3284	757	1648
2010	20973	16698	3625	7972	4275	915	1965
2011	21987	17519	3989	8836	4468	949	2172
2012	21260	16943	3856	8724	4317	919	2118
2013	24059	19778	4745	10331	4281	947	2219
2014	20740	16938	3836	8651	3802	816	1915
2015	20608	16995	3949	9144	3613	818	1897
2016	22305	18345	3380	8068	3960	730	1748
2017	23671	19349	3899	9823	4322	883	2118
2018	22158	18022	3240	8861	4136	781	1986
2019	21751	17682	3236	9398	4069	788	2042
2020	19618	15944	2686	8080	3674	670	1810

B Relative price wedges

Concerning the relative price wedge for investment goods in the valuation of investment in the resource constraint (37e) but not in the capital accumulation (37m), note the following.

Consider a Paasche price index of the aggregator X in t with basis year 0 read $PI^{P0}_{xt} = \frac{\sum_{i=1}^{N} P_{xit}X_{it}}{\sum_{i=1}^{N} P_{xi0}X_{it}}$. Further, a nominal aggregator is the sum of the nominal subaggregates, and a real aggregator the sum of real subaggregates, i.e.,

$$\begin{aligned} &P_{xt}X_t = P_{yt}Y_t + P_{zt}Z_t \\ \Leftrightarrow\, &X_t = Y_t + Z_t \end{aligned}$$

by deflating every (sub)aggregator with its own Paasche price index (PI^{P0}_{xt}, PI^{P0}_{yt}, PI^{P0}_{zt}). However, this does not apply to the nowadays usually used Chain indices PI^{C0}_{xt}, i.e.,

$$\begin{aligned} &P_{xt}X_t = P_{yt}Y_t + P_{zt}Z_t \\ \not\Leftrightarrow\, &X_t = Y_t + Z_t \end{aligned}$$

by deflating every (sub)aggregator with its chain price index (PI^{C0}_{xt}, PI^{C0}_{yt}, PI^{C0}_{zt}). To avoid this problem, we deflate with one common price index PI^{C0}_{xt} whenever necessary and define relative price wedges $P_{\tau xyt} = P_{yt}/PI^{C0}_{xt}$, i.e.,

$$\begin{aligned} &P_{xt}X_t = P_{yt}Y_t + P_{zt}Z_t \\ \Leftrightarrow\, &X_t = P_{\tau xyt}Y_t + P_{\tau xzt}Z_t. \end{aligned}$$

Note that this problem does not appear concerning recursive sums, e.g., capital accumulation. First, the value of the aggregated capital stock $P_{kt}K_t = \sum_{i=1}^{N} P_{ikt}K_{it}$ is expressed in replacement costs—$P_{ikt} = P_{iit}$. Second, the capital stock is the sum of not depreciated investment—$K_t = \sum_{s=1}^{\infty}(1-\delta)^{s-1}I_{t-s} = \sum_{i=1}^{N}\sum_{s=1}^{\infty}(1-\delta_i)^{s-1}I_{it-s}$. Hence,

$$\begin{aligned} &P_{kt}K_t = \sum_{i=1}^{N} P_{ikt}K_{it} = \sum_{j=1}^{N}\sum_{s=1}^{\infty}(1-\delta_j)^{s-1}P_{ijt}I_{jt-s} \\ \Leftrightarrow &K_{t+1} = \sum_{s=0}^{\infty}(1-\delta)^s I_{t-s} = (1-\delta)K_t + I_t \end{aligned}$$

as price vectors—not deflators—for capital and investment quantities are the same when the capital stock is valued in replacement costs. Consequently, we have a relative price wedge for investment goods in the valuation of investment in the resource constraint but not in the capital accumulation when real quantities of national accounts are deflated with chain price indices. The problem is quantitatively minor for non-investment goods, which is why we ignore the wedges there.

C Model details

This appendix presents the detailed derivation of the models' dynamic equilibrium (37). Since both regions i face the same setup, we neglect the country indices i for ease of notation. Recall the following functional forms:

$$Y_t^D = \omega_t^Z F_t(M_{Tt}, M_{NTt}) = \omega_t^Z M_{Tt}^{\eta_t} M_{NTt}^{1-\eta_t}, \tag{C.1a}$$

$$X_{jt} = \omega_{jt}^e f_{jt}(K_{jt}, h_{jt}, L_{jt}) = \omega_{jt}^e K_{jt}^{\alpha_j} (h_{jt} L_{jt})^{1-\alpha_j}, \tag{C.1b}$$

$$u(c_t, g_t, \bar{l} - l_t) = \ln(c_t + g_t) + \theta \ln(\bar{l} - l_t), \tag{C.1c}$$

$$h_{jt} = H(s_{jt}) = e^{\chi(s_{jt})}. \tag{C.1d}$$

C.1 Financial (domestic and international) and labor intermediaries

Given the derivations in section 3.2, we can write capital and labor market wedges by

$$\omega_{jt}^L w_{jt} = w_t, \tag{C.2a}$$

$$\omega_{jt}^K (1 + \rho_{jt}) = 1 + \rho_t, \tag{C.2b}$$

and the interregional bond wedge by

$$\omega_{t+1}^B q_{Et+1} = q_{Wt+1}. \tag{C.2c}$$

C.2 Final goods firms

This firm has to solve the following static maximization problem:

$$\max_{Y_t^D, M_{Tt}, M_{NTt}} \Pi_t = Y_t^D - p_{Tt} M_{Tt} - p_{NTt} M_{NTt} \tag{C.3}$$

subject to the production function (C.1a). The first-order conditions for all t are

$$p_{Tt} = \eta_t \frac{Y_t^D}{M_{Tt}}, \tag{C.4a}$$

$$p_{NTt} = (1-\eta_t)\frac{Y_t^D}{M_{NTt}}, \tag{C.4b}$$

Deviding both sides of equations (C.1a), (C.4a), and (C.4b) by population level N_t lead to (37j) and (37k), and (37l) for both i in the main text.

C.3 Intermediate goods firms

Each firm j has to solve the following dynamic maximization problem:

$$\begin{aligned}
\max_{L_{jt},K_{jt+1},V_{jt+1}} \Xi_{j0} &= \sum_{t=0}^{\infty} R_{j0,t}\pi_{jt}, \\
\text{s.t.: } \pi_{jt} &= p_{jt}X_{jt} - w_{jt}L_{jt} - d_t(I_{jt} - \Delta K_{jt}) - \rho_{jt}V_{jt} - \Delta V_{jt}, \\
K_{jt+1} &= (1-\delta_t)K_{jt} + I_{jt} - \Delta K_{jt}, \\
\Delta V_{jt} &= V_{jt} - V_{jt+1}, \\
V_{jt+1} &= d_t K_{jt+1},
\end{aligned}$$

and the production function (C.1b). After inserting the secondary conditions in the intermediate firms j objective function Ξ_{j0}, we can write the problem as follows:

$$\begin{aligned}
\max_{L_{jt},K_{jt+1}} \Xi_{j0} = \sum_{t=0}^{\infty} R_{j0,t}\Big\{ & p_{jt}\omega_{jt}^{e}K_{jt}^{\alpha_j}(h_{jt}L_{jt})^{1-\alpha_j} - w_{jt}L_{jt} \\
& - d_t\left[K_{jt+1} - (1-\delta_t)K_{jt}\right] - (1+\rho_{jt})d_{t-1}K_{jt} + d_t K_{jt+1}\Big\}.
\end{aligned}$$

Hence, the first-order conditions of the intermediate firm j with respect to L_{jt} and K_{jt+1} are given by:

$$w_{jt} = p_{jt}(1-\alpha_j)\frac{X_{jt}}{L_{jt}}, \tag{C.5a}$$

$$1+\rho_{jt+1} = \frac{1}{d_t}\left(p_{jt+1}\alpha_j\frac{X_{jt+1}}{K_{jt+1}} + (1-\delta_{t+1})d_{t+1}\right). \tag{C.5b}$$

Additionally, the intermediate firm faces the following transversality conditions

$$\lim_{t\to\infty} R_{j0,t} V_{t+1} = 0, \tag{C.5c}$$

$$\lim_{t\to\infty} R_{j0,t} d_t K_{t+1} = 0. \tag{C.5d}$$

C.4 Households

The representative household solves the following dynamic maximization problem:

$$\max_{c_t, l_t, b_{t+1}, v_{t+1}} U_0 = \sum_{t=0}^{\infty} \beta^t N_t u\left(c_t, g_t, \bar{l} - l_t\right),$$

$$\text{s.t.: } C_t + V_{s+1} + q_t p_{Tt} B_{t++1} + Tax_t \leq w_t L_t + (1+\rho_t) V_t + p_{Tt} Tr_t + \Sigma_t + p_{Tt} B_t,$$

$$w_t L_t^C \geq w_t L_t,$$

and the utility function (C.1c). Using that per-capita variables are $\upsilon = \frac{\Upsilon}{N_t}$ with $\Upsilon \in \left\{C_t, L_t, G_t, B_t, V_t, Tr_t, Tax_t, \Sigma_t, L_t^C\right\}$ and $g_{Nt+1} = \frac{N_{t+1}}{N_t}$, the Lagrangian $\mathscr{L}$ of the household optimization problem writes

$$\mathscr{L} = \sum_{t=0}^{\infty} \beta^t \Big\{ N_t \left[\ln(c_t + g_t) + \theta \ln\left(\bar{l} - l_t\right)\right] - \phi_t \left[w_t L_t^C - w_t L_t\right] + \lambda_t \left[w_t L_t + (1+\rho_t) V_t + p_{Tt} Tr_t + \Sigma_t + p_{Tt} B_t - C_t - V_{t+1} - q_t p_{Tt} B_{t+1} - Tax_t\right] \Big\},$$

where λ_t and ϕ_t denote the Lagrange multipliers on the budget and labor supply constraints. Hence, the households fist-order conditions are

$$\phi_t (L_t^C - L_t) = 0 \tag{C.6a}$$

$$C_t + V_{t+1} + q_t p_{Tt} B_{t+1} + Tax_t = w_t L_t + (1+\rho_t) V_t + p_{Tt} Tr_t + p_{Tt} B_{it} + \Sigma_{it} \tag{C.6b}$$

$$N_t \frac{1}{c_t + g_t} = N_t \lambda_t, \tag{C.6c}$$

$$N_t \frac{\theta}{\bar{l} - l_t} = N_t (w_t \phi_t + w_t \lambda_t), \tag{C.6d}$$

$$\frac{N_{t+1} \lambda_t}{\beta N_{t+1} \lambda_{t+1}} = (1 + \rho_{t+1}), \tag{C.6e}$$

$$\frac{N_{t+1} \lambda_t}{\beta N_{t+1} \lambda_{t+1}} = \frac{q_t p_{Tt}}{p_{Tt+1}}. \tag{C.6f}$$

Additionally, the household faces the following transversality conditions

$$\lim_{t\to\infty} \beta^t \lambda_t V_{t+1} = 0, \tag{C.6g}$$

$$\lim_{t\to\infty} \beta^t \lambda_t q_t p_{Tt} B_{t+1} = 0. \tag{C.6h}$$

Combining the households' optimal consumption demand (C.6a) in the optimal labor supply (C.6d) and rearranging, we can write in per-capita terms

$$\frac{\theta(c_t + g_t)}{\bar{l} - l_t} = w_t \left(1 + \frac{\phi_t}{\lambda_t}\right),$$

which boils down to

$$\frac{\theta(c_t + g_t)}{\bar{l} - l_t} \omega_t^{QL} = w_t, \tag{C.7a}$$

in conjecture with the labor constraint wedge equation (25) from the main text. We plug (C.6c) for λ_t and λ_{t+1} in the households' optimal deposits and bonds choices—(C.6e) and (C.6f)—to get the per-capita Euler equations

$$\frac{c_{t+1} + g_{t+1}}{\beta(c_t + g_t)} = 1 + \rho_{t+1}, \tag{C.7b}$$

$$\frac{p_{Tt}}{p_{Tt+1}} \frac{c_{t+1} + g_{t+1}}{\beta(c_t + g_t)} = \frac{1}{q_t}. \tag{C.7c}$$

Combining (C.7b) and (C.7c) delivers the interconnection of the households' asset returns by

$$q_t(1 + \rho_{t+1}) = \frac{p_{Tt+1}}{p_{Tt}}. \tag{C.8}$$

C.5 Equilibrium conditions

Recall the market clearing conditions:

$$\Delta K_{Tt} + \Delta K_{NTt} = 0, \tag{C.9a}$$

$$V_t = V_{Tt} + V_{NTt}, \tag{C.9b}$$

$$V_{jt} = d_{t-1} K_{jt}, \tag{C.9c}$$

$$K_t = K_{Tt} + K_{NTt}, \tag{C.9d}$$

$$L_t = L_t^C = L_{Tt} + L_{NTt}, \tag{C.9e}$$

$$X_{NTt} = M_{NTt}, \tag{C.9f}$$

$$(1-\omega_t^D)X_{Tt} = M_{Tt}, \tag{C.9g}$$

$$Y_t = Y_t^D + \omega_t^D p_{Tt} X_{Tt}, \tag{C.9h}$$

and the government and trade balances:

$$Tax_t = \omega_t^G Y_t^D, \tag{C.9i}$$

$$p_{Tt}(q_t B_{t+1} - B_{it}) - p_{Tt} Tr_t = \omega_t^D X_{Tt}. \tag{C.9j}$$

The equations (C.9d) – (C.9h) expressed in per-capita variables deliver (37f), (37h), (37i), (37n), and (37o) for both i in the main text.

In equilibrium, we combine the optimality conditions of households, final goods firms, and intermediate goods firms and derive our model in in per-capita terms. Plugging the intermediate firms' optimal labor demand choice (C.5a), expressed in per-capita variables, for w_{jt} and the households labor supply condition (C.7a) for w_t in the labor wedge equation (C.2a) yields

$$\frac{\theta(c_t + g_t)}{\bar{l} - l_t}\omega_t^{QL} = \omega_{jt}^L (1-\alpha_j)\frac{p_{jt}x_{jt}}{l_{jt}}, \tag{C.10}$$

which leads to equation (37a) for all i and t in the main text. Next, substitute the intermediate firms' condition (C.5b), expressed in per-capita variables, for $1+\rho_{jt+1}$ and the households deposits condition (C.7b) for $1+\rho_{t+1}$ into the capital market wedge equation (C.2b), resulting in

$$\frac{\omega_{jt+1}^K}{d_t}\left(p_{jt+1}\alpha_j\frac{x_{jt+1}}{k_{jt+1}} + (1-\delta_{t+1})d_{t+1}\right) = \frac{c_{t+1}+g_{t+1}}{\beta(c_t+g_t)}, \tag{C.11}$$

which implies equation (37b) for both i in the main text. Dividing households $i=E$ by the households $i=W$ bonds conditions (C.7c) and substituting for q_W and q_E into the bond wedge equation (C.2c) delivers

$$\omega_{t+1}^B \frac{p_{WTt}}{p_{WTt+1}}\frac{c_{Wt+1}+g_{Wt+1}}{\beta_W(c_{Wt}+g_{Wt})} = \frac{p_{ETt}}{p_{ETt+1}}\frac{c_{Et+1}+g_{Et+1}}{\beta_E(c_{Et}+g_{Et})} \tag{C.12}$$

which leads to equation (37c) in the main text.

Equilibrium profits of final goods firms Inserting optimality conditions (C.4a) and (C.4b) in the per-period profits $\Pi_t = Y_t^D - p_{Tt}M_{Tt} - p_{NTt}M_{NTt}$ it is straightforward to show that $\Pi_t = 0$ and

$$Y_t^D = p_{Tt}M_{Tt} + p_{NTt}M_{NTt} \tag{C.13}$$

for all t.

Equilibrium profits of intermediate goods firms Recall the per-period cash-flows of intermediate goods firm j (3) given by

$$\pi_{jt} = p_{jt}X_{jt} - w_{jt}L_{jt} - d_t(I_{jt} - \Delta K_{jt}) - \rho_{jt}V_{jt} - \Delta V_{jt}. \tag{C.14a}$$

Using capital and debt law-of-motions—(4) and (5)—, and rearranging (C.14a) yields

$$\pi_{jt} = p_{jt}X_{jt} - w_{jt}L_{jt} - d_tK_{jt+1} + d_t(1-\delta_t)K_{jt} - (1+\rho_{jt})V_{jt} + V_{jt+1} \tag{C.14b}$$

Using $V_{jt+1} = d_tK_{jt+1}$ yields

$$\pi_{jt} = p_{jt}X_{jt} - w_{jt}L_{jt} - (1+\rho_{jt})d_{t+1}K_{jt} + d_t(1-\delta_t)K_{jt}. \tag{C.14c}$$

Then, inserting intermediate firms' optimality conditions (C.5a) and (C.5b) in (C.14c) it is straightforward to show that $\pi_{jt} = 0$ and, hence,

$$p_{jt}X_{jt} = w_{jt}L_{jt} + d_t(I_{jt} + \Delta K_{jt}) + \rho_{jt}V_{jt} + \Delta V_{jt}. \tag{C.14d}$$

for all j and t.

Equilibrium profits from intermediation Recall the total profits from labor and capital market intermediation (1) given by

$$\Sigma_t = (w_{Tt} - w_t)L_{Tt} + (w_{NTt} - w_t)L_{NTt} + (\rho_{Tt} - \rho_t)V_{Tt} + (\rho_{NTt} - \rho_t)V_{NTt}. \tag{C.15a}$$

Inserting the labor market wedges (C.2a) and the capital market wedges (C.2b) in (C.15a) implies

$$\Sigma_t = (1-\omega_{Tt}^L)w_{Tt}L_{Tt} + (1-\omega_{NTt}^L)w_{NTt}L_{NTt}$$

$$+(1-\omega^K_{Tt})(1+\rho_{Tt})V_{Tt}+(1-\omega^K_{NTt})(1+\rho_{NTt})V_{NTt}. \tag{C.15b}$$

Note that different to the profits of the firms (π_{jt}=$\Pi_t = 0$), the profits from intermediation are $\Sigma_t \in \mathbb{R}$.

Regional capital accumulation Inserting the sectoral capital accumulations (4) in the market clearing condition for capital (C.9d) yields for all t

$$K_t = (1-\delta_t)(K_{Tt}+K_{NTt})+(I_{Tt}+I_{NTt})-(\Delta K_{Tt}+\Delta K_{NTt}).$$

Using the market clearing on traded capital (C.9a) and investments it follows

$$K_{t+1} = (1-\delta_t)K_t + I_t, \tag{C.16}$$

which leads, together with $g_{Nt+1} = \frac{N_{t+1}}{N_t}$, to the per-capital capital accumulation (37m) for all i and t in the main text.

Resource constraint Recall the binding household budget constraint given by

$$C_t + p_{Tt}(q_t B_{t+1} - B_{it}) - p_{Tt}Tr_t + Tax_t = w_t L_t + (1+\rho_t)V_t - V_{t+1} + \Sigma_t. \tag{C.17a}$$

Disaggregating L_t and V_t with (C.9e) and (C.9b), and inserting total profits of intermediaries (C.15a) on the right-hand side of (C.17a) delivers

$$\begin{aligned} &C_t + p_{Tt}(q_t B_{t+1} - B_{it}) - p_{Tt}Tr_t + Tax_t \\ &= w_{Tt}L_{Tt} + w_{NTt}L_{NTt} + (1+\rho_{Tt})V_{Tt} + (1+\rho_{NTt})V_{NTt} - V_{t+1} \end{aligned} \tag{C.17b}$$

Next, the final goods zero profits condition (C.13) in conjecture with the market clearing conditions (C.9f), (C.9g), and (C.9h) implies the condition for the GDPs production side

$$Y_t = p_{Tt}X_{Tt} + p_{Tt}X_{NTt}. \tag{C.17c}$$

Inserting intermediate goods firms' zero chash flow conditions (C.14d) for both j in (C.17c) delivers

$$Y_t = w_{Tt}L_{Tt} + d_t(I_{Tt} + \Delta K_{Tt}) + \rho_{Tt}V_{Tt} + \Delta V_{Tt}$$

$$+ w_{NTt}L_{NTt} + d_t(I_{NTt} + \Delta K_{NTt}) + \rho_{NTt}V_{NTt} + \Delta V_{NTt}. \tag{C.17d}$$

The debt market clearing condition (C.9b) and $\Delta V_{jt} = V_{jt} - V_{jt+1}$ imply $\Delta V_{Tt} + \Delta V_{NTt} = V_t - V_{t+1}$. Using this, the intersectoral traded capital market clearing (C.9a) and rearranging, we can write (C.17d) as follows

$$Y_t - d_t(I_{Tt} + I_{NTt}) = w_{Tt}L_{Tt} + w_{NTt}L_{NTt} + (1 + \rho_{Tt})V_{Tt} + (1 + \rho_{NTt})V_{NTt} - V_{t+1}. \tag{C.17e}$$

Substituting the right-hand side of equation (C.17b) by the right-hand side of equation (C.17e) delivers

$$C_t + p_{Tt}(q_t B_{t+1} - B_{it}) - p_{Tt}Tr_t + Tax_t = Y_t - d_t(I_{Tt} + I_{NTt}). \tag{C.17f}$$

Finally, government and trade balances, (C.9i) and (C.9j), imply that our open economy resource constraint, expressed in terms of final goods prices, is given by:

$$Y_t = C_t + p_{iTt}\omega_t^D X_{Tt} + \omega_t^G Y_t^D + d_t I_t. \tag{C.18}$$

Equation (37e), expressed in per-capita variables, in the main text follows from (C.18) and (37f).

D Computational details

Here, we provide further details regarding our quantitative implementation and simulation of the wedge-accounting models. First, we pin down the steady state of our model. Second, we compute the models' transition paths to that steady state. Third, we solve the nonlinear deterministic models assuming actual and counterfactual paths of the exogenous variables, i.e., the wedges' paths. Finally, we give a brief overview of the counterfactuals presented in the main body of the paper. This procedure is in line with Fehrle and Konysev (2025).

D.1 Steady state

Given the dynamic equation system (37) from the main text, the steady-state version of our model reads as follows:

$$\omega_{ij}^{L} = \omega_{i}^{QL}\frac{\theta_i(c_i+g_i)}{\bar{l}-l_i}\frac{l_{ij}}{(1-\alpha_{ij})p_{ij}x_{ij}}, \tag{D.1a}$$

$$\omega_{ij}^{K} = \frac{1}{\beta_i}\left(\frac{p_{ij}}{d_i}\alpha_{ij}\frac{x_{ij}}{k_{ij}}+(1-\delta_i)\right)^{-1}, \tag{D.1b}$$

$$\omega_B = \frac{\beta_E}{\beta_W}, \tag{D.1c}$$

$$\omega_{ij}^{e} = \frac{x_{ij}}{k_{ij}^{\alpha_{ij}}\left(h_{ij}l_{ij}\right)^{1-\alpha_{ij}}}, \tag{D.1d}$$

$$\omega_{i}^{Z} = \frac{y_i^D}{m_{iT}^{\eta_i}(m_{iNT})^{1-\eta_i}}, \tag{D.1e}$$

$$\omega_{i}^{G} = 1-\frac{c_i}{y_i^D}-\frac{d_i i_i}{y_i^D}, \tag{D.1f}$$

$$y_i = y_i^D + p_{iT}\omega_i^D x_{iT}, \tag{D.1g}$$

$$m_{iT} = (1-\omega_i^D)x_{iT}, \tag{D.1h}$$

$$m_{iNT} = x_{iNT}, \tag{D.1i}$$

$$p_{iT} = \eta_i\frac{y_i^D}{m_{iT}}, \tag{D.1j}$$

$$p_{iNT} = (1-\eta_i)\frac{y_i^D}{m_{iNT}}, \tag{D.1k}$$

$$\frac{k_i}{y_i^D} = (g_{Ni}-1+\delta_i)\frac{i_i}{y_i^D}, \tag{D.1l}$$

$$1 = \frac{k_{iT}}{k_i} + \frac{k_{iNT}}{k_i}, \tag{D.1m}$$

$$1 = \frac{l_{iT}}{l_i} + \frac{l_{iNT}}{l_i}. \tag{D.1n}$$

$$g_i = \omega_i^G y_i^D \tag{D.1o}$$

Note that instead of both sectoral price conditions, we can replace one of them by

$$y_i^D = p_{iT} x_{iT} + p_{iNT} x_{iNT}. \tag{D.1p}$$

In the main text, we describe our strategy to calibrate parameters and select long-run targets (section 4.2.1). Given our targets $\left\{ \frac{c_i}{y_i^D}, \frac{i_i}{y_i^D}, \omega_i^{QL}, x_{ij}, p_{ij}, d_i, s_{ij}, y_i^D, \frac{l_{iT}}{l_i}, \frac{k_{iT}}{k_i}, l_i, \delta_i, g_{Ni} \right\}$ from Table D.2, the constant parameters $\{\beta_i, \theta_i, \bar{l}, \alpha_{ij}, \gamma_1, \gamma_2, \gamma_3\}$ and the equation system (D.1), we deduce the steady-state values of the variables $\{h_{ij}, k_i, y_i, m_{ij}, c_i, i_i, l_{ij}, k_{ij}, y_i, g_i, \omega_{ij}^e, \omega^B, \omega_{ij}^L, \omega_{ij}^K, \omega_i^D, \eta_i, \omega_i^G, \omega_i^Z\}$. The computation steps are as follows:

1) To begin with, we determine the levels of sectoral human capital h_{ij} given the targets for average sectoral years of schooling s_{ij} and parameters $\{\gamma_1, \gamma_2, \gamma_3\}$ on Mincerian returns. 2) Regional GDP per capita levels y_i follow from the value-added identity (D.1p), given sectoral price indices p_{ij} and output levels x_{ij}. 3) The regional resource constraint (D.1f) delivers the steady-state value of the regional government consumption wedge ω_i^G, given the target ratios of the remaining domestic use subaggregates. 4) The level of the steady-state government consumption follows from equation (D.1o). 5) Given the steady state value of regional absorption y_i^D and the targeted ratios of its subaggregates, we compute the levels $\{c_i, i_i\}$. 6) According to equation (D.1g), the difference between y_i and y_i^D corresponds to the level of net inflows valued in final good prices. Given the price indices and sectoral output levels, we pin down the steady-state values of the regional demand wedges ω_i^D. 7) We determine the regional final production inputs m_{ij} from the values of the sectoral outputs x_{ij} and the demand wedges ω_{it}^D, the clearing conditions of the goods markets (D.1h) and (D.1i). 8) Given regional investment-to-absorption ratios $\frac{i_i}{y_i^D}$, the regional capital-to-absorption ratios $\frac{k_i}{y_i^D}$ follow from the fixed point of the capital law of motions (D.1l). Given y_i^D, the levels of regional capital stocks k_i are determined from the ratios $\frac{k_i}{y_i^D}$. 9) Given the targets $\left\{ l_i, \frac{l_{iT}}{l_i}, \frac{k_{iT}}{k_i} \right\}$, the deduced k_i, and factor markets clearing conditions (D.1m) and (D.1n), we compute sectoral capital and labor levels - k_{ij}

and l_{ij}. 10) The shares of tradable inputs in final production η_i follow from the tradable price conditions (D.1j). 11) Deduced shares η_i, final production inputs m_{ij}, and outputs y_i^D jointly determine the final goods productivity wedges ω_i^Z from equations (D.1e). 12) Steady sectoral capital wedges ω_{ij}^K are derived from steady-state Euler equation (D.1b). 13) Similarly, we endogenously determine the steady sectoral labor wedges ω_{ij}^L from the steady-state consumption-leisure trade-off (D.1a). 14) Following equation (D.1c), the relative bond wedge reads $\omega^B = \frac{\beta_W}{\beta_E}$. 15) All steady-state sectoral production input and output levels determine the steady-state sectoral productivity wedges ω_{ij}^e from the production functions (D.1d).

Table D.2: Long-run targets

Variable	Value		Description
	East	West	
$\frac{c}{y^D}$	0.578	0.573	Private consumption-to-domestic use ratio
$\frac{i}{y^D}$	0.184	0.221	Investment-to-domestic use ratio
$\frac{g}{y^D}$	0.239	0.206	Government consumption-to-domestic use ratio
l	687.8	746.0	Worked hours per capita
s_T	12.11	12.00	Average years of schooling per capita in tradable sector
s_{NT}	12.98	12.93	Average years of schooling per capita in nontradable sector
y^D	30150	35125	Real domestic use per capita
x_T	8451	12408	Tradable output per capita
x_{NT}	17705	26268	Nontradable output per capita
p_T	1.011	1.006	Relative tradable price index (2015=1)
p_{NT}	0.994	0.996	Relative nontradable price index (2015=1)
d	1.006	1.008	Investment price index (2015=1)
$\frac{k_T}{k}$	0.218	0.164	Tradable capital share
$\frac{l_T}{l}$	0.297	0.278	Tradable labor share
ω^{QL}	1.073	1.042	Labor quantity constraint wedge
g_N	0.998	1.001	Population Growth Factor
δ	0.021	0.023	Capital Depreciation rate

D.2 Computation of paths after T

Recall that in our wedge accounting exercise in section 3.2 all 69 (for all i and j) variables and time-varying-parameters of the model in periods $t = 0 \dots T$ are either observed or deduced from the system (37). We assume that after period T our model economy converges to the steady state derived in Appendix D.1, satisfying system (37). Following the methodology proposed by del Río and Lores (2021), we project the paths of the variables $\{\Upsilon_t\}_{t=T+1}^{T_1}$ with $\Upsilon_t \in \{c_{it}, i_{it}, x_{ijt}, p_{ijt}, k_{iTt}, l_{ijt}, s_{it}, \delta_{it}, g_{iNt+1}, g_{it}, d_{it}, \omega_{it}^{QL}, \omega_{it}^{G}\}$ using the exponential convergence formula

$$\Upsilon_t = \Upsilon_T e^{-\lambda(t-T)} + \Upsilon - \Upsilon e^{-\lambda(t-T)}, \, T \leq t \leq T_1,$$

where λ is the convergence speed and is set to $\lambda = 0.03$ as del Río and Lores (2021, 2023), which is a common order of magnitude (see Barro and Sala-i-Martin, 1995, Chapter 11), T_1 is the terminal period before the variables Υ_t enters the steady state by assumption, i.e., $\{\Upsilon_t\}_{t=T_1+1}^{\infty} = \Upsilon$. As a result, we determine the variables Υ_t ranging from $t = 0$ to $t = \infty$.

Using the subset $\{i_{it}, \;\; \delta_{it}, \;\; g_{iNt+1}\}_{t=0}^{T_1}$, we compute $\{k_{it+1}\}_{t=0}^{T_1}$ from the capital law-of-motion (37m) for given initial value k_{i0}. We set the terminal period to $T_1 = T + 1000$, so that the deviation of the value of terminal capital stock k_{iT_1+1} from its exact steady-state value k_i is numerically small, i.e. less than 10^{-6} % of the steady state value. Next, we solve the static equations (37a), (37d)–(37l), and (37n)–(37o) for the sequence of variables $\{\omega_{ijt}^{L}, \; \omega_{ijt}^{e}, \; \omega_{it}^{D}, \; \omega_{it}^{Z}, \; y_{it}, \; y_{it}^{D}, \; m_{ijt}, \; l_{it}, \; k_{iNTt}, \; g_{it}, \; \eta_{it}\}_{t=0}^{T_1}$. Given the sequence $\{k_{ijt}, p_{ijt}, x_{ijt}, l_{ijt}, l_{it}, c_{it}, g_{it}\}_{t=0}^{T_1}$, we back out $\left\{\omega_{ijt+1}^{K}, \; \omega_{t+1}^{B}\right\}_{t=0}^{T_1}$ from the Euler equations (37b) and (37c), respectively. For the terminal values of the capital and bond wedges, we assume they satisfy the steady-state versions of equations (37b) and (37c). Accordingly, we compute them as $\omega_{ijT_1+1}^{K} = \frac{d_i}{\beta_i} / \left(p_{ij} \alpha_{ij} \frac{x_{ij}}{k_{ij}} + (1 - \delta_i) d_i \right)$ and $\omega_{T_1+1}^{B} = \frac{\beta_W}{\beta_E}$. By proceeding in this manner, the values of all variables and time varying parameters are pinned down for $t = 0, \ldots, \infty$ given the set of constant parameters.

D.3 Computation of the transition dynamics given counterfactuals

In our counterfactual exercises, we specify sequences of exogenous variables (in particular the wedges) and time-varying parameters along counterfactual paths denoted with upper bars in the main text. Therefore, we need a solver to compute the counterfactual transition dynamics of our models' endogenous variables, given the initial per-capita capital stock k_{i0}, the constant parameters $\{\beta_i, \; \theta_i, \; \bar{l}, \; \alpha_{ij}, \; \gamma_1, \; \gamma_2, \; \gamma_3\}$, sequences of (partly counterfactual) exogenous variables and time-varying parameters, and that the transversality condition $\lim_{s \to \infty} \beta^s \frac{k_{it+1+s}}{g_{it+s} + c_{it+s}} = 0$ hold. As our counterfactual experiments (listed in the Appendix D.4) will not change the solution of the WG's endogenous variables, we can reduce the problem by solving only for the EG part of the model. Hence, we use a version of the equation system (37) only with the region index $i = E$. We solve it by searching for the sequences $\{k_{Et+1}\}_{t=0}^{T_1-1}$, $\{k_{ETt}\}_{t=0}^{T_1}$, $\{l_{ETt}\}_{t=0}^{T_1}$ and $\{l_{Et}\}_{t=0}^{T_1}$ that satisfy the reduced version of the nonlinear equation system:

$$0 = (1-\delta_{Et})k_{Et} + i_{Et} - g_{Nit+1}k_{Et+1}, \quad t = 0, 1, \ldots, T, T+1, \ldots, T_1. \tag{D.2a}$$

$$0 = \omega^K_{iTt+1}\frac{1}{d_{Et}}\left(p_{ETt+1}\alpha_{ET}\frac{x_{ETt+1}}{k_{ETt+1}} + (1-\delta_{Et+1})d_{Et+1}\right) - \frac{c_{Et+1}+g_{Et+1}}{\beta_E(c_{Et}+g_{Et})}, \quad t = 0, 1, \ldots, T, T+1, \ldots, T_1 - 1. \tag{D.2b}$$

$$0 = \omega^K_{iNTt+1}\frac{1}{d_{Et}}\left(p_{ENTt+1}\alpha_{ET}\frac{x_{ENTt+1}}{k_{ENTt+1}} + (1-\delta_{Et+1})d_{Et+1}\right) - \frac{c_{Et+1}+g_{Et+1}}{\beta_E(c_{Et}+g_{Et})}, \quad t = 0, 1, \ldots, T, T+1, \ldots, T_1 - 1. \tag{D.2c}$$

$$0 = \omega^L_{ENTt}(1-\alpha_{ij})\frac{p_{ENTt}x_{ENTt}}{l_{ENTt}} - \omega^{QL}_{Et}\frac{\theta(c_{Et}+g_{Et})}{\bar{l}-l_{Et}}, \quad t = 0, 1, \ldots, T, T+1, \ldots, T_1, \tag{D.2d}$$

$$k_{ET_1+1} = k_{ET_1}, \tag{D.2e}$$

$$\text{given } k_{E0}. \tag{D.2f}$$

Assuming that the equation system converges fully to a steady state in T_1+1, reduces the infinite number of equations and unknowns to a finite number. Further, the terminal condition of capital stock converging to its steady state (D.2e) implies that the transversality condition holds (see Heer and Maussner, 2024, Chapter 6.2). Given the four sequences, all variables on the right-hand side of the equations (D.2a)–(D.2d) are either exogenous variables or time-varying parameters (here the actual ones without upper bars), or follow endogenously from system (37). To see this: given the four sequences, we calculate $\{k_{ENTt}\}_{t=0}^{T_1}$ and $\{l_{ENTt}\}_{t=0}^{T_1}$ using the factors market clearing conditions (37n) and (37o). With the sectoral factor inputs, we compute the sequence $\{x_{Eit}\}_{t=0}^{T_1}$ from the intermediate goods production (37d), and, consequently, $\{m_{Eit}\}_{t=0}^{T_1}$ from the goods market clearing conditions (37h) and (37i). Given values for the final production inputs, we compute sequences $\{y^D_{Et}\}_{t=0}^{T_1}$ and $\{p_{Eit}\}_{t=0}^{T_1}$ from the final good production (37l), and the price conditions (37j) and (37k). Given $\{y^D_{Et}\}_{t=0}^{T_1}$, we uncover $\{g_{Et}\}_{t=0}^{T_1}$ from equation (37g), which allows us to compute $\{c_{Et}\}_{t=0}^{T_1}$ from the labor supply condition (37a) for the sector $j = T$. Next, we derive $\{i_{Et}\}_{t=0}^{T_1}$ from the resource constraint (37e). Finally, note that the bond wedge and the equations defining GDP, (37c) and (37f), are auxiliary equations in our solution procedure.

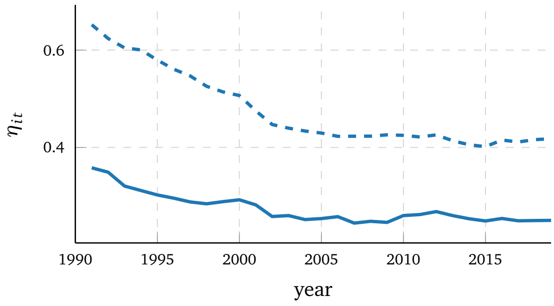
Taken together, we solve a nonlinear equation system with $4 \times T_1$ unknowns. We solve for all periods simultaneously by employing the gradient-based solver proposed by Heer and Maussner (2024, Algorithm 15.3.2) for the stacked nonlinear equation system. The MATLAB and Gauss programs used in this study are available from the authors upon request.

D.4 Summary of counterfactuals

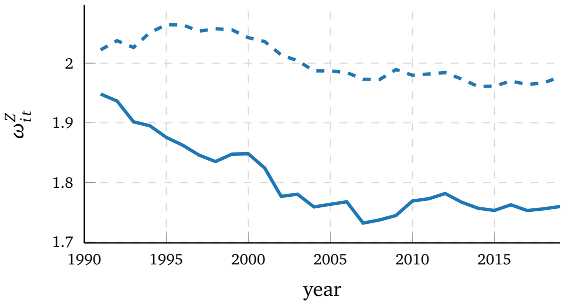
Table D.3 lists all the counterfactual experiments we have simulated—reported or unreported in the paper. Column 2 in each row documents the assumptions on the paths we met for the exogenous variables. Building on this list, we provide additional results on our welfare and GDP distance measures in Table E.6.

E Additional Figures & Tables

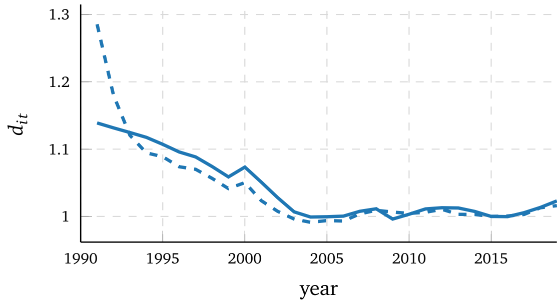
Figure E.3: Wedge accounting



(a) Tradables input elasticity in final production η_{it}



(b) Final good sector productivity wedge ω^Z_{it}

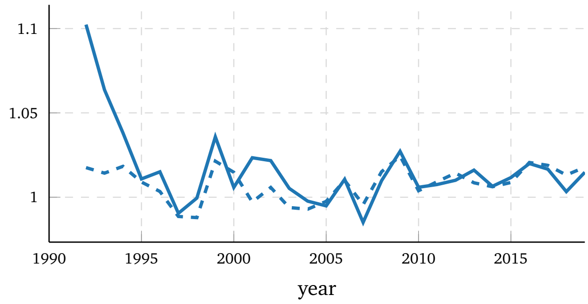


(c) Investment relative to output prices d_{it}

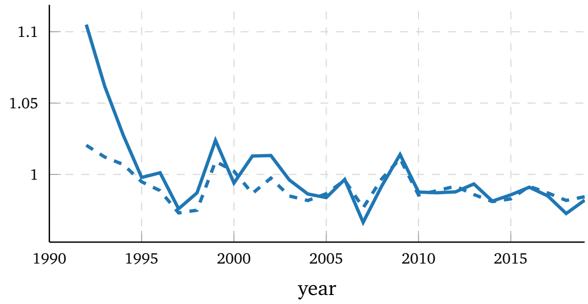
West Germany - - - East Germany

Notes: We identify the input elasticities in final production η_{it} using equation (37d) and the final production efficiency ω^Z_{it} using equation (37m). Both equations (37d) and (37m) contain the latent variables m_{iTt} and m_{iNTt} which we can measure with equations (37h) and (37i), respectively. The relative price of investment d_{it} is an observable variable.

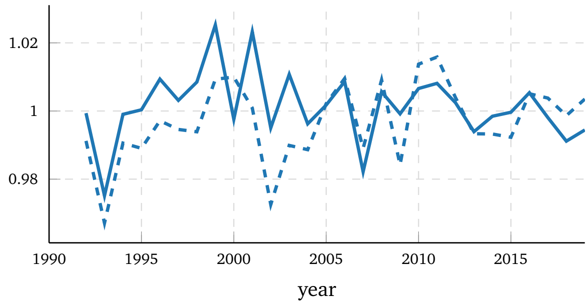
Figure E.4: Capital wedges and investment prices



(a) EG's capital wedge, nontradable



(b) EG's capital wedge, tradable

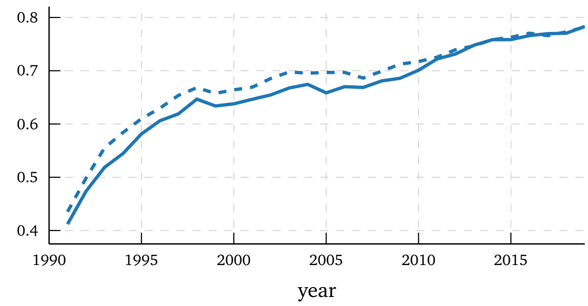


(c) WG's capital wedge, nontradable

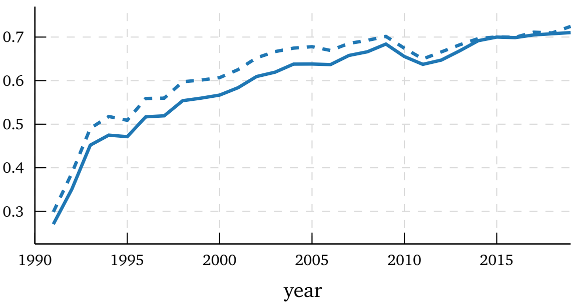
(d) WG's capital wedge, tradable

with d_{it} without d_{it}

Figure E.5: Relative labor productivities EG to WG



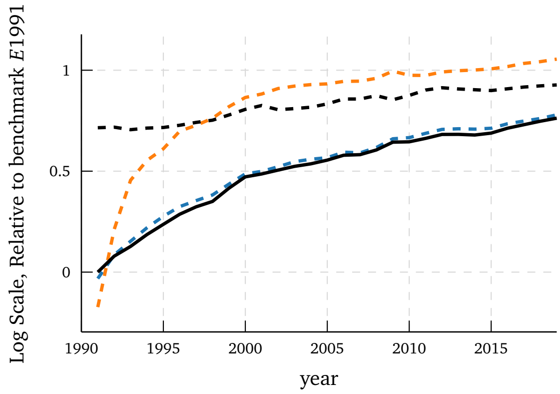
(a) Nontradable



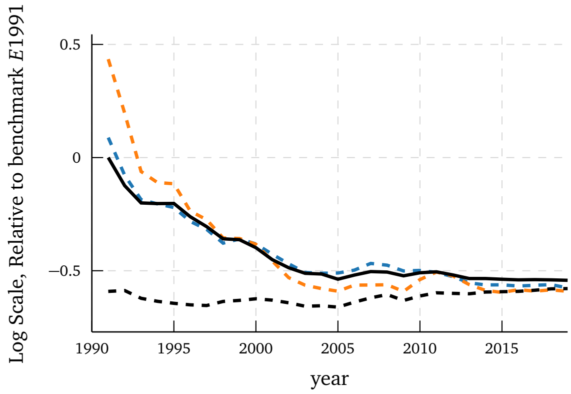
(b) Tradable

Notes: We identify the model-implied sectoral quality-labor productivities rearranging the Hicks-neutral sectoral production technology $x = \omega^e k^\alpha (hl)^{1-\alpha}$ to $\frac{x}{hl} = (\omega^e)^{\frac{1}{1-\alpha}} \left(\frac{k}{x}\right)^{\frac{\alpha}{1-\alpha}}$ (straight lines), where labor productivities write $\frac{x}{l} = (\omega^e)^{\frac{1}{1-\alpha}} \left(\frac{k}{x}\right)^{\frac{\alpha}{1-\alpha}} h$ (dashed lines).

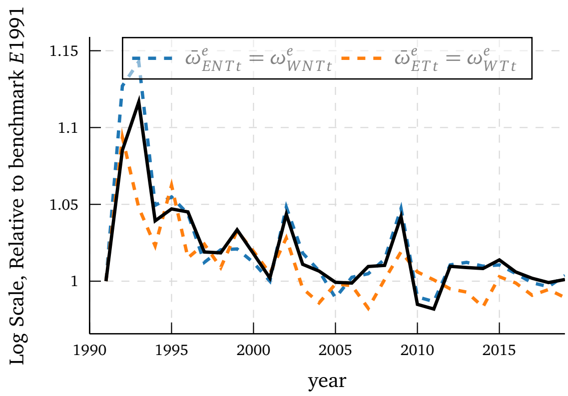
Figure E.6: Further quantitities Figure 9 Panel (a)



(a) Consumption



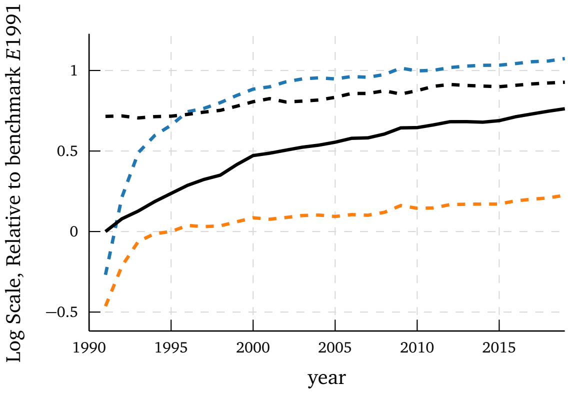
(b) Total hours



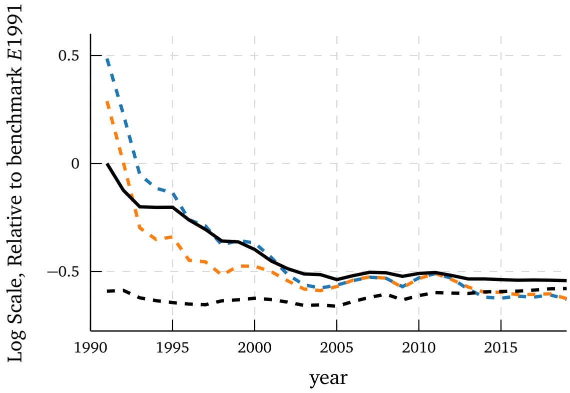
(c) Bond wedge

Benchmark West Germany

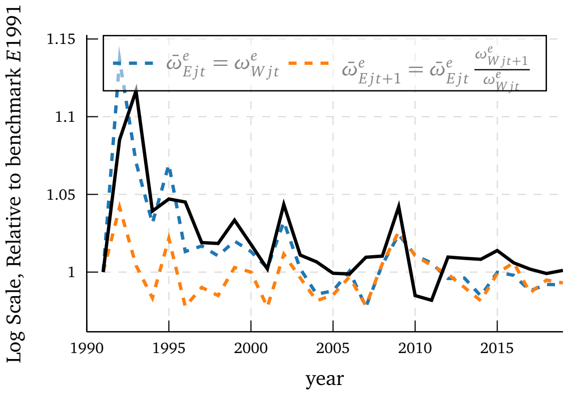
Figure E.7: Further quantitities Figure 9 Panel (b)



(a) Consumption



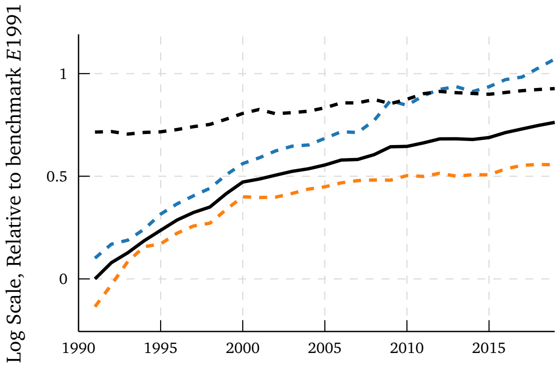
(b) Total hours



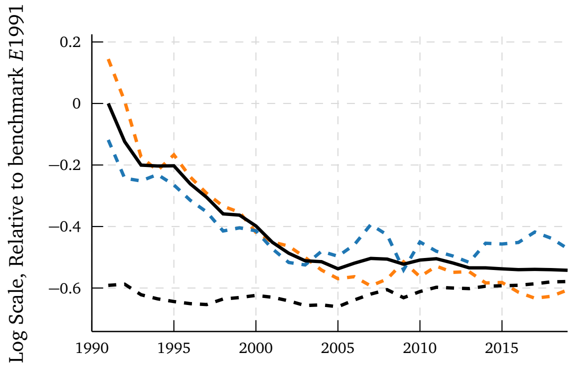
(c) Bond wedge

Benchmark — West Germany

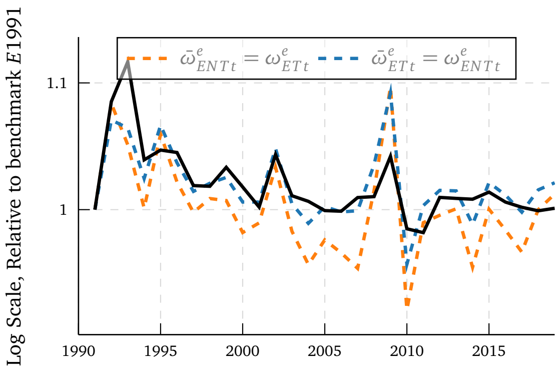
Figure E.8: Further quantitities Figure 9 Panel (c)



(a) Consumption



(b) Total hours



(c) Bond wedge

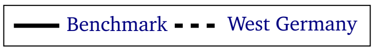
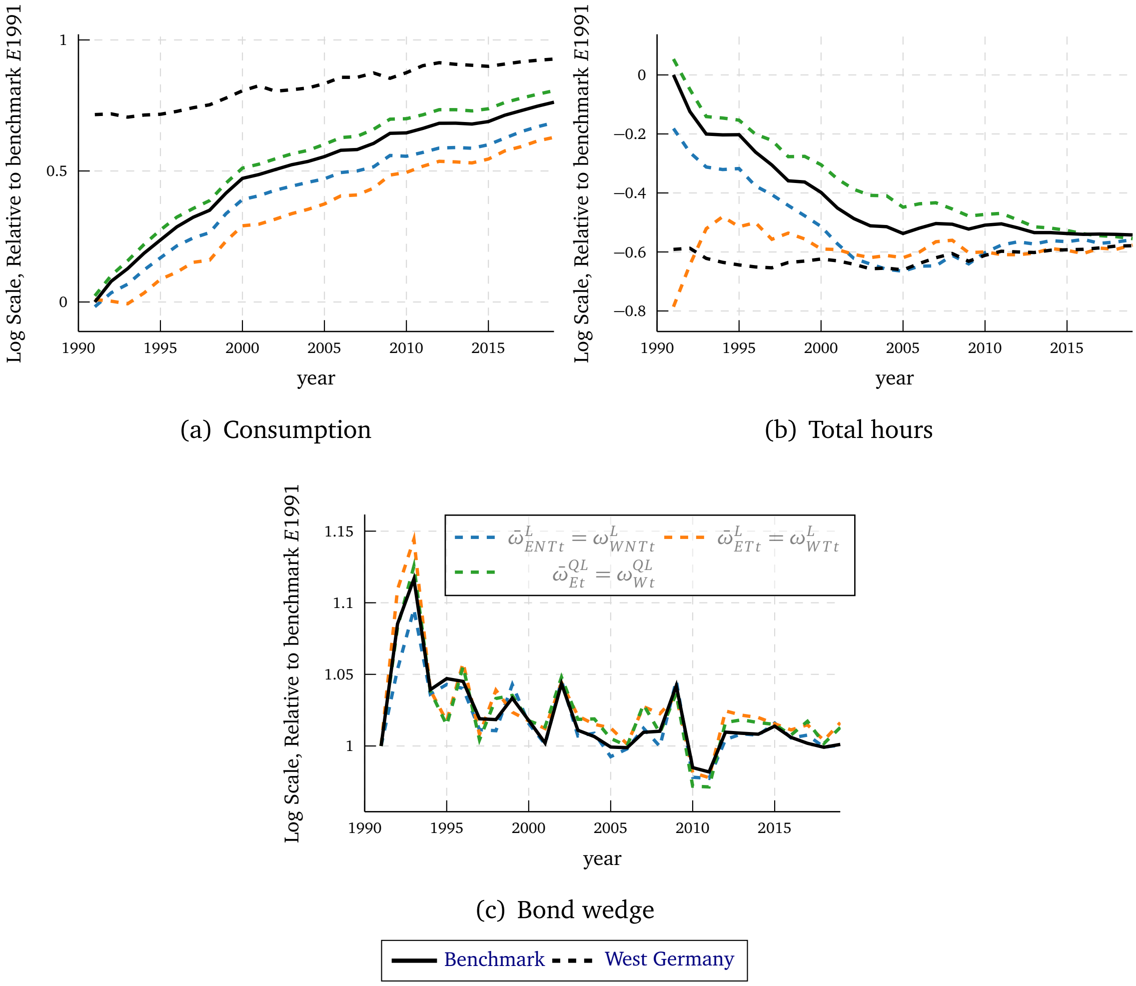


Figure E.9: Further quantitities Figure 10 Panel (a)

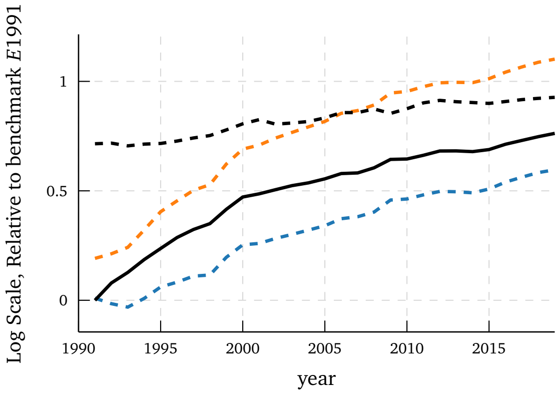


(a) Consumption

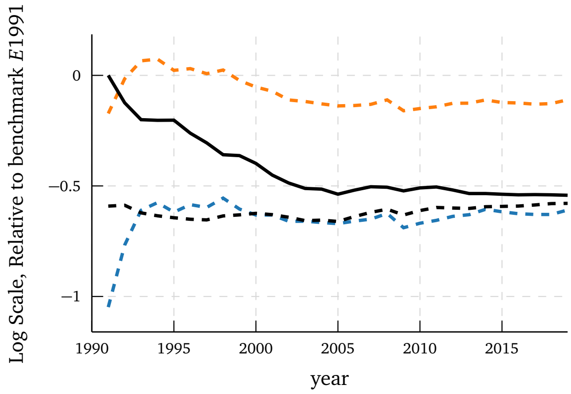
(b) Total hours

(c) Bond wedge

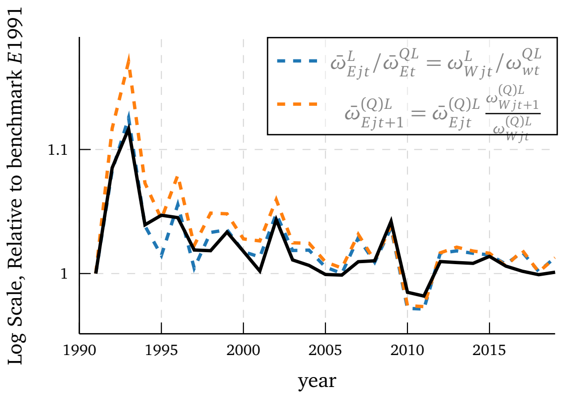
Figure E.10: Further quantitities Figure 10 Panel (b)



(a) Consumption



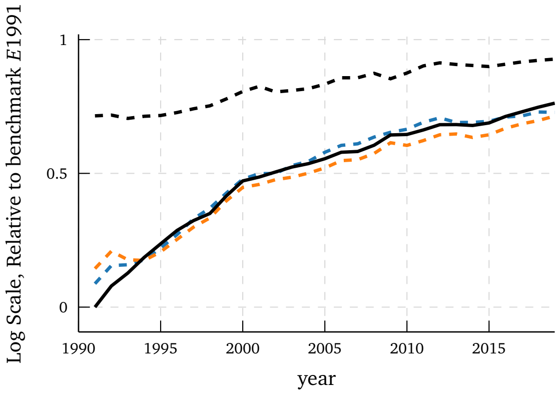
(b) Total hours



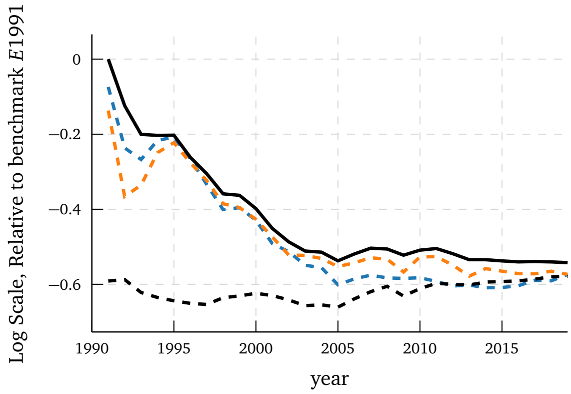
(c) Bond wedge

Benchmark — West Germany

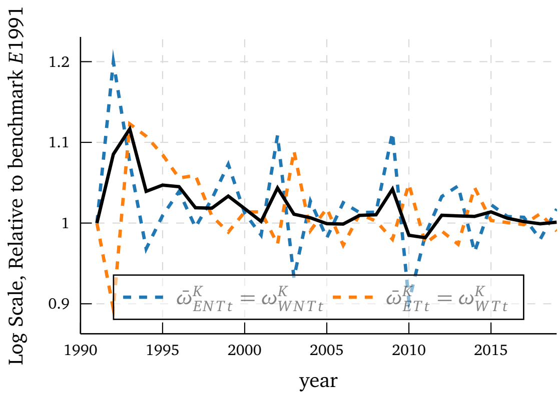
Figure E.11: Further quantitities Figure 11 Panel (a)



(a) Consumption



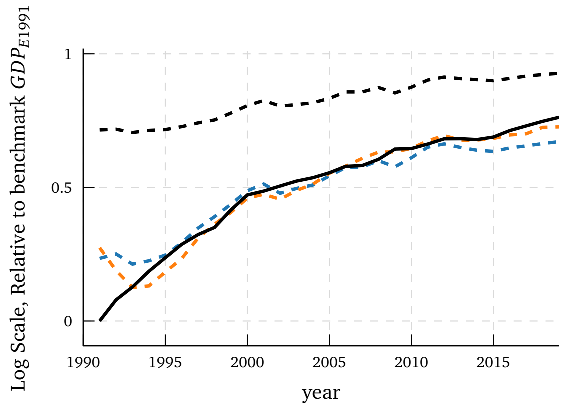
(b) Total hours



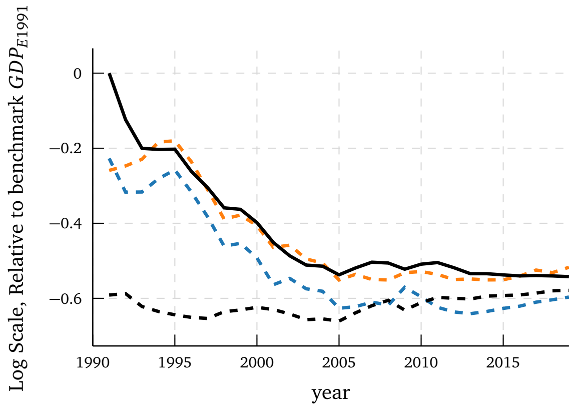
(c) Bond wedge

Benchmark West Germany

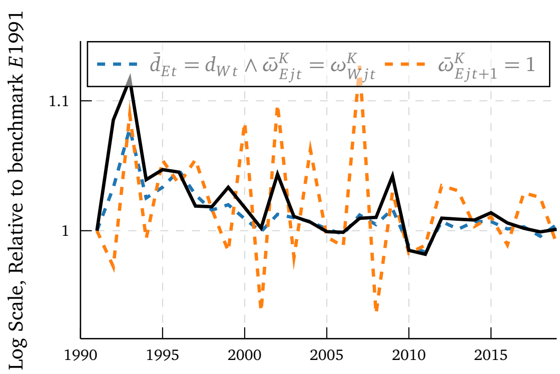
Figure E.12: Further quantitities Figure 11 Panel (b)



(a) Consumption



(b) Total hours



(c) Bond wedge

Benchmark — West Germany

Table E.6: Complete set of welfare and economic activity distance measures in %

Counterfactual	Δ	Δz_{BM}^{CF}	Δz_{WG}^{CF}
Zero net inflows (Benchmark after)	−33.8	−25.1	−25.1
Tradable TFP growth EG same as WG	−23.6	−29.2	−47.5
Nonradable TFP growth EG same as WG	−11.2	−13.6	−35.6
TFP growth EG same as WG	−31.7	−38.5	−54.6
Tradable capital wedge EG same as WG	2.6	−8.5	−31.4
Nontradable capital wedge EG same as WG	4.9	−7.3	−30.6
Capital wedge EG same as WG	9.0	−14.7	−36.0
Tradable labor wedge EG same as WG	5.2	−16.9	−37.5
Nontradable labor wedge EG same as WG	3.4	−9.3	−32.0
Labor wedge EG same as WG	8.2	−24.6	−43.2
Labor quantity wedge EG same as WG	−2.8	5.6	−20.9
Labor wedge and labor quantity wedge EG same as WG	7.7	−20.1	−39.8
No convergence of EG tradable labor wedge	−10.6	18.2	−11.3
No convergence of EG nontradable labor wedge	−7.5	12.3	−15.6
No convergence of EG labor wedge	−16.8	33.2	0.3
EG tradable TFP level equal EG nontradable TFP level	−11.5	−12.1	−34.6
EG nontradable TFP level equal EG tradable TFP level	16.6	21.1	−8.8
EG sectoral acTFP levels swapped	3.0	4.0	−22.1
Tradable TFP level EG same as WG	31.3	47.9	9.4
Nonradable TFP level EG same as WG	1.1	2.8	−23.2
TFP levels EG same as WG	33.5	52.8	12.6
No convergence of EG tradable labor wedge and labor quantity wedge	−10.9	18.7	−10.9
No convergence of EG nontradable labor wedge and labor quantity wedge	−7.6	12.8	−15.3
No convergence of EG labor wedge and labor quantity wedge	−17.0	33.6	0.6
Shut EG tradable capital wedge off	−3.1	3.9	−22.0
Shut EG nontradable capital wedge off	4.9	−7.3	−30.6
Shut EG capital wedge off	3.0	−3.1	−27.3
Tradable capital wedge and investment prices EG same as WG	1.8	−8.3	−31.3
Nontradable capital wedge and investment prices EG same as WG	4.0	−7.1	−30.5
Capital wedge and investment prices EG same as WG	8.3	−14.5	−36.0

Notes: This Table reports discounted consumption equivalent welfare and average relative GDP distance measures in % for the observation period 1991 until 2019 in various counterfactual simulations. Columns 1 and 2: The zero net residual case in row 1 uses EG's observed consumption, hours worked and GDP paths as a benchmark. All other cases in rows from 2 use the paths of the zero net residual counterfactual as their benchmark.

Table D.3: Summary of counterfactuals

Description	
Zero net inflows in EG	$\bar{\omega}^{D}_{Et} = 0$
Tradable TFP growth EG same as WG	$\bar{\omega}^{e}_{ETt} = \omega^{e}_{ETt-1} \frac{\omega^{e}_{WTt}}{\omega^{e}_{WTt-1}}$
Nonradable TFP growth EG same as WG	$\bar{\omega}^{e}_{ENTt} = \omega^{e}_{ENTt-1} \frac{\omega^{e}_{WNTt}}{\omega^{e}_{WNTt-1}}$
TFP growth EG same as WG	$\bar{\omega}^{e}_{Ejt} = \omega^{e}_{Ejt-1} \frac{\omega^{e}_{Wjt}}{\omega^{e}_{Wjt-1}}, \forall j$
Tradable capital wedge EG same as WG	$\bar{\omega}^{K}_{ETt} = \omega^{K}_{WTt}$
Nontradable capital wedge EG same as WG	$\bar{\omega}^{K}_{ENTt} = \omega^{K}_{WNTt}$
Capital wedge EG same as WG	$\bar{\omega}^{K}_{Ejt} = \omega^{K}_{Wjt}, \forall j$
Tradable labor wedge EG same as WG	$\bar{\omega}^{L}_{ETt} = \omega^{L}_{WTt}$
Nontradable labor wedge EG same as WG	$\bar{\omega}^{L}_{ENTt} = \omega^{L}_{WNTt}$
Labor wedge EG same as WG	$\bar{\omega}^{L}_{Ejt} = \omega^{L}_{Wjt}, \forall j$
Labor quantity wedge EG same as WG	$\bar{\omega}^{QL}_{Et} = \omega^{QL}_{Wt}$
Labor wedge and labor quantity wedge EG same as WG	$\bar{\omega}^{L}_{Ejt} = \omega^{L}_{Wjt}, \forall j \wedge \bar{\omega}^{QL}_{Et} = \omega^{QL}_{Wt}$
No convergence of EG tradable labor wedge	$\bar{\omega}^{L}_{ETt} = \omega^{L}_{ETt-1} \frac{\omega^{L}_{WTt}}{\omega^{L}_{WTt-1}}$
No convergence of EG nontradable labor wedge	$\bar{\omega}^{L}_{ENTt} = \omega^{L}_{ENTt-1} \frac{\omega^{L}_{WNTt}}{\omega^{L}_{WNTt-1}}$
No convergence of EG labor wedge	$\bar{\omega}^{L}_{Ejt} = \omega^{L}_{Ejt-1} \frac{\omega^{L}_{Wjt}}{\omega^{L}_{Wjt-1}}, \forall j$
EG tradable TFP level equal EG nontradable TFP level	$\bar{\omega}^{e}_{ETt} = \omega^{e}_{ENTt}$
EG nontradable TFP level equal EG tradable TFP level	$\bar{\omega}^{e}_{ENTt} = \omega^{e}_{ETt}$
EG sectoral TFP levels swapped	$\bar{\omega}^{e}_{Ejt} = \omega^{e}_{Ekt}, \forall j, k$
Tradable TFP level EG same as WG	$\bar{\omega}^{e}_{ETt} = \omega^{e}_{WTt}$
Nonradable TFP level EG same as WG	$\bar{\omega}^{e}_{ENTt} = \omega^{e}_{WNTt}$
TFP levels EG same as WG	$\bar{\omega}^{e}_{Ejt} = \omega^{e}_{Wjt}, \forall j$
No convergence of EG tradable labor and labor quantity wedge	$\bar{\omega}^{L}_{ETt} = \omega^{L}_{ETt-1} \frac{\omega^{L}_{WTt}}{\omega^{L}_{WTt-1}} \wedge$
	$\bar{\omega}^{QL}_{ETt+1} = \omega^{QL}_{ETt} \frac{\omega^{QL}_{WTt+1}}{\omega^{QL}_{WTt}}$
No convergence of EG nontradable labor and labor quantity wedge	$\bar{\omega}^{L}_{ENTt} = \omega^{L}_{ENTt-1} \frac{\omega^{L}_{WNTt}}{\omega^{L}_{WNTt-1}} \wedge$
	$\bar{\omega}^{QL}_{ENTt} = \omega^{QL}_{ENTt-1} \frac{\omega^{QL}_{WNTt}}{\omega^{QL}_{WNTt-1}}$
No convergence of EG labor wedge and labor quantity wedge	$\bar{\omega}^{L}_{Ejt} = \omega^{L}_{Ejt-1} \frac{\omega^{L}_{Wjt}}{\omega^{L}_{Wjt-1}}, \forall j \wedge$
	$\bar{\omega}^{QL}_{Ejt} = \omega^{QL}_{Ejt-1} \frac{\omega^{QL}_{Wjt}}{\omega^{QL}_{Wjt-1}}, \forall j$
Shut EG tradable capital wedge off	$\bar{\omega}^{K}_{ETt} = 1$
Shut EG nontradable capital wedge off	$\bar{\omega}^{K}_{ENTt} = 1$
Shut EG capital wedge off	$\bar{\omega}^{K}_{Ejt} = 1, \forall j$
Tradable capital wedge and investment prices EG same as WG	$\bar{\omega}^{K}_{ETt} = \omega^{K}_{WTt} \wedge \bar{d}_{Et} = d_{Wt}$
Nontradable capital wedge and investment prices EG same as WG	$\bar{\omega}^{K}_{ENTt} = \omega^{K}_{WNTt} \wedge \bar{d}_{Et} = d_{Wt}$
Capital wedge and investment prices EG same as WG	$\bar{\omega}^{K}_{Ejt} = \omega^{K}_{Wjt}, \forall j \wedge \bar{d}_{Et} = d_{Wt}$

Notes: This Table summarizes the formal representations of all counterfactuals we have computed. All formulations hold for all t.

Table E.4: Estimated coefficients from equation (39)

Wedge		1991-1999	2000-2009	2010-2019	full period
Nontradable efficiency	α	-0.18^{**}	-0.05^{***}	-0.01	-0.11^{***}
	β	0.02^{**}	0.00	0.01^{***}	0.01^{***}
Tradable efficiency	α	-0.55^{***}	-0.37^{***}	-0.36^{***}	-0.46^{***}
	β	0.02^{**}	0.01^{***}	0.01^{***}	0.01^{***}
Aggregate efficiency	α	-0.39^{***}	-0.21^{***}	-0.20^{***}	-0.29^{***}
	β	0.02^{**}	0.00^{***}	0.01^{***}	0.01^{***}
Quantity labor	α	0.06^{***}	0.10^{***}	0.05^{***}	0.10^{***}
	β	0.00^{***}	0.00^{***}	0.00^{***}	0.00^{***}
Nontradable labor	α	0.59^{***}	0.29^{***}	0.17^{***}	0.47^{***}
	β	-0.04^{***}	-0.01^{***}	-0.01^{***}	-0.01^{***}
Tradable labor	α	1.06^{***}	0.50^{***}	0.39^{***}	0.79^{***}
	β	-0.07^{**}	-0.02^{***}	-0.02^{***}	-0.02^{***}
Aggregate labor	α	0.75^{***}	0.35^{***}	0.23^{***}	0.57^{***}
	β	-0.05^{**}	-0.01^{***}	-0.01^{***}	-0.02^{***}
Nontradable capital	α	0.09^{***}	0.00	0.00	0.03
	β	-0.01^{**}	0.00	0.00^{**}	0.00
Tradable capital	α	0.12^{***}	0.02^{***}	0.02^{***}	0.05^{*}
	β	-0.02^{**}	0.00	0.00^{**}	0.00
Aggregate capital	α	0.10^{***}	0.01^{*}	0.01	0.04
	β	-0.01^{**}	0.00	0.00^{**}	0.00
Residual	α	-14.56^{***}	-5.86^{***}	-3.08^{***}	-10.63^{***}
	β	0.96^{***}	0.33^{**}	0.09^{***}	0.36^{***}

Notes: α and β are OLS estimates from $R_t = \alpha_j^{\Upsilon} + \beta_j^{\Upsilon} t + \epsilon_{1jt}^{\Upsilon}, \quad t = 0, 1, \ldots, T$. *, **, and *** denote HAC-robust p-values of < 0.1, < 0.01, and < 0.001, respectively, for the null hypotheses $H_0 : \alpha = 0$ and $H_0 : \beta = 0$. Detailed results corresponding to Table 3 in the main text.

Table E.5: Estimated coefficients from equation (40)

Wedge		1991-1999	2000-2009	2010-2019	full period
Nontradable efficiency	α	−1.78	−3.02	−5.26	−2.60
	β	0.22**	0.05*	−0.19	0.06**
Tradable efficiency	α	−0.60	−0.98	−1.02	−0.79
	β	0.05***	0.01***	0.02***	0.02***
Aggregate efficiency	α	−0.96	−1.55	−1.61	−1.26
	β	0.08***	0.02***	0.04***	0.03***
Quantity labor	α	−2.79	−2.19	−2.82	−2.08
	β	−0.03	0.07***	0.16***	0.06***
Nontradable labor	α	−0.52	−1.21	−1.75	−0.58
	β	0.09***	0.04***	0.09***	0.07***
Tradable labor	α	0.05	−0.69	−0.92	−0.22
	β	0.09***	0.04***	0.05***	0.04***
Aggregate labor	α	−0.28	−1.02	−1.46	−0.44
	β	0.09***	0.04***	0.07***	0.06***
Nontradable capital	α	−2.40	−5.77	−6.90	−4.43
	β	0.32***	−0.02	−0.37	0.03
Tradable capital	α	−2.10	−4.02	−3.73	−3.81
	β	0.33**	−0.03	−0.06	−0.01
Aggregate capital	α	−2.25	−5.02	−5.10	−4.24
	β	0.34**	−0.01	−0.17	0.01
Residual	α	2.70***	1.76***	1.13***	2.43***
	β	0.10***	0.08***	0.03***	0.06***

Notes: γ and λ are OLS estimates from $\ln(|R_t|) = \gamma_j^{\Upsilon} - \lambda_j^{\Upsilon} t + \epsilon_{2jt}^{\Upsilon}, \quad t = 0, 1, \ldots, T$. *, **, and *** denote HAC-robust p-values of < 0.1, < 0.01, and < 0.001, respectively, for the null hypotheses $H_0 : \gamma \leq 0$ and $H_0 : \lambda \leq 0$. Detailed results corresponding to Table 3 in the main text.