Transforming Institutions

Labor Reallocation and Wage Growth in a Reunified Germany

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Abstract

How do institutions affect economic performance? We exploit a unique historical episode, the German Reunification, to investigate how this radical change transformed East Germany's labor market allocation, igniting wage growth in the early years after reunification. Using matched employer-employee data constructed from the universe of German social security records, we show that the sharp growth in East German wages strongly correlates with a rapid reallocation of workers across plants *within* East Germany. Moreover, reallocation was disproportionately larger among older cohorts, suggesting that longer exposure to communist institutions led to more severe misallocation: In a competitive market, these older workers would have switched jobs or been fired at a younger age. By the same token, only East German plants that already existed at the time of reunification display different reallocation patterns compared to their Western counterparts: Large plants downsize, indicating that they had previously been inefficiently large, while all plants experience significant levels of worker turnover. We find that plants with larger levels of reallocation experience larger wage growth. This provides rare, direct empirical evidence that the reallocation of workers — both within and across plants— spurred by new labor market institutions, was consequential for wage growth.

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1 Introduction

Well-functioning institutions are a pillar of economic development: high-income countries have stronger institutions, and the process of economic growth is accompanied by their overall improvement (Kremer, Willis, and You, 2021). These correlations suggest that institutional development could lead to economic growth. Direct evidence however, is inherently difficult to obtain. In fact, while evidence abounds that current economic outcomes can be traced back to the persistent effects of historical differences in institutions (Acemoglu, Johnson, and Robinson, 2005; Dell, 2010), we have very limited knowledge on how a country-wide institutional transformation can impact growth and through which process changes can manifest themselves.

In this paper, we contribute to filling this knowledge gap by studying a unique historical episode, the reunification of Germany in 1990, which triggered a sudden, yet radical transformation of East Germany's institutions. While the regime change rippled through many dimensions, we focus on its effects on the allocation of talent,. We characterize how worker and firms transitioned from a planned economy —with limited mobility and little discretion in hiring — to a market economy with low barriers to job mobility and minimal hiring restrictions. We show that, as a result, the allocation of workers to firms was transformed, unraveling previous misallocation in just a few years and contributing to the very large wage growth observed in East Germany.

Using the universe of German social security records, we document that the main impact of reunification on East German labor was not migration across the former border, but rather a radical reallocation of workers across firms *within* the former East Germany (the German Democratic Republic, or GDR).[1,2] This large initial burst in labor mobility in the East all but disappears in just a few years as all measures of labor market dynamism converge to the West benchmark. Additional and important evidence comes from cross-cohort differences in the reallocation levels of firms and workers: Both older workers and older firms, exposed longer to communist institutions, reallocated more after reunification, suggesting that they had previously been more severely misallocated. Conversely, younger East and West German workers and firms entering the market after reunification display identical levels of reallocation.

The extensive micro-level reallocation went hand in hand with large aggregate effects: East German wages, barely half of West German levels in 1992, grew to two-thirds in just 5 years. We show, using a wage growth decomposition, that the initial period of East Germans' labor reallocation explains at least a third of their faster wage growth compared to West Germans.

These results provide, to the best of our knowledge, the first proof-of-concept that institutional transformation can lead to quick and complete convergence in allocative efficiency,

[1] We will refer to the former socialist republic as GDR, and the part of Germany that was formerly GDR as East Germany.

[2] Establishments in our data from IAB, the German Unemployment Agency, cannot be traced back to firms. Henceforth, we will interchangeably use "firms," "plants" and "establishments."

and ultimately economic growth. While the context is specific, several insights generalize. Most importantly, instituting a properly functioning labor market can deliver fast results, even between two populations that may differ in their underlying set of skills or preferences (which would take a longer time to adjust). Second, our empirical approach provides a way to directly quantify the aggregate wage cost of misallocating workers across firms, which we estimate to be large.

Germany provides a unique setting to overcome the identification concerns well-known in the literature. On the one hand, relying on institutional variation to explain cross-country income or wage differences is plagued by confounding factors. On the other hand, analyzing the effect of a specific reform only offers identification from micro-level variation within-country, thus remaining silent on aggregate effects. Moreover, such reforms are usually small, and it is rare that a country implements a transformation of its labor institutions that is sufficiently large-scale to allow one to study its effects on reallocation and wage growth. In the case of East Germany, not only was institutional transformation large and quick, but it was also a (near) complete adoption of West German institutions. Thus, we can relate differences in labor market outcomes across the two regions to differences in past institutions.

The first few years after reunification have seen a steep rise in East German wages and a concurrent overhaul of the allocation of labor to firms, with high-levels of workers flowing across firms *within* East Germany, as well as East German firms experiencing abrupt shifts in size (job reallocation) and high levels of worker turnover even conditional on size, which we call *excess worker reallocation*. Aggregate reallocation patterns in the East are all but identical to the West by the end of the 1990s, soon after wage convergence stagnates with the wage gap shrinking by only one percentage point per year post-1995. Wage gains and reallocation are unrelated to workers' and firms' distances to the former border and almost uniform across space, consistent with wage growth being due to a transformation of institutions within East Germany, rather than the movement of production inputs across the former border. Indeed, while gross migration is higher closer to the border, net migration is not, rendering the notion of migration having been a trigger for East Germans' wage growth unlikely.[3]

We posit that the timing of the reunification is plausibly exogenous, generating quasi-experimental variation across different birth cohorts in terms of how long they had been exposed to the centralized institutions of GDR's planned economy.Under this hypothesis, upon liberalization of the labor market, worker flows across firms should be largest among older East German cohorts relative to their Western counterparts, reflecting the longer period of time they were unable to leave their firm in search of new jobs and also spared from firms restructuring. Not only do we confirm this hypothesis, but we also find that most firm switches coincide with a change in workers' occupations, much more so than a change in industries. In fact even within firms, older cohorts changed occupations at a higher rate than younger cohorts.[4]

[3]Otherwise, we should observe faster convergence closer to the border.

[4]All statements about East Germany or East Germans are relative to their counterparts in the West. This is an additional advantage of the German setting beyond its reunification episode providing a unique natural ex-

By the same token, most of East German firms' high levels of job and excess worker reallocation stemmed from firms that already existed at the time of reunification. These are the firms that experienced high employee turnover, which in particular resulted in significant downsizing of large plants. Such patterns are consistent with old firms having been both inefficiently large and also having had a suboptimal composition of workers under the former communist regime. Thus, the liberalization of the labor market would have led them to target better matches, also allowing them to shrink in size.

Importantly, from the later 1990s, reallocation rates are all but identical between East and West German cohorts who enter the workforce after reunification. This is reflected among firms as well: Eastern German plants enter with almost the same number of employees, and also grow in size and exit at near identical rates, as their Western counterparts. Together with the evidence on the very high rates of reallocation among old East firms and workers which quickly moved close to West levels over time, these findings show rapid convergence of labor market structure and dynamism. The remaining question is: How much of East German's wage growth be attributed to such institutional transformation?

Quantitatively tying aggregate wage gains to reallocation requires to interpret the data through a model framework. The development and estimation of such a framework is currently work-in-progress. As an intermediate step, we implement a wage regression with time-varying firm fixed effects, also allowing for a full set of education-cohort-specific age effects. We confirm that the dominant source of wage growth are increasing firm effects, consistent with reallocation being the driver of wage gains. We then implement an extended version of an Olley and Pakes (1996) decomposition on the firm effects and show that in 1992-1997, at least a third of East Germany's faster wage growth is directly attributable to larger firms downsizing yet paying higher and higher wages.[5]

Importantly, we do not claim that early wage convergence between East and West Germany was solely due to labor reallocation. In particular, improved management imported from the West (Dyck, 1997), collective bargaining agreements (CBA) and their fallout in the early 1990s (Burda and Hunt, 2001; Snower and Merkl, 2006), the massive levels of capital investment from West to East Germany (Sinn, 2002), mass migration coupled with the coincident integration of the German product market (Uhlig, 2008), and persistent inefficiencies in the industrial structure (Klodt, 2000; Uhlig, 2008), among other things, are all important considerations for wage convergence at the aggregate level, as we discuss in more detail below. By contrast, our analysis takes such changes as exogenous, and has the objective to show how labor market dynamics and reallocation responded to these changes and how

periment. Existing studies on the role of factor allocation in economic development typically rely on comparing countries with vastly different institutions and social-cultural backgrounds, say, China and India to the U.S. (Hsieh and Klenow, 2009). In contrast, it is natural to compare East Germany to the West, who share a relatively homogeneous culture. While there is a literature that debates whether comparing East and West German outcomes can be viewed as a natural experiment (see, e.g. Fuchs-Schündeln and Schündeln, 2020; Becker, Mergele, and Woessmann, 2020), our analysis does not rely on East and West Germans being ex ante identical except for its mid-20th century institutions. Rather, we view reunification as an exogenous, unanticipated shock, and simply measure all East German outcomes against West Germany as a reference group.

[5]Our decomposition also extends the approach by Melitz and Polanec (2015), who added firm entry and exit.

they contributed to wage growth. Furthermore, all our findings are robust to the inclusion of industry and regional fixed effects, the level at which union or agglomeration effects would operate.

Our results indicate that the newly competitive labor market succeeded in quickly unraveling most of the misallocation between East German workers and East German firms generated by the GDR's planned economy, igniting wage growth.[6] Our study is unique in that we use micro-level employer-employee data (workers and their workplace) to attribute East German wage gains post-reunification to worker flows across firms, thus providing a magnifying glass on the process of how the change in institutions affected the labor market.[7]

Related Literature. Our paper contributes to several strands of the literature. First, our work fits within a relatively small, but growing literature that studies the role of the allocation of talent for economic growth and prosperity. The most closely related paper is Hsieh, Hurst, Jones, and Klenow (2019), which shows that a large share of U.S. economic growth in the second half of the 20th century has been due to a reduction in distortions causing talent misallocation.[8] Relative to this work, our contribution is to focus on a unique historical episode that allows us to provide direct evidence of the relationship between labor market institutions and talent allocation.

More broadly, we contribute to the literature on resource misallocation, such as Hsieh and Klenow (2009); Bartelsman, Haltiwanger, and Scarpetta (2013); Adamopoulos and Restuccia (2014). These papers focus on how micro-level misallocation can lead to aggregate productivity differences across countries or regions, but they do not bring evidence of the specific source of said misallocation, nor whether and how it can be unraveled. Two important exceptions are Bau and Matray (2020), which shows how a policy change in India that favoured foreign direct investment also decreased misallocation of capital, and Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas-Sanchez (2017) which illustrate that the introduction of the Euro led to more capital misallocation in the Spanish manufacturing sector. Relative to all this work, our paper, by focusing on labor rather than capital markets, can go a step further by showing direct evidence of misallocation at the individual firm and worker-level, as well as tracking how it unraveled by following the movement of individuals across firms over time.

Second, we contribute to the literature studying cross-country differences in labor market outcomes and the role of job flows for economic development – e.g. Dustmann and Pereira

[6]Conversely, it is perhaps natural that convergence continued only at a slow pace since the 1995, since the allocative effect of institutions was more or less finalized within a few years after impact. Cross-border migration continues today, possibly explaining some of the convergence, and other factors such as human capital accumulation would also only manifest in the long-run.

[7]There are many studies that use German matched employer-employee data, but they typically focus only on West Germany due to the structural break caused by reunification. For example, Card, Heining, and Kline (2013) study the sources of rising wage inequality in West Germany.

[8]While empirical applications of the literature are recent, the idea that human capital misallocation could hinder economic growth dates back at least as far as Murphy, Shleifer, and Vishny (1991). For recent studies on the allocation of talent, see Porzio (2017), who studies the relationship between allocation of talent and technology adoption, and Akcigit, Pearce, and Prato (2020), who highlight the importance of talent allocation for innovation.

(2008); Hobijn and Şahin (2009); Donovan, Lu, Schoellman, et al. (2018). Two papers stand out as most closely related: Engbom (2020) shows that more fluid labor markets allow workers to faster reallocate to jobs where they can better use their skills, incentivizing accumulation of skills; Lagakos, Moll, Porzio, Qian, and Schoellman (2018) shows that earning profiles are lower in low-income countries, consistent with poor functioning labor markets. While this literature focuses on cross-country comparisons, which can be challenging to interpret, our unique setting allows us to attenuate the obvious identification concerns. Furthermore, rather than focusing on long-run differences across countries, we show that cross-country differences can be reduced, if only we could engineer institutional transformations.

Third, we provide new evidence to the very extensive literature studying the role of economic institutions for cross-country income differences.[9]. Our core contribution is to analyze how a country-wide institutional transformation can lead, very quickly, to large economic benefits through an improvement in the efficiency of the resource allocation. This perspective is in stark contrast with the previous work that mostly focused on documenting the persistent economic effects of historical institutional differences.

Finally, our paper is related to work that uses firm-level data to study the transition of former communist economies (De Loecker and Konings, 2006; Orbán, 2019).[10]. Relative to these papers, our setting allow us to directly studying worker flows, and to have a reference group, West Germans, which allow us to quantify the extent of the role of institutions in generating economic growth. Of course, we are not the first to study the unique context of the German reunification.[11] This literature, however, has mostly ignored the role of labor reallocation, and rather focus on Collective Bargaining Agreements or capital investments (Sinn, 2002).

The following section discusses the historical background, followed by a description of the German administrative data we use in our analysis. Section 4 contrasts East and West German labor markets at the aggregate level over time, which motivates Section 5 where we dissect reallocation patterns by worker and firm cohorts. Section 6 documents wage dynamics by worker and firm cohorts, and estimates how much of aggregate wage gains can be attributed to the reallocation of workers across firms. Section 9 concludes.

2 Historical Background

> *One of the dramatic aftereffects of unification was the swift emergence of a free labor market in the former G.D.R. Initially, it has to be mentioned that the term "labor market" is a new term for the Eastern German economy. Under socialism and its planned economy there was no labor market - except for some fringe black market categories. The work force*

[9] A few seminal contributions in this literature are Acemoglu, Johnson, and Robinson (2001), Dell (2010), Michalopoulos and Papaioannou (2016)

[10] See also Aghion and Blanchard (1994); Blanchard (1998); Brown, Earle, and Telegdy (2006); Brown, Earle, and Álmos Telegdy (2010).

[11] For example, Lipschitz and McDonald (1990); Burda and Hunt (2001); Fuchs-Schündeln and Schündeln (2020). See also Heise and Porzio (2021) for a recent investigation of the persistent East-West gap.

was allocated by plan. Individual careers were essentially determined by prescription set by the plan.

-Hoene (1991), *Labor Market Realities in Eastern Germany*

How were workers allocated to firms in the GDR and how was Germany's labor market affected by reunification? In this section, we present a shortened historical background. We first discuss the labor market in the GDR and in particular describe the rigidity of the firm-worker allocation in the centrally-planned economy. Second, we present a brief history of reunification around and after the event, including migration patterns in the aftermath.

2.1 The GDR Economy

Until the political events starting in the fall of 1989, the GDR was a Soviet-style planned economy. Almost all firms were integrated into around 230 vertically and horizontally integrated groups ("Kombinate," Siebert and Schmieding, 1990), which were directly controlled by different ministries of the central government or regional authorities (Mayer and Thumann, 1990). Elaborate central planning steered the allocation of inputs and product prices to influence the distribution of output. Firms organized as such faced minimal competition and were instead pressured to maintain "full-employment."[12]

The allocation of young workers (labor market entrants) to their workplaces was very closely tied to GDR's education and apprenticeship training system. Selection into different tracks (higher education or various apprenticeships) was heavily influenced by various political factors (Fischer, 1992).[13] Some of the training took place directly in the firms and other parts were in the form of education in state-run vocational schools. Around 70% of the workforce had an apprenticeship degree in 1988; the other 30% a degree from a post-secondary institution (Krueger and Pischke, 1995), which were also under state control. Within a Kombinate, workers were expected to follow a segmented career path, which was more or less predetermined (Zühlke and Goedicke, 2000).

Since worker turnover made central planning more difficult (Grünert, 1997), long plant tenure was propagandized as a virtue and encouraged by the government (Goedicke, 2002). This idea was based on the notion that loyalty and stability in a person's work life is advantageous for the stability of the political-economical system. In practice, firms were bound to offer permanent positions to apprentices at the end of their training, and young workers were usually prevented from switching jobs outside the Kombinate for three years (Wehrmeister, 2005). An official GDR survey found that as much as a third of apprentices ended up in occupations they did not desire (Anweiler, 1988).

East German workers had comparably little financial incentives to switch jobs. Wages were centrally set by the Kombinate, conditional on workers' education-occupation and

[12] Detailed accounts and analysis of the GDR economy can be found, for example, in Jeffries, Melzer, and Breuning (1987); Berghoff and Balbier (2013).

[13] Besides political and military nepotism, the number of college and apprenticeship slots were centrally planned to target deficiencies from previous years. Central planning targets were typically set every 5 years (Hoene, 1991).

tenure (Grünert, 1997), with little differences across sectors as well (Mayer and Thumann, 1990). Consistent with such policies, overall wage variance was compressed in the GDR, especially compared to the West (Krueger and Pischke, 1995).

Still, it was not impossible for East German workers to switch firms if they so desired, and another firm agreed to employ them. Job mobility was limited, however, as geographical moves were made difficult by rationed housing, and changing occupations required retraining as well. Grünert (1997) reports that job-to-job flows across plants were about a third of West Germany's in the 1980s, mostly attributable to arranged worker dispatches and recalls. Uunk, Mach, and Mayer (2005), based on the German Life History Study (a relatively small sample, retrospective survey), find that while there was some job turnover, most were job changes within the same Kombinate. Using the same data, Zühlke and Goedicke (2000) argue that even most of this was driven by men returning from compulsory military service and women from maternity leave, whom the state obliged firms to re-employ.

At the macro-level, centralized planning preserved an industrial structure that in the late 1980s was still heavily skewed towards agriculture and heavy manufacturing, while West Germany was increasingly transitioning towards services (Klodt, 1996).[14] A single level of state-owned banks controlled investment in the economy according to plan. Prices did not reflect market forces in any consistent way (Siebert and Schmieding, 1990). In summary, the institutional details and available data all point to high levels of misallocation in the GDR labor market.

2.2 Reunification

While some change was expected in the late 1980s, the exact timing of German reunification was unexpected and dramatically quick. Reunification was not even a remote possibility when anti-electoral fraud protests and mass border crossings through Hungary began in May 1989 (e.g., Schmemann, 1989; Stelzenmüller, 2019). Half a year later in November, the Berlin Wall fell and Germans were instantaneously granted free mobility across the former border. Even then, reunification was not taken for granted by either side. The process was expedited by the first free elections in the GDR in March 1990, after which an economic and financial merger with West Germany was completed in a mere matter of months, in July, and legal and political reunification on 3 October 1990 (Lipschitz and McDonald, 1990). Under the Unification Treaty, the GDR in essence agreed to dissolve itself and the Federal Republic of Germany (FDR) was to absorb its 5 states (*Länder*) and Berlin, thus making reunified Germany an enlarged continuation of the former West Germany (German Unification Treaty, 1990).

The economic transformation of East Germany was spearheaded by the operations of the *Treuhandanstalt* (THA), the large trust fund mandated to privatize and liquidate virtually all GDR enterprises, and the 1:1 currency conversion coupled with West German-style CBA's.[15] Important for us is that both THA's operations and CBA's were by and large completed by

[14] Also apparent in our Figure 2(b).
[15] Assets were exchanged at an average rate of 1.8:1 (Schinasi, Lipschitz, and McDonald, 1990).

1992, the year in which we begin our analysis. Thus, while both had a large impact on the East German labor market, neither could have been the direct drivers of what transpired in the aftermath, as we discuss further below. Given the speed at which privatization and CBA's were implemented, we take it as part of the reunification shock that formed the initial conditions of the East German labor market in 1992

Macroeconomic Indicators The quality of official GDR data is questionable, but best estimates suggest that GDP per worker, nominal wages and labor productivity were about a third of West German levels at the eve of reunification (Lipschitz and McDonald, 1990; Akerlof, Rose, Yellen, and Hessenius, 1991); see also Figure 1(a), where we use the estimates from the German statistical office. It is arguably even harder to gauge exactly what happened upon impact of reunification given the turmoil and change in statistical base, but it is widely agreed that GDP fell by 40-50% in those first two years. Still, the East German economy bounced back quite quickly, reaching a level on par or slightly exceeding its estimated pre-reunification level by 1992. On the other hand, unemployment shot up to above 10% from virtually zero, and has remained persistently high (Figure 1(b)).

What was the reason for the crash? The most obvious culprit would be the instantaneous drop in demand for East German products, especially given the 1:1 currency exchange rate (Akerlof et al., 1991). Large scale manufacturing production by the *Kombinate* collapsed, as did agriculture and the public sector (Figure 2(a)). At the same time, more than a million East Germans migrated to the West between 1989 and 1991 (Figure 3(a)), and firm restructuring and Western-style CBA's came into force almost immediately.[16].

Treuhandanstalt Conceived in March 1990 and beginning operations in May, THA was mandated to privatize all GDR enterprises as quickly and profitably as possible, while also protecting East German jobs and expertise (Carlin, 1993; Dyck, 1997). Despite a sluggish start till mid-1991, more than 99% of the firms it had controlled were privatized or liquidated by the time it ceased to exist in 1994. More precisely, around 14,500 firms were sold in total. 80% of the transactions were concluded by the summer of 1992 and 95% by the summer of 1993. Around 3,200 firms were liquidated (Priewe, 1993; Roesler, 1994; Dyck, 1997).

While there were hopes that the THA could contribute to the preservation of jobs (Lipschitz and McDonald, 1990; Carlin and Mayer, 1992, 1994), the quick dismantling of the *Kombinate*-led manufacturing sector (Figure 2(a)) led to a 70% drop in manufacturing employment, leading to high unemployment (Carlin, 1993). Many observers at the time argued for a longer adjustment period (Carlin, 1993; Priewe, 1993), and many were pessimistic about East Germany's future post-THA (Akerlof et al., 1991; Roesler, 1994). More than 75% of all

[16]While there is a common notion that the 1:1 exchange rate was too high for wages, most authors then and now believe that East German wages being about a third of West Germany's as a result was not far of the mark, both in terms of official figures (as shown in Figure 1(a)) and also since East Germans were relatively high-skilled both compared to other Eastern European countries and also their Western counterparts Schinasi et al. (1990); Klodt (1996); Burda and Hunt (2001)

businesses were sold to large West German enterprises, and only 20% to East Germans, which also raised concerns that THA was unfairly prioritizing Western German companies.

Its lingering unpopularity in the public conscience notwithstanding, there is evidence that points to THA having contributed to efficient restructuring. Dyck (1997) argues that quick sales to West German firms facilitated better management input than could be provided by the government or former GDR expertise, and most recently Mergele, Hennicke, and Lubczyk (2020) finds that GDR firms with higher productivity were more likely to be privatized, sold at a higher price, more likely acquired by West German investors and also more likely to remain active 20 years later.

In this paper, we take THA's operations as part of the reunification shock that forms the initial allocation of firms and workers in 1992.[17] Thus, we cannot rule out the fact that at least some of the reallocation patterns especially between 1992 and 1993 are not affected by privatization. However, worker reallocation patterns across firms are robust to the inclusion of plant fixed-effects, so that workers' behavior seem not not driven by THA operations. In addition, the firms entering the market post-1992 behave in terms of employment growth, on average, almost identically to the West German start-ups, suggesting THA had minimal influence from 1992 onward. Moreover, voluntary moves by workers between firms, as well as job and reallocation patterns *within firms*, which do not involve any changes in a worker's workplace, are also consistent with labor market liberalization, and thus could not have been driven by exogenous restructuring agreed upon during privatization.[18] The magnitude of reallocation between 1992 and 1993 is not an anomalous outlier either and smoothly declines from 1992 onward.

Collective Bargaining Agreements There exists a debate in the literature on whether CBA's were the underlying cause of early wage convergence, as many employers promised to continue to raise wages for as long as 5 years. Several authors have argued that East German wages were set too high, which led to the high levels of unemployment and stagnation in wage convergence post-1995, when a majority of employers no longer abode by previous agreements (Akerlof et al., 1991; Sinn, 2002; Snower and Merkl, 2006). Conversely, others argue that wage levels were not far from reflecting productivity Schinasi et al. (1990); Burda and Hunt (2001); Burda (2008), and that wages were sufficiently flexible to respond to market forces due to the peculiar structure of German CBA's under which plants can, under certain conditions deviate from centralized bargaining outcomes at the industry or region level. This seemed to happen especially from 1993 onwards, after many employer associations walked out on agreements from 1993 onwards (Burda and Hunt, 2001). Some

[17] The fact that reallocation and wage gains are consistent with efficient labor markets is by no means a validation of THA operations. Indeed, the massive reallocation in early years may be a symptom of the resulting allocation from privatization having made firm-worker matches worse. On the other hand, it can also be because THA on the whole correctly anticipated firm-investor matches that were conducive for efficient reallocation. We cannot speak to this issue, because our data does not go back further.

[18] The fact that our results are robust to industry and region fixed effects also point to THA having minimal impact on our results, since privatization was not implemented at a uniform speed across industries and regions (Carlin and Mayer, 1995).

authors have argued that, in fact, this flexibility allowed East Germany to grow at comparably high rates in relation to other regions like Southern Italy (Burda, 2013; Boltho, Carlin, and Scaramozzino, 2018). Despite this, it is unlikely that CBA's had no role in the aggregate wage hikes up to 1995 (Sinn, 2002; Snower and Merkl, 2006). To deal with this, we pay special attention to the roles played by union agreements by showing that results are robust to the inclusion of industry and regional fixed effects, the level at which CBA's take place. Moreover, we show that worker reallocation patterns are robust to plant fixed-effects, and that firms entering post-1992 grow at a similar pace as their Western counterparts, making it unlikely that reallocation was driven by CBA's.

Migration to the West Between 1989 and 1991, more than a million East Germans migrated to the West, amounting to more than 5% of the former GDR's population. However, migration flows were much smaller from 1992 onward, smoothly declining to reach zero net migration around 2015, the last year of our analysis (Figure 3). Thus, even if high relative wages played a role in preventing even more migration, as argued in Hunt (2006), it is hard to argue for a tight relationship between migration and East-West wage convergence at the aggregate level.[19] Thus while our analysis is affected by this, just as it is with the case with THA and CBA, we can consider it as part of the reunification shock rather than the driver of ensuing reallocation.

Gross migration flows post-1992, while large in magnitude, are still only about 1% of East Germany's population, making it unlikely to have been a driver of labor market reallocation patterns we find *within* East Germany. Rather, it should be viewed more appropriately as part of the reallocation that happens in a flexible labor market. In particular, West to East migration is also non-negligible, indicating a continuous change in the pool of workers in the East German labor market. Thus in all our reallocation and wage gain results, we also compare the gains to locals (East Germans who work in East Germany) against those who migrate to the West.[20] While the cumulative effect of migration steadily grows even up to 2015, we find that the size and returns to migration are too small to explain the early speed of convergence and, consistent with our hypothesis, are dominated by local labor market reallocation effects.[21]

The considerably large West German labor market only had to absorb relatively few East German migrants flows, which were less than 1% of West German employment, even at its peak. West German GDP growth and unemployment were quite stable throughout the observation period, as shown in Figure 1, as were population growth and West to East migration, as shown in Figure 3. As shown in Figure 4, life-cycle earnings profiles have also remained more or less constant for West Germans (remarkably for the entire past half-century).

[19] Our analsyis focuses on men only. While both younger men and women tend to migrate more, there is no significant difference in migration flows between the sexes, until recently (Stawarz, Sander, Sulak, and Rosenbaum-Feldbrügge, 2020).

[20] Since migrants tend to be young and the old tend to be unemployed, migration has an additional effect on the selection of the employment pool, which we also separate.

[21] As with other factors, however, we cannot discern whether migration had a lasting effect on the structure of the economy itself, as argued in Uhlig (2008).

The fact that West Germany was much less affected by reunification is conducive for considering West German labor market dynamics as a natural benchmark and comparison group for the East.

3 Data

Our main dataset is constructed from the social security records of the German unemployment insurance agency, which are processed by the Institute for Employment Research (IAB).[22] We observe the universe of private sector workers in Germany, excluding the self-employed. In each year from 1978 to 2014, we observe a worker on June 30. This database includes each worker's age, gender, nationality, education, daily wage, type of employment, occupation, and most importantly, an establishment identifier of the worker's workplace along with its industry and location ("Landkreise und kreisfreie Städte", roughly equivalent to a county in the U.S.).[23] [24] The data is highly reliable due to its original purpose of calculating retirement pensions, but wage records are right-censored at the social security contribution ceiling. We address this issue by applying the imputation procedure in Card et al. (2013). All earnings are converted into constant 2010-Euros using the consumer price index of the *Bundesbank*.

Many of our results rely on comparing East Germans and West Germans as defined by where they are from. However, the data neither includes information on workers' parents nor their place of birth. We therefore proxy an individual's origin by his workplace location when he first appears in the dataset. East German plants were included in the social security database in 1992. So, for older cohorts, the majority of workers who appear in the database for the first time in 1992 are classified as East German. For the rest, we proxy their birthplace (East or West) by location at first appearance in the social security data. For individuals, who enter the labor market without further training after compulsory schooling, this is typically around the age of 18. The majority of individuals in Germany take up an apprenticeship after secondary schooling and appear in the social security data at the start of their training, around ages 18-20 in most cases. Individuals with tertiary education typically appear around age 25 for the first time.

We restrict our attention to German men aged 25-54 to avoid worker flows that may be due to education or retirement decisions.[25] The reason is that womens' wages are harder

[22] Specifically, we use data from the Employee History File (Beschäftigtenhistorik – BEH, Version V10.01.00. See Oberschachtsiek, Scioch, Seysen, and Heining (2009) for a detailed description of an earlier version of this dataset. Access to this data is provided to the scientific community under the regulations of paragraph 75 of the German Social Code Book I and requires an application granted by the German Federal Ministry of Labor and Social Affairs.

[23] The universe of worker records, the 100% sample, is available at an annual frequency. Since this misses within-year transitions in a worker's status, we corroborate our findings on job-to-job transitions by analyzing a 30% sample that records all changes in a worker's status at a daily frequency.

[24] Our data does not allow us to distinguish between East and West Berlin. Our benchmark results treat Berlin as West, but are robust to alternatives.

[25] In particular, the age 54 cut-off is chosen because a special clause allowed East Germans aged 55 and above in 1992 to claim generous early retirement benefits.

Origin:	East		West	
Individuals	2,483,361		12,702,317	
Observations	29,780,426		161,735,648	
Plants	264,322		1,451,116	
	Mean	(St. Dev.)	Mean	(St. Dev.)
Wage	62.28	(27.73)	112.62	(64.07)
Age in 1990	38.83	(8.81)	37.82	(9.07)
Share with College degree	0.13	(0.34)	0.13	(0.34)
Share working in East	0.87	(0.34)	0.07	(0.25)

Table 1: Descriptive overview

Summary statistics of German men aged 25-54 between years 1992-2014 in the IAB dataset. Standard deviations in parentheses. Origin approximated by first date of appearance in the dataset. Wages (workplace location) measured in first (last) observation of each individual. Right-censored wages are imputed, as in Card et al. (2013).

to compare due to the high East-West differences in female labor force participation — see among others Boelmann, Raute, and Schönberg (2020). This issue makes it challenging, but in future work we are trying to also study of allocation in the labor market on female wages.

To compare East and West Germans, we focus on the years 1992-2014, since East German plants were only included in the database from 1992 onward. Data prior to 1992 is used to check whether there are any structural breaks in West German trends before and after reunification. Our core sample covers approximately 12.5 million West Germans observed over 47 years, and 2.5 million East Germans observed over 23 years. Table 1 reports some key summary statistics of our dataset.

4 Aggregate Dynamics Post-Reunification

Section 2 summarized the situation in East Germany at the time of reunification. We now use our data to contrast the aggregate labor market dynamics between East and West Germany. From the worker perspective, we compare the time series of average wages, and worker flows between and within firms, as well as net migration across the former border. From the firm perspective, we compare job and excess worker reallocation across firms. Importantly, we find that all differences between the East and West German labor markets are widespread throughout the East, independently of distance to the West, and that migration does not drive any of the aggregate dynamics.

4.1 Worker Dynamics

Average Wages Figure 6(a) plots the growth rate of average nominal wages over time, separately for workers in East and West Germany. East Germany's rapid growth in GDP-per-worker from 1992 to 1996 (Figure 1(a)) was accompanied by rapid wage growth, at an

average rate above 5%. West German average wage growth was effectively zero for the same observation period, in stark contrast.

Perhaps surprisingly, wage growth was quite homogeneous across East Germany during this period. Figure 7(a), which maps average wage growth by districts, shows a clear discontinuity at the former border and no systematic pattern within the East. More formally, Figure 8(a) plots wage growth within each Kreis as a function of its distance to the former East-West border. Clearly, wage growth is evenly spread out across districts, regardless of distance to the former border.

Worker flows As discussed in Section 2.1, labor mobility across firms was low in the GDR, especially when compared to West Germany. This was turned on its head after reunification.

To compare mobility between the two regions (East and West) post-reunification, we separate within-region mobility from cross-border migration. For each pair of consecutive years, we first count only those workers who are employed in the same region and do not cross the former border. Then within either region, we compute the share of these workers who switched firms between those two years. The results are plotted in Figure 6(b).

Like average wages, labor mobility in West Germany is mostly constant throughout the observation period, in stark contrast to East Germany. During the first few years after reunification, workers in East Germany are more than twice as likely to switch firms than those in the West. This "extra reallocation" rapidly declines over time, all but disappearing by 1999. And, as was the case with wage growth, Figure 7(b) shows that extra reallocation was evenly spread out across East Germany. Figure 8(b) shows that extra reallocation, just like extra wage growth, had no particular relationship with a district's distance to the former border.[26]

Consistent both with the notion that workers reallocate towards better matches and that firms restructure their organization to improve efficiency, we also observe more frequent within-firm occupational changes in the East. This result can be seen in Figure 6(c), which computes, among those that stay in the same firm between any two periods, the share of workers that switch occupations (recorded at the 3-digit level). As with wages and worker flows, within-firm occupation switches are also spread throughout East Germany regardless of the distance to the former border, as shown in Figures 7(c) and 8(c).

Net Migration A standard neoclassical model would predict large net migration flows from East to West, since the large wage gap would be interpreted as a large gap in the marginal product of labor. Such flows should then be a key driver of wage convergence. But as we already argued in Section 2, migration flows are unlikely to explain the early speed of convergence between East and West Germany.

In Figure 6(d), we plot net migration shares in our data sample which only includes prime-age males with at least some attachment to the labor market (employed at least once over the observation period), which differs from Figure 3(a) that includes the entire popu-

[26] Figure A1 shows that East-West patterns are robust to different measures of labor mobility.

lation. For each pair of consecutive years, we only include individuals who appear in our sample in both years, and define net migration as the percentage change in the regional sample size from one year to the next. It turns out that net migration shares are small and even marginally positive in the years 1992-1995 towards East Germany, and not the other way around. Figures 7(d) and 8(d) show that net migration does not display any stark relationship with distance to the border either. Dissecting the flows reveals why (Figure A1(c)): While East-to-West outflows are sizable, they are compensated by West-to-East inflows.[27, 28]

Thus, the data seems to rule out a neoclassical explanation for aggregate wage growth between the two regions and, instead, points to the importance of worker flows from the firm perspective, which are analyzed next.

4.2 Firm Dynamics

Gross worker flows in the East were accompanied by large net flows of labor across firms (changes in size). That is, extra reallocation in the East was also a symptom of firm restructuring. Large worker flows also indicate that firms were swapping their workers, even without changing size. To demonstrate that both these mechanisms played a role, we show that both job and excess worker reallocation were larger in East Germany.

Job Reallocation We define job reallocation (JR) as the sum of job creation (JC) and job destruction (JD) divided by the total employment between periods t and $t+1$. Specifically:

$$JR_t = \frac{JC_t + JD_t}{\sum_j (N_{j,t} + N_{j,t+1})},$$

where $N_{j,t}$ is the size of firm j at time t, and the summation is taken over all firms in the sample.[29] Note that firm size, as well as job creation and destruction are also defined within our sample of prime-age men.

Job creation and destruction include firms that enter and exit, formally

$$JC_t = \sum_{j \in \mathbb{I}_t} \max\{0, N_{j,t+1} - N_{j,t}\} + \sum_{j \in \mathbb{N}_{t+1}} N_{j,t+1}$$
$$JD_t = \sum_{j \in \mathbb{I}_t} \max\{0, N_{j,t} - N_{j,t+1}\} + \sum_{j \in \mathbb{X}_t} N_{j,t},$$

where $\mathbb{I}_t$ is the set of firms extant in both periods t and $t+1$, and $\mathbb{N}_{t+1}$ and $\mathbb{X}_t$ are the set of firms that enter and exit between t and $t+1$, respectively.

[27] As expected, gross flows are larger closer to the former East-West border, see Figure A6

[28] This is partly due to our sample selection, since prime-age men were less likely to migrate to the West than the young and women.

[29] We depart slightly from the classic definition in the literature (see Davis and Haltiwanger (1999)) and divide by total rather than average employment, following other previous work (see Davis and Haltiwanger (1992)). Dividing by total employment makes the magnitude comparable to one for worker flows shown in 6(b).

Figure 6(e) plots JR, separately for firms in East and West Germany. The time series imply massive levels of extra reallocation among firms in the East compared to the West, with a quickly declining but still remaining gap.[30]

To get a better sense of the differences, Figure A2 breaks down JR between incumbent firms ($\mathbb{I}_t$) and those who enter or exit ($\mathbb{N}_t$ or $\mathbb{X}_t$, respectively), separately for East and West Germany. Visibly, East Germany displays extra reallocation both at the extensive and intensive margin, with high shares of employment in firms that enter and exit. Still, incumbents account for most of East Germany's extra reallocation, and especially related to job destruction. For example, job destruction by incumbents makes up almost 20% relative to total employment in the East, compared to less than 8% in the West, between 1992 and 1993. Consequently, Eastern firms are on average downsizing (as we discuss later, see Figure 14).

Excess Worker Reallocation The magnitude of the extra job reallocation in the East compared to West Germany might lead one to conclude that firm restructuring alone can account for all the extra worker flows in the East. However, Figure 6(f) shows that East Germany also witnessed larger excess worker reallocation, which we define as

$$EWR_t = \frac{H_t + F_t - JC_t - JD_t}{2 * \sum_j \min\{N_{j,t}, N_{j,t+1}\}}.$$

The numerator of EWR is the sum of hires (H) and separations (F) beyond those required to fill in new jobs created and vacate old jobs destroyed.[31] It can be interpreted as the amount of worker turnover among firms that do not undergo a change in firm size. Since we only observe workers once a year, by construction, such excess worker flows only happen among jobs that exist for two consecutive years, or what we will call "stable jobs." Thus, we use the total number of stable jobs, over the years t and $t+1$, as the denominator for EWR to measure the turnover.[32]

Figures 6(e) and 6(f) show that the extra worker flows in East Germany originate not only from firm restructuring, as already noted above, but also from firms swapping workers in existing jobs in search of a better workforce composition. Figures 7(e)-7(f) and 8(e)-8(f) complement the analysis by showing that there are conspicuous discontinuities at the former border for both job and excess worker reallocation.

Thus, in order to understand the transformation of East Germany's labor market, we must take into account both the firm and worker side of the labor market. In the next Section, we will show micro-evidence that extra worker flows in the East were associated with workers searching for better matches, and firms restructuring both in size and in worker composition.

[30] Figures 15 and A3 confirm that this led to large changes in the East firm size distribution during the first few years after reunification.

[31] New hires includes workers who just joined the labor force (turned 25 according to our sample restriction), are hired from unemployment, or are poached from other firms. Separations include workers who retire, turn age 55 and exit our sample, are fired, and are poached by other firms.

[32] As for job reallocation, we use the total number of stable jobs to keep the magnitude comparable to workers flows. Notice that one worker flow generates one hire and one fire over the two years window.

5 Labor Reallocation and Institutional Convergence

We have established that the initial period of quick convergence was accompanied by large worker flows and firm restructuring *within* East Germany. Importantly, faster wage growth, and larger levels of job and worker reallocations were widespread throughout East Germany rather than concentrated towards the former border. Furthermore, while aggregate wage growth stagnated after the first few years, aggregate reallocation patterns all but converged between East and West.

These results motivate us to zoom into firm and worker-level dynamics *within* the East German labor market. In this subsection, we exploit variation across worker birth cohorts, across firm cohorts and across the firm size distribution, to show that reallocation patterns are consistent with directed reallocation post-reunification.

5.1 Reallocation by Birth Cohort

We first document how the magnitude of job switches differed across worker birth cohorts. Our working assumption is that the unexpected nature of reunification generated exogenous variation across birth cohorts that we can exploit. Specifically, since older East German cohorts were exposed to GDR's rigid labor market institutions for a longer period of time, we expect them to be misallocated compared to their western counterparts, and thus to display larger levels of extra mobility. In contrast, younger cohorts, especially those that entered the labor market post-reunification, should face similar institutions throughout Germany and thus display similar levels of labor mobility.

The relative exposure to GDR depends on where the worker was before 1990, rather than his current location, since workers could migrate across the former border post-reunification. For this reason, for all remaining results, we categorize workers by their inferred place of living before reunification, using the imputation procedure described in Section 3.

Between-Firm Mobility by Cohort In Figure 9 we plot, separately for workers *from* East and West, the share of workers who switch firms from one year to the next for thirty cohorts, ordered by their age at reunification. The first subfigure shows this age-mobility plot in 1992, and the rest of the subfigures are averaged over multiple years. In general, job transition rates are declining in age. This overall pattern of the age-mobility plots are consistent with most standard job search models with frictions: Workers climb a job or match ladder so they display higher transition rates when young, but then transition rates decline as older workers settle into better jobs and/or matches.

Strong evidence of institutional transformation comes from the fact that — in every time period — the difference between East and West Germans is increasing in age. This is consistent with older East German workers finding themselves in worse matches after reunification, compared to their western counterparts. When suddenly exposed to liberal labor market institutions, it is older workers from East Germany who would reallocate at relatively higher rates in order to make up for the missed opportunities.

Figure 9 also makes it clear that a large portion of extra reallocation and its decline over time (shown in Figure 6(b)) is a cohort composition effect. For cohorts that entered the labor market after reunification, extra reallocation is small and close to zero from 1996 onward. All remaining extra reallocation at that point is due to older cohorts, and even that collapses to minimal levels in recent years.

Such cross-cohort differences offer us a path to understand East Germans' extra reallocation in aggregate. Cross-cohort and aggregate differences between East and West are captured by the *slope* and *level* differences in the two lines plotted in Figure 9, respectively. To the extent that cohort reallocation patterns (slopes) are a symptom of older East Germans' past mismatch, we can deduce that at least some of East Germans' overall extra reallocation is an indicator for overall mismatch in East Germany post reunification.

According to our interpretation, Figure 9 suggests that East Germans' allocative efficiency quickly converged to the level of the West. And if we interpret allocative efficiency as an outcome of the underlying labor market institution, the evidence also implies institutional convergence between East and West.

Robustness The reallocation patterns in Figure 9 *across cohorts* form the backbone of our evidence that aggregate reallocation patterns led to improvements in East Germans' allocative efficiency *over time*. Thus, it is crucial to validate that the cross-cohort patterns we observe are due to East Germans' exposure to GDR *before* reunification. Could it be that the patterns are driven by older Eastern cohorts being more concentrated in certain industries and/or occupations that underwent larger reforms after reallocation, thus experiencing larger rates of labor mobility?

To check this is not the case, we run the following linear probability model for each year in our sample:[33]

$$\text{move}_{i,r,c} = \sum_{k} \left[\mathbb{1}_{c=k} \cdot \left(\sum_{R} \mathbb{1}_{r=R} \cdot \kappa_{R,k} \right) \right] + B\mathbf{X}_{i,r,c} + \epsilon_{i,r,c} \tag{1}$$

where $\text{move}_{i,r,c}$ is a dummy variable equal to 1 if individual i switches firms, $\mathbf{1}_{c=k}$ and $\mathbf{1}_{r=R}$ are dummies equal to 1 if individual i is in cohort k, or born in region $R \in \{\text{East,West}\}$, respectively, and zero otherwise, and $\mathbf{X}_{i,r,c}$ is a vector of controls. For controls, we include either a full set of industry or occupation dummies, both at the 3-digit level.

In Figure 10, we plot $\hat{\kappa}_{E,k} - \hat{\kappa}_{W,k}$ for each k, that is, the estimated difference in the probability that a East or West German worker of cohort k switches firms. It is clear that controlling for either industries or occupation only marginally affect our main result. Overall, East Germans are employed in industry and occupations with slightly more mobility. However, if anything, this selection is stronger for younger cohorts and thus does not explain the extra reallocation of older East Germans.

[33] For each year t, we restrict the sample only to individuals that work in both t and $t+1$. The results are more or less identical if we drop this restriction.

We have also checked that the results remain robust when controlling for both industry and occupation, and also against a full set of industry×state ("Land") interactions. Nonetheless, this does not rule out that older cohorts may have been working in firms that were subject to reforms *after* reunification, even within the same industry and state.

To examine whether older cohorts' extra reallocation was due to older East German cohorts working in specific firms, we compute the reallocation rates of coworkers, rather than the workers themselves. Specifically, for each worker, we compute the share of his coworkers who switch firms, but only if they belong to a different cohort. The results are shown in Figure 13. Co-workers of young and old cohorts are almost as likely to switch jobs, meaning that even within the same firms, older cohorts display higher extra reallocation.[34] Thus, the data supports older East German cohorts having been in worse matches even within the same firms.

Unpacking Labor Mobility A more detailed anatomy of job changes can refine our interpretation of labor mobility as the unraveling of misallocation, as well as provide further robustness checks. Therefore, we now unpack overall labor mobility into different types of job switches. For succinctness, we categorize workers into three broadly defined birth cohort groups and analyze their average transition rates over time: Old cohorts born from 1937 to 1957; middle cohorts born from 1958 to 1967; and young cohorts born from 1968 to 1988.

Figure 11 plots, for twelve different types of job mobility rates, the ratios between East and West Germans. These ratios should be compared against Figure 12, which shows the level of each rate computed for West Germans. As a benchmark, panel (a) plots the East-West ratio of the share of between-firm switches, the same measure we used for Figure 9. Two expected patterns emerge: i) large extra mobility in the first few years after reunification, which is more pronounced for old cohorts; and ii) younger cohorts have almost identical labor mobility especially from 1997 onward. The first result is evidence that reunification led to reallocation which unraveled lingering misallocation from the rigid GDR labor market. The second finding suggests that labor market institutions converged in just a few years.

Panels (b)-(e) show similar patterns for job switches that involve a change in occupation or industry. Old cohorts are more likely to change either occupation or industry when they switch firms, but especially occupations. More interestingly, they are also more likely to switch occupations even when they remain in the same firm. This suggests that a large portion of older East Germans were stuck in occupations that were undesirable, either from the firm's or worker's perspective, or both.

Could it be that a wave of new firms entering post-reunification actively hired older East Germans, or that older East Germans were concentrated in firms that layoff their workers and exit the market? Panels (f)-(h) strike out firm entry-exit as a potential driver of the cross-cohort patterns we saw in Figure 9. If anything, extra reallocation toward firm entrants or away from exits was higher for younger cohorts. Furthermore, combined with Figure 12

[34] There are small differences in the slopes for East and West Germans, especially in the very first year. So the specific firms older cohorts were working in does contribute to their overall extra reallocation, but only to a minor degree.

panels (f)-(h), it is clear that labor reallocation overall happens among surviving, incumbent firms.

Importantly, the extra reallocation of old cohorts does not seem to be driven by higher firing rates. To show this, we track workers' daily employment history using a 30% sample (and not the 100% full sample in which we only observe individuals once a year). Extra mobility is larger for older cohorts and quickly converges for all cohorts, both in terms of job-to-job (JJ) transitions in panel (i), and for annual firm switches with a non-employment spell in-between (JUJ) in panel (j).

East Germans' high level of JUJ transitions as well as transitions into non-employment (panel (k)) is consistent with East Germany's persistently higher level of unemployment. This may also be related to improvements in allocative efficiency, since some firms and workers may have found better matches after dissolving a bad match with a delay. Furthermore, only older cohorts display extra flows into unemployment, so to the extent that older cohorts in the East are more misallocated, larger exit rates would improve overall allocative efficiency.

Finally, panel (l) shows that East Germans are more likely to migrate across the former border than West Germans. However, migrants account for only a minuscule share of labor mobility (Figure 12 panel (l)). This evidence further disqualifies the possibility that cross-regional migration played an important role in early wage convergence, although we will find that it contributes slowly but persistently to East Germans' wage growth over the entire sample period.

Before concluding this subsection, we address a final caveat. All the results so far hinge on comparing East against West Germans. In principle, however, West Germans may also be affected by reunification, thus serving as a biased benchmark. While obviously West Germans must have been affected by reunification albeit to a lesser degree, we point back to the fact that their age-wage profiles were all but constant for the past half century (Figure 4). In Appendix Figure A10, we show that West Germans' aggregate job mobility rates and also their age-mobility profiles remained more or less constant as well.

5.2 Firm Restructuring by Firm Cohort and Size

The evidence thus far indicates that older East German workers display high extra mobility because they were the most misallocated. Similarly, then, it should be older firms who display higher levels of restructuring, since they would have missed that many more opportunities to attain an efficient workforce allocation.

Two issues make a simple comparison of firm cohorts challenging. First, the data only contains age of a plant if it entered after 1992 for East Germany (and 1978 for West Germany). Second, more importantly, as we discussed in Section 2.2, East German firms in 1992 are by and large products of THA's massive restructuring and sales, so age differences among existing firms may have little meaning.

We therefore choose to simply compare plants that were already present in 1992 with those that enter afterward. Additionally, we also examine heterogeneity by firm size: For firms already present in 1992, size could be interpreted as a proxy to longer exposure to GDR economic institutions as firm size and age typically are positively correlated, but also as a proxy of less exposure to THA operations, which split up East German Kombinate into smaller pieces.

Reallocation by Firm Cohort We classify firms into five different groups by when they first appear in our sample, separately for East and West. The first group includes all firms present in 1992. This is the group directly affected by exposure to different labor market institutions, hence the group we expect to show the largest differences between East and West Germany. The other groups are firms that enter in the time periods 1993-1995, 1996-2000, 2001-2005, and 2006-2010. If institutional convergence were successful, we would expect the East-West trajectories of these four groups to be more similar.

For each group of firms and each time period, Figure 14 computes four key moments that summarize how firms were affected by labor market institutions: (a) firm size; (b) job reallocation; (c) excess worker reallocation; and (d) firm exit rates.[35,36] The figure shows that 1992 firms display very different behavior between East and West Germany, supporting our hypothesis of differential exposure. In panel (a), it is clear that 1992 East German firms shrunk on average, consistent with them having had extra labor due to GDR's focus on full-employment, even after THA interventions.

Panels (b) and (c) show that the relative downsizing of 1992 East firms was associated with larger levels of job reallocation as well as excess worker reallocation, compared to their Western counterparts. This extra reallocation across firms is the mirror image of the extra reallocation of older East German workers that we have emphasized in the previous subsection: Since workers were misallocated across firms, both firms and workers reallocated at high rates once the opportunity arose.

Allocative efficiency from the firm perspective, however, is more multifaceted than from the worker perspective. Their higher rates of job reallocation indicate that 1992 East firms were employing an undesirable number of jobs prior to 1992. For plants, the high rates of excess worker reallocation suggests that, even for the same number of jobs, their workforce composition was inefficient prior to 1992. Thus, they continued to hire and fire workers in search of a better match and/or to improve the composition of their workforce, just as older East German cohorts switched firms and jobs at a higher rate in search of a better match. Furthermore, the East-West difference for 1992 firms declines but persists over time for both job and excess worker reallocation.

The last panel shows that 1992 East firms were also more likely to exit, consistent with the GDR having shielded firms from competition, thus allowing low-productivity firms to survive. Such firms may have been unproductive due to inferior technologies, but also because

[35] Refer to Section 4 for the exact definitions of job reallocation and excess worker reallocation.

[36] Extra care is taken to measure only true firm exits and not just establishments that change their firm ID due to mergers, splits or other reasons. See Section 3 for details.

of severe levels of labor misallocation. Once these firms became exposed to competition from the West and new firms in the East, they were no longer profitable and shut down.

Strikingly, firms that enter post-1992 follow almost identical trajectories in East and West Germany, even at the entry stage (our definition of job reallocation includes firms' entry and exit). As is usually the case in most countries, new entrants are on average smaller, experience larger flows, and only a few survive. As firms age, their sizes grow and they become relatively more stable. To the extent that firms' growth trajectories are affected by labor market frictions (e.g. Acemoglu and Hawkins, 2014), the fact that they barely differ between East and West is evidence of rapid labor market institution convergence. And despite the persistent gap in 1992 firms' job and excess worker reallocation, the aggregate economy gradually becomes dominated by post-1992 firms and thus closer to institutional convergence.

Reallocation by Firm Size If firm size and age are positively correlated, that would mean that large firms in 1992 are older, and thus were exposed to GDR institutions for a longer time. On the other hand, a large size in 1992 may also suggest the firm was spared from THA's radical restructuring, which may instead lead to restructuring in the market down the road. Either way, we would expect larger firms in the East to be affected by reunification more, and regardless of the reason, firm size dynamics are important for understand the evolution of aggregate wages (Olley and Pakes, 1996).

To this end, we classify 1992 firms into 16 groups based on size.[37] We then compute the annual change in size, job and excess worker reallocation, and exit rates of each group, separately for East and West, between every two years from 1992 to 2014. Figure 15 plots the average of each statistic over two time periods, 1992-1997 and 1997-2014.

For extant East and West German firms in 1992, firm dynamics are very different along the firm size distribution, mostly in the first few years. Panel (a) shows a large and sudden change in the East firm size distribution. Large firms shrink, while small ones grow faster than in the West. The decline in firm size is significant, with the largest firms shrinking by more than 20% per year on average. Even so, job reallocation in panel (b) is large along the entire distribution and some firms expand, in particular smaller firms with fewer than 20 employees. In line with our previous results, this indicates that large firms had too many and smaller firms too few workers in the early years, just as the large rates of excess worker reallocation across the board in panel (c) points to inefficient matches between all firms and workers.

Since larger firms tend to be older, it should not be surprising that exit rates decline with size due to survival bias. What is interesting in panel (d) is that in 1992-1997, the "extra exit rate" (Eastern firms' exit rate relative to the West) is concentrated among large firms, consistent with our hypothesis that older firms were relatively more misallocated than young firms. In contrast, differences are mostly muted for the latter 16 years, consistent with quick convergence in labor market institutions. Furthermore, the figures show that firm

[37] These size categories are: 1; 2; 3; 4; 5-7; 8-12; 13-19; 20-29; 30-39; 40-49; 50-69; 70-99; 100-199; 200-500; 500-999; 1000+.

dynamics in the West are fairly constant between the two periods, justifying our use of West German firms as a benchmark, as we did with West German workers.

If East institutions indeed converged to the West's, firms that enter post-1992 should have similar dynamics even when disaggregated by firm size. Figure A3, in which we repeat the same exercise for firms that entered post-1992, shows exactly that. To a certain extent, since we already showed above that post-1992 firms follow similar life-cycle trajectories by cohort, it may not be so surprising that firm dynamics do not differ much by size either. Still, we find it remarkable that evidence for institutional convergence endures no matter how we slice the data.

6 Wage Gains from Labor Reallocation

If reallocation led to improvements in allocative efficiencies, such institutional convergence should also have led to wage growth. But while early extra reallocation in aggregate did coincide with wage growth (Section 4), that alone is hardly evidence since labor market reforms were only one of many large-scale transformations East Germany underwent post-reunification (Section 2.2). In this section we conduct a formal analysis to estimate how wage growth and reallocation are interrelated.

Two limitations qualify our results. First, we have no basis for causality, even as we can decompose how wage growth is related to reallocation down to the individual firm and worker levels.[38]

Second, we do not claim that all wage growth was due to reallocation. This is already apparent even in the aggregate time series, since extra reallocation persists for a few years even after East German wage growth all but ceases. Instead, our empirical approach is to only estimate how much of wage growth can be directly attributable to reallocation, aiming to establish a lower bound, as we explain below.

6.1 Relating Wage Growth to Reallocation

We first decompose how much of each individual's wage is attributable to the firm in which the individual works, as opposed to other individual effects that are transferable across firms. If wage growth is indeed attributable to extra reallocation, then it must be explained by growth in the part that is attributable to firms.

Specifically, we run the following wage regression on our entire sample:

$$\log w_{isrct} = \log \theta_{j(i,t),t} + \underbrace{\kappa_{src} + \alpha_{srct} + \epsilon_{isrct}}_{\log h_{isrct}} \tag{2}$$

for each individual i of skill s from $r \in$ {East,West}, born in year c, working at firm j at time t. We define skill s as college attainment. The firm effect $\theta_{j(i,t),t}$ captures the returns for

[38] That said, we do find it hard to believe that reverse causality is dominant here. It would imply that most individual wage gains would have realized even in the absence of firm reallocation.

individual i who works in firm j at time t. Importantly, the firm effects $\theta_{j,t}$ are time-varying and not fixed over time. This is so that we can relate the large rates of labor reallocation we found among East German firms to changes in their firm wage, especially during the turbulent early years after reunification.

Individual worker effects are captured as $\log h_{isrct}$, which has three parts. The first is a skill, region and cohort-specific intercept κ_{src}. Next, the age effects, α_{srct}, are also cohort-skill-origin dependent. Appendix Figure 5 shows that older East Germans experienced steeper wage growth than younger cohorts. Thus, if the age effects are not cohort-specific but assumed to be equal across cohorts, we may spuriously attribute older East Germans' faster wage growth to changes in θ. That is, it could be the case that older workers gain more than younger workers when switching firms, which would be included in α_{srct}, in addition to any life-cycle effects that differ across cohorts.

Since we assume fully stratified cohort-age dummies, we need to normalize a reference cohort and age. Let $\underline{t}$ denote the earliest year in our sample (1992), and $\underline{c}$ the cohort one year older than the oldest cohort (age 55 in 1992). We assume that

$$\kappa_{sr\underline{c}} = \alpha_{src\underline{t}} = \alpha_{sr,t-24,t} = 0.$$

The first normalization means that all estimated cohort effects are relative to the oldest cohort. The second normalization assumes no age effects in 1992, and the last normalization means that all cohort-specific age effects are relative to the youngest age we observe each cohort (age 25). Since our sample is restricted to men aged 25+, $t-24$ is the youngest age in year t. Additional details on identification are explained in Appendix Section B.[39]

6.2 Wage Growth by Birth Cohorts

In Section 5.1, we showed that old East-born cohorts display extra labor reallocation relative to the West-born ones. We next show that the extra reallocation was associated with relatively fast wage growth and unpack its proximate drivers.

Before we move to the regressions results, we start by computing, for each birth-cohort, the wage growth from 1992 to 1993 and plot it as a function of cohort age. Panel 1 of Figure 16 shows that East-born cohorts experience, on average, faster wage growth than West-born ones.[40] Importantly, the gap is larger for relatively old cohorts, consistent with the hypothesis that the extra labor mobility was, in fact, conducing to an improvement in their allocation efficiency.

[39] An alternative specification for decomposing wages would be the popular AKM model (Abowd, Kramarz, and Margolis, 1999). However the AKM model, while widely used, assumes firm and worker effects that are fixed over a chosen time interval of typically at least 5 years long. This is undesirable in our setting in which East German firms undergo rapid large-scale restructuring.

[40] We restrict the sample to workers that are present in both 1992 and 1993 to prevent changes in the composition of the labor force from affecting the results.

Unpacking Wage Growth If job movers experience bigger wage gains on average, the extra reallocation could, mechanically, contribute to the faster wage growth in the East. To gauge this possibility, we first compute the wage gains separately for workers that stay in the same establishment and those that do not. Results are in panel 2 of Figure 16. As expected, job movers enjoy on average larger wage gains. Furthermore, this is even more evident for East-born, suggesting that their job moves are more directed, consistent with the narrative of unraveling labor misallocation. However, the wage gains are larger for both stayers and movers in the East, and they are relatively larger for old cohorts for both groups, suggesting that the direct role of extra reallocation is limited. To formalize this point, we show two counterfactuals in panel 3 of Figure 16. First, we compute the hypothetical wage gains if each East-born cohort has the same shares of movers and stayers as the corresponding West-born cohort, but keep their own wage gains for both groups. This counterfactual wage gains are very similar to the actual ones, confirming the limited mechanical role of the higher share of job movers among East-born individuals. Second, we compute the wage gains keeping the region-cohort specific shares of movers, but assigning the corresponding wage growth of West-born individuals. Consistent with the previous result, we find that this counterfactual shows wage gains that are almost identical to the ones of the West-born cohorts.

Our analysis so far has focused on overall wages. Next, we use the results from specification (2) to unpack, in panel 4 of Figure 16, the relative wage gains across cohorts into cohort-specific age effects ($\alpha_{r,c,t+1} - \alpha_{r,c,t}$) and differences in the growth rates of firm effects ($\log \theta_{r,c,t+1} - \log \theta_{r,c,t}$). As discussed in Section 6.1, the level of the age effect is not separately identified from the average growth in the firm effect, hence we focus on cross-cohorts differences and we normalize the age effects to be zero for the youngest East and West cohorts. We find that the relatively faster wage growth of old East-born cohorts is mostly driven by age effects rather than firm effects. While the age effects of young West-born individuals are larger, consistent with the well-known concavity of experience profiles, among East-born, the age effects of old and young individuals are almost identical. We conclude that the faster relative wage growth of old cohorts in the East is not due to them being more likely to move towards high-paying workplaces. Rather, it is due to their wages growing relatively faster even conditional on firm effects. This result suggests that the extra reallocation of old cohorts is leading them mostly to move to better matches, rather than to firms that pay all workers a higher wage. Notice that this conclusion is consistent with the limited mechanical role of extra reallocation discussed in the previous paragraph.

Wage Growth Over Time Next, we move past the first year in our data, and show how wage growth evolves over time. Following Section 5, we focus on three groups of cohorts to distinguish between individuals that have been more or less affected by the planned economy. Figure 17 shows on the left panel the aggregate wage growth of East-born relative to West-born individuals and on the right panel the decomposition into age and firm effects.[41] The figure confirms the results shown for 1992-1993. The wage growth among East-born is

[41] This figure focuses on East-West gaps, but Figure A12 shows the level of wage growth for West-born. Also, Figures A11 and A13 show very similar pattern focusing only on workers that change job between periods

relatively larger for old cohorts, and this is mostly driven by age effects. Also, as already noticed in Section 4, the wage growth mostly converges after the first few years.

Robustness All the results shown are unconditional wage means, computed by following a group of individuals over time, without controlling for any observable time-varying characteristic, such as occupation or industry. We conclude this section by showing that the results are not affected by the inclusion of controls. Figure A14 shows, for the sample of workers that do not change firms, that the cohort-specific wage growth gap between East-born and West-born cohorts, and in particular the relatively faster wage growth for old East-born cohorts, is not affected by the inclusion of either occupation or industry controls. Figure A15 shows the same for the sample of workers that make a job to job move.

6.3 Firm Effects by Firm Cohort and Size

In Section 5.2, we have shown that the entirety of the extra labor reallocation is due to firms that already existed in the first year of our data, many of which were plausibly in operation during the GDR and thus exposed to the negative effects of the planned economy. We would thus expect that the aggregate wage convergence between East and West Germany is driven by those same firms, as the ones that entered after the reunification should follow similar trajectories irrespective of their geographical location.

Panel 1 of Figure 18 confirms this hypothesis. The cohorts of firms that started producing on or before 1992 display in East Germany the fastest relative growth in their average firm effect in the years of the great convergence, between 1992 and 1996. For the cohorts that entered post-1992, the increase in firm effects is broadly comparable in East and West Germany, and even slightly faster in the West.

Mirroring again the analysis in Section 5.2, we next turn to study the role of firm size. Panel 2 of Figure 18 shows that the establishment-size wage premium was much smaller in the East right after the reunification,[42] signaling that firm size was likely not only a signal of high productivity, but also of an excessively large labor force. As shown in Figure 15, the first few years after the reunification have witnessed a dramatic firm restructuring, characterized by the exit and shrinking of many large firms. This process transformed the firm size distribution and was accompanied by unbalanced wage growth. Figure 18 shows that the large firms, which have been the most affected by the restructuring, are also the ones that have seen their wages grow faster. As a result, by the year 2000, the relationships between firm effects and establishment sizes are virtually identical in the East and West Germany.[43] While we focus on the firm effects for brevity, the results are almost identical for average wages (See Figure A16).

[42] For the year 1992, a regression of log firm effect on log size gives as coefficients 0.015 (0.003) in East Germany and 0.052 (0.004) in West Germany.

[43] For the year 2000, a regression of log firm effect on log size gives as coefficients 0.0.99 (0.002) in East Germany and 0.092 (0.001) in West Germany.

6.4 Wage Growth Decomposition

Summing up to this point, we have documented that:

1. Older cohorts experience wage gains associated with reallocation; both when switching jobs or not.
2. Entering worker cohorts in East Germany behave very differently relative to older ones, compared to cohort differences in West Germany. Existing plants in East Germany behave very differently relative to newly founded plants, compared to the same cohort difference in West Germany.

This suggests a tight relationship between extra reallocation and wage growth by worker and firm cohorts at the micro-level. However, this still does not tell us how much East Germans' extra reallocation contributed to aggregate wage gains at the macro-level. This is not merely a question of whether micro-elasticities can be extrapolated to macro-dynamics, since reallocation in our setting involves both sides of the market transforming simultaneously (labor demand and supply, i.e. firms and workers). Moreover, there are multiple layers of reallocation involved with institutional convergence: Not only do workers reallocate across firms, but the set of firms and workers are also affected as new cohorts enter the labor market and old cohorts retire, as do firms enter and exit the market.

To allow all channels to act at the same time, we now conduct an Olley-Pakes style decomposition (Olley and Pakes, 1996) on aggregate wage gaps. Our extended decomposition can separately capture all such empirical effects of interest. We introduce the following notation:

1. Firm and worker sets:
   - Given a set $\mathbf{A}$ of workers, $\tilde{\mathbf{A}}$ is the set of firms with at least one worker in $\mathbf{A}$
   - Given a set $\tilde{\mathbf{A}}$ of firms, $\mathbf{A}$ is the set of all workers working in $\tilde{\mathbf{A}}$
2. Means over sets: for a variable x, define the following:
   - $\bar{x}(\mathbf{A}) := \mathbb{E}\left[x_i | i \in \mathbf{A}\right]$: mean of x over workers in set $\mathbf{A}$
   - $\bar{x}(\tilde{\mathbf{A}}) := \mathbb{E}\left[x_j | j \in \tilde{\mathbf{A}}\right]$: mean of x over firms in set $\tilde{\mathbf{A}}$

In what follows, we will drop time subscripts (t), and superscripts will denote origin (birth region, also $r \in \{E, W\}$ for East or West). Thus $\bar{w}\left(\mathbf{T}^r\right)$ denotes the average wage of all workers *from* region r, and wage growth from one period to the next can be written as

$$\frac{\bar{w}'\left(\mathbf{T}^{r\prime}\right)}{\bar{w}\left(\mathbf{T}^r\right)} = \underbrace{\frac{\bar{\theta}'\left(\mathbf{T}^{r\prime}\right)}{\bar{\theta}\left(\mathbf{T}^r\right)}}_{\text{firm growth}} \times \underbrace{\frac{\bar{h}'\left(\mathbf{T}^{r\prime}\right)}{\bar{h}\left(\mathbf{T}^r\right)}}_{\text{worker growth}} \times \underbrace{\frac{\bar{\rho}'\left(\mathbf{T}^{r\prime}\right)}{\bar{\rho}\left(\mathbf{T}^r\right)}}_{\text{type corr}}, \tag{3}$$

where primes denote the next period and each statistical component represents

1. firm growth: average wage growth due to growth in firm effects θ
2. worker growth: average wage growth due to growth in worker effects h
3. type corr: average wage growth due to change in correlation between (θ, h).

	1992	1997	2002	2007	2012	**2014**
East Wage Gap (%)	**53.0**	66.7	68.1	67.5	70.1	**72.2**

Table 2: Average East German Wage as a Share of Average West German Wage
German men aged 25-54. Place of origin proxied by location at first appearance in the social security dataset.

For each year, East Germans' extra wage growth relative to West Germans can be decomposed in these three effects by dividing (3) when $r = E$ by the same equation when $r = W$. The results are shown in Figure 19.

The figure demonstrates that neither the worker nor type correlation component can explain the rapid closing of the East-West wage gap, which is predominantly explained by a narrowing firm gap, especially in the earlier years.[44] In what follows, we focus only on the firm component of East Germans' extra wage growth, and establish its association with labor reallocation.

Growth Decomposition of Firm Effects. Our decomposition extends the canonical Olley-Pakes decomposition beyond just firm entry and exit (see also (Melitz and Polanec, 2015)), and introduces changes in firms' worker composition, migration, and composition of workers in the entire workforce. For a set of workers $\mathbf{A}$, let subscripts denote current work region ($r \in \{E, W\}$) as opposed to origin, which we denote with superscripts. Specifically, our benchmark decomposition is:

$$\underbrace{\frac{\bar{\theta}'(\mathbf{T^{r\prime}})}{\bar{\theta}(\mathbf{T^{r}})}}_{\text{b/w firm growth}} = \underbrace{\frac{\bar{\theta}'(\tilde{\mathbf{S}}_\mathbf{r})}{\bar{\theta}(\tilde{\mathbf{S}}_\mathbf{r})}}_{\text{Common}} \times \underbrace{\frac{\frac{\bar{\theta}'(\mathbf{S}'_\mathbf{r}\cap\mathbf{C}^\mathbf{r}_\mathbf{rr})}{\bar{\theta}(\mathbf{S}_\mathbf{r}\cap\mathbf{C}^\mathbf{r}_\mathbf{rr})}}{\frac{\bar{\theta}'(\tilde{\mathbf{S}}_\mathbf{r})}{\bar{\theta}(\tilde{\mathbf{S}}_\mathbf{r})}}}_{\text{Shuffling}} \times \underbrace{\frac{\frac{\bar{\theta}'(\mathbf{C}^\mathbf{r}_\mathbf{rr})}{\bar{\theta}(\mathbf{C}^\mathbf{r}_\mathbf{rr})}}{\frac{\bar{\theta}'(\mathbf{S}'_\mathbf{r}\cap\mathbf{C}^\mathbf{r}_\mathbf{rr})}{\bar{\theta}(\mathbf{S}_\mathbf{r}\cap\mathbf{C}^\mathbf{r}_\mathbf{rr})}}}_{\text{Firm Entry/Exit}} \times \underbrace{\frac{\frac{\bar{\theta}'(\mathbf{C}^\mathbf{r})}{\bar{\theta}(\mathbf{C}^\mathbf{r})}}{\frac{\bar{\theta}'(\mathbf{C}^\mathbf{r}_\mathbf{rr})}{\bar{\theta}(\mathbf{C}^\mathbf{r}_\mathbf{rr})}}}_{\text{Migration}} \times \underbrace{\frac{\frac{\bar{\theta}'(\mathbf{T^{r\prime}})}{\bar{\theta}(\mathbf{T^{r}})}}{\frac{\bar{\theta}'(\mathbf{C^{r}})}{\bar{\theta}(\mathbf{C^{r}})}}}_{\text{Workforce}}$$

with these defintions:

$(\mathbf{T^r}, \mathbf{T^{r\prime}})$**:** set of all workers from r employed in r at time t and $t+1$, respectively

$\tilde{\mathbf{S}}_\mathbf{r}$**:** set of surviving firms from time t to $t+1$ in r (present in both periods)

$\mathbf{C}^\mathbf{r}_\mathbf{rr}$**:** set of workers from r continuously employed only in r in both periods

$\mathbf{C^r}$**:** set of workers from r continuously employed in both periods

And an overview what each component captures

1. Common: average growth across all surviving firms
   (a) Not directly attributable to worker flows

[44] That worker effects play no role in aggregate wage catchup may be puzzling, since in the cross-section, old East Germans on average experienced larger wage gains. But in the aggregate, such relative differences across cohorts are small compared to the large gap in the overall reallocation and wage gains between East and West. Consequently, almost all of wage convergence is explained solely by the firm component, especially in earlier years.

(b) Interpreted as a change in TFP×MPL increase, or *average match quality*

2. Shuffling: direct gains from reallocation.
   (a) Changes in the joint distribution of pay premia and firm size for existing plants
3. Firm entry/exit: wage gains from firm selection
   (a) Firm entrants pay higher wages over time
   (b) Exiting firms pay lower premia on average
4. Migration: wage gains from border crossings and existing migrants. This captures both
   (a) Workers crossing the border from one period to the next (in either direction); and
   (b) Workers who already migrated in a previous period and remain in the foreign region, without returning to their region of origin
5. Workforce: wage gains from worker selection. This captures both
   (a) New cohorts or newly employed workers getting allocated to better matches; and
   (b) Old cohorts or newly unemployed workers having been worse allocated and/or getting selectively fired.

We compute each component for every period in East and West, and plot East Germans' extra growth in each element in Figure 20. Table 3 summarizes cumulative extra growth rates in 5-year intervals, and for the entire sample period in the last column. As already noted in the introduction, of the 19ppt wage catchup in our sample period 1992-2014, more than half is directly attributable to reallocation (components two to five). More important, most of the reallocation effects are attributable to job-job moves among incumbent firms during East Germany's initial growth spurt in the first five years (component two), while during the ensuing stagnation period it is more due to workforce selection — component five — which captures improvements in plant pay premia for newly entering cohorts and newly employed workers. Keep in mind that for each component, the numbers capture East Germans' extra wage growth against their West German counterparts.

The shuffling component captures East Germans' wage gains from staying in (firms located in) the East. However, these gains only measure the gains from workers' job-to-job moves, and do not capture firms' job and excess worker reallocation. To get a sense of the effect of firms' restructuring, we further decompose the shuffling component as follows:

$$\underbrace{\frac{\frac{\bar{\theta}'(\mathbf{S}'_{\mathbf{r}}\cap\mathbf{C}^{\mathbf{r}}_{\mathbf{rr}})}{\bar{\theta}(\mathbf{S}_{\mathbf{r}}\cap\mathbf{C}^{\mathbf{r}}_{\mathbf{rr}})}}{\frac{\bar{\theta}'(\tilde{\mathbf{S}}_{\mathbf{r}})}{\bar{\theta}(\tilde{\mathbf{S}}_{\mathbf{r}})}}}_{\text{Shuffling}} = \underbrace{\frac{\frac{\bar{\theta}'(\mathbf{S}'_{\mathbf{r}}\cap\mathbf{C}^{\mathbf{r}}_{\mathbf{rr}})}{\bar{\theta}(\mathbf{S}_{\mathbf{r}}\cap\mathbf{C}^{\mathbf{r}}_{\mathbf{rr}})}}{\frac{\bar{\theta}'(\mathbf{S}'_{\mathbf{r}})}{\bar{\theta}(\mathbf{S}_{\mathbf{r}})}}}_{\equiv\sigma} \times \frac{\frac{\bar{\theta}'(\mathbf{S}'_{\mathbf{r}})}{\bar{\theta}'(\tilde{\mathbf{S}}_{\mathbf{r}})}}{\frac{\bar{\theta}(\mathbf{S}_{\mathbf{r}})}{\bar{\theta}(\tilde{\mathbf{S}}_{\mathbf{r}})}} \approx \frac{\eta'(\tilde{\mathbf{S}}_{\mathbf{r}})}{\eta(\tilde{\mathbf{S}}_{\mathbf{r}})},$$

where the last approximation holds if $\sigma \approx 1$, which captures worker selection effects. Specifically, σ measures, within the same set of surviving firms, whether the average wage growth

		5-Year extra Growth Rate				**Total**
		1992-1997	1997-2002	2002-2007	2007-2012	**1992-2014**
I	extra Growth	**25.7**	2.1	-0.9	3.9	**36.3**
	b/w firms	**24.7**	2.1	-0.3	2.8	**33.0**
II	common year effect	**14.0**	-0.4	-0.3	1.1	**15.4**
	reallocation	**10.7**	2.5	0.0	1.7	**17.6**
III	Shuffling	**7.3**	-1.4	-2.3	-0.1	**2.5**
	firm entry/exit	**0.6**	-0.3	0.5	0.0	**1.0**
	migration	**1.4**	1.9	1.0	1.0	**6.3**
	workforce	**1.5**	2.3	0.8	0.7	**7.8**

Table 3: Plant Pay Premia: Growth Decomposition

All units in percentage points. Items in panel II add up to the "b/w firms" element in panel I, and items in panel III add up to "reallocation" in panel II.

of domestic workers who are present in both periods differ from the average wage growth of all workers in those firms.[45] Now letting s_j denote the size of firm j,

$$\eta(\tilde{\mathbf{S}}_\mathbf{r}) \equiv \underset{j\in\tilde{\mathbf{S}}_\mathbf{r}}{\text{Cov}}(s_j,\theta_j) = \mathbb{E}\left[\left(s_j - \bar{s}(\tilde{\mathbf{S}}_\mathbf{r})\right)\cdot\left(\theta_j - \bar{\theta}(\tilde{\mathbf{S}}_\mathbf{r})\right)|j\in\tilde{\mathbf{S}}_\mathbf{r}\right]$$

is the covariance of size and θ_j among surviving firms in r. The covariance can further be split into wage improvements conditional on size, and changes in size conditional on wages:

$$\frac{\eta'(\tilde{\mathbf{S}}_\mathbf{r})}{\eta(\tilde{\mathbf{S}}_\mathbf{r})} = \underbrace{\frac{\text{Cov}(s'_j,\theta_j)}{\text{Cov}(s_j,\theta_j)}}_{\text{(extensive)}} \times \underbrace{\frac{\text{Cov}(s'_j,\theta'_j)}{\text{Cov}(s'_j,\theta_j)}}_{\text{(intensive')}} = \underbrace{\frac{\text{Cov}(s_j,\theta'_j)}{\text{Cov}(s_j,\theta_j)}}_{\text{(intensive)}} \times \underbrace{\frac{\text{Cov}(s'_j,\theta'_j)}{\text{Cov}(s_j,\theta'_j)}}_{\text{(extensive')}}. \tag{4}$$

The first equality measures how the change in the size distribution of firms affects wages, holding firms' θ constant (extensive margin), and then the added effect coming from the change in θ's (intensive margin). The second equality is the same, but first measures the effect of the change in the distribution of θ, and then the change in the size distribution. Since we know that East extra flows were concentrated among large, extant firms in 1992, which rapidly downsized in ensuing years, we would expect the extensive margin to lead to aggregate wage losses if θ's were constant. But downsizing may also directly lead to θ-growth if firms faced decreasing returns to size and paid wages according to marginal product (job reallocation). Furthermore, even if the firm size distribution remained constant, we would expect θ to rise faster among larger firms due to improvements in worker composition (excess worker reallocation), leading to aggregate wage gains. The time-varying θ's in (2) are thus important for us to be able to measure these intensive margins to aggregate wage gains.

[45] Since both migration and workforce effects are small, we find that $\sigma \approx 1$ in both East and West Germany in the early years.

	5-Year extra Growth Rate				**Total**
	1992-1997	1997-2002	2002-2007	2007-2012	**1992-2014**
Shuffling	**7.3**	-1.4	-2.3	-0.1	**2.5**
Cov. gap	**8.3**	-0.2	-2.2	-0.5	**5.1**
Extensive	**3.7**	0.9	0.2	-0.2	**5.4**
Intensive	**8.0**	-0.4	-1.2	-0.3	**6.6**

Table 4: Decomposition of Average θ Growth by size and θ-distribution(s)
All units in percentage points. See text for definition of θ, the firm effect.

Table 4 shows the cumulative decomposition results in 5-year intervals, and for the entire sample period in the last column. First, note that the difference between the shuffling component and the covariance gap in the first and second rows is σ, which is small in all years. Second, especially in the first 5 years, East Germans' extra growth in its intensive margin is much larger. Even if the firm size distributions had remained constant in both the East and West, East German wages would have grown faster due to larger firms experiencing faster θ-growth.

To understand where these gaps are coming from, Figure 21 plots the annual decomposition of the shuffling component separately for East and West Germans. For both East and West, the intensive margin is larger than the total shuffling component prior to the 2007 financial crisis, except for 1992 in the East. Moreover, the extensive margin is small, except for the first 3 years in the East. Thus, rather than changes in the size distribution of firms, we conclude that relative changes in East Germany's firm effects θ was the dominant source of its wage catchup.

However, while we can conclude that the change in the size distribution itself played only a secondary role in aggregate wage gains, we cannot identify whether θ-growths were due to firms becoming more efficient in size (from job reallocation) or more efficient in their composition of workers (from excess worker reallocation).

7 Model

We now present and estimate a model that captures key features of the data, so that we can estimate aggregate gains. The goal design a model to quantify the impact of reallocation on productivity and wages. This is a measure of the returns to "capitalism in the labor market."

To be more precise, we want to quantify how much of the "year effect" estimated from the Olley-Pakes style decomposition can in fact be attributed to the appearance of competitive forces in the labor market following reunification. In that sense, our model can be viewed as a model of "endogenous aggregate productivity."

To that end, we first estimate the model to the current East Germany, assuming that today's labor market institutions are identical across both East and West Germany—this is

supported by the fact that reallocation rates are identical between the two regions. Then we assume that GDR can be viewed as a "distorted" version of a market economy. That is, we can model it as if GDR were a market economy, just with a high level of frictions.

Since we do not directly observe any micro data from GDR, we compute the transition path of East Germany *after* distortions are removed, and calibrate the path to the data to *after* reunification to infer the magnitude of distortions that would have existed *before* reunification in the GDR. Finally, the model is used to counterfactually compute what the labor market would look like in East Germany today, had institutions not transformed—i.e., we allow for exogenous productivity gains, but keep the distortions that prevent workers from flowing across firms.

7.1 Environment

Our model extends Burdett and Mortensen (1998) to incorporate overlapping generations of workers, firm-worker match qualities and also a firm's scale of operation. Every instant, a mass of n_0 individuals enter the workforce, who build experience at rate φ_0 and die at a rate of φ_1. An inexperienced worker has human capital 1, and a worker with experience has human capital of $h > 1$. Firms differ in productivity $q \sim P(q)$, and also in their "scale of operation" $v \sim C_q(v)$. That is, a firm is characterized by its productivity, and how many vacancies it can post.

Both employed and unemployed workers file for job applications. Applicants receive offers from heterogeneous firms, and either accept or reject the offers. If an offer is accepted, the worker-firm pair draw a match quality z_i with probability ω_i.

We will ignore writing the aggregate state for now.

7.2 Firms

Firms differ both in their output and vacancy postings, captured by (q, v). In steady state, firms offer workers a wage-schedule

$$\max_w \left\{ \frac{q}{\gamma} \cdot H(w)^\gamma - wH(w) \right\} v, \quad H(w) \equiv \sum_a h_a \sum_i z_i l_{ai}(w)$$

where l_{ai} is the mass of workers per vacancy. We will maintain that firms always post wages to maximize steady state profits, even on a transition path. This is equivalent to assuming that firms have an infinitely high discount rate.

Note that the production function is concave in effective labor per vacancy, and not in labor itself. This assumption is convenient because it clearly separates the sources of misal-

location that stems from wage versus vacancy postings. Since the above admits an optimal wage posting strategy $w(q)$, the actual production technology is

$$y(q,v) = \frac{q}{\gamma} \cdot \left[\sum_a h_a \sum_i z_i g_{ai}(q,v) \right]^{\gamma} v^{1-\gamma},$$
$$g_{ai}(q,v) = l_{ai}(w(q))v.$$

where $g_{ai}(q,v)$ is the mass of workers working in firm (q,v). Thus, firms can be large either because they post a high wage (which will be those with a high q), or have a large "scale" (high v).

The solution to the wage-posting problem is

$$(M(q,w) - w) \cdot H'(w) = H, \quad M(q,w) \equiv \frac{q}{H(w)^{1-\gamma}}, \tag{5}$$

so with some abuse of notation we can write

$$w'(q) = [M(q) - w(q)] \cdot \frac{H'(q)}{H(q)}$$

assuming that w is monotonic in q.

Note that we assume that v itself is exogenous, so it is not a choice variable of the firm. We could of course easily endogenize it by assuming some convex vacancy costs with heterogeneous marginal costs. However, to the extent that we want to model to be consistent the wage-size distribution in the data, assuming heterogeneous marginal costs is equivalent to assumign exogenous vacancies, so we make this assumption outright for quantitative purposes.

7.3 Workers

If $w(q)$ is monotonic, the value of an age a unemployed worker can be written

$$rU_a - \dot{U}_a = b_a + \varphi_a(U_{a+1} - U_a) + \max_s \left\{ s\lambda \left[\int V_a^U(q') dF(q') - U_a \right] - \psi_a^U(s) \right\}$$

where b_a is the period return from remaining unemployed, and $V_a^U(q)$ denotes the expected value of being hired by a firm of productivity q that offers wages $w_a(q)$. Note that b_a is allowed to be age-dependent, which is consistent with the data but also simplifies the numerical problem, as we will see below. F is the distribution of wages offered by firms to workers, and λ is the arrival rate of offers per unit of job applications.

Upon getting an offer, workers experience a Gumbel shock that generates the CCP of accepting the offer

$$\mu_a^U(q') = 1/\left[1 + \exp\left(\frac{U - \bar{W}_a(q') + \kappa_a^U}{\sigma} \right) \right] \tag{6}$$

where κ_a^U is a switching cost, $\bar{W}$ is the expected value over match productivities and

$$V_a^U(q') = \sigma \log \left[\exp\left(\frac{\bar{W}_a(q') - \kappa_a^U}{\sigma} \right) + \exp\left(\frac{U_a}{\sigma} \right) \right] = \bar{W}_a(q') - \kappa_a^U - \sigma \log \mu_a^U(q').$$

Workers employed in a i-match of age a by firm q have value

$$\begin{aligned} rW_{ai}(q) - \dot{W}_{ai}(q) = w(q) h_a z_i - \delta_{ai} \left[W_{ai}(q) - U_a \right] + \varphi_a [W_{a+1,i}(q) - W_{ai}(q)] \\ + \max_s \left\{ s\lambda \left[\int V_{ai}(q, q') dF^a(q') - W_{ai}(q) \right] - \psi_a(s) \right\}. \end{aligned}$$

Similarly as the unemployed, the CCP and value of acceptance are

$$\mu_{ai}(q, q') = 1 / \left[1 + \exp\left(\frac{W_{ai}(q) - \bar{W}_a(q') + \kappa_a}{\sigma} \right) \right] \tag{7}$$

$$V_{ai}(q, q') = \sigma \log \left[\exp\left(\frac{\bar{W}_a(q') - \kappa_a}{\sigma} \right) + \exp\left(\frac{W_{ai}(q)}{\sigma} \right) \right] = \bar{W}_a(q') - \kappa_a - \sigma \log \mu_{ai}(q, q').$$

Assume that the cost of search is isoelastic (with some abuse of notation):

$$\psi_a^U(s) = \frac{s(s/\psi_a^U)^{1/\psi_1}}{1 + 1/\psi_1}, \quad \psi_a(s) = \frac{s(s/\psi_a)^{1/\psi_1}}{1 + 1/\psi_1}$$

Then the solution to the search decision is

$$s_a^U = \psi_a^U \left\{ \lambda \left[\int V_a^U(q') dF(q') - U_a \right] \right\}^{\psi_1} \tag{8a}$$

$$s_{ai}(q) = \psi_a \left\{ \lambda \left[\int V_{ai}(q, q') dF^a(q') - W_{ai}(q) \right] \right\}^{\psi_1} \tag{8b}$$

so the values can be written

$$rU_a = b_a + \varphi_a(U_{a+1} - U_a) + \frac{s_a^U (s_a^U/\psi_a^U)^{1/\psi_1}}{1 + \psi_1} \tag{9a}$$

$$rW_{ai}(q) = w(q) h_a z_i - \delta_{ai} \left[W_{ai}(q) - U_a \right] + \varphi_a [W_{a+1,i}(q) - W_{ai}(q)] + \frac{s_{ai}(q)(s_{ai}(q)/\psi_a)^{1/\psi_1}}{1 + \psi_1}. \tag{9b}$$

7.4 Search and Matching

Assume a CRS matching function $\Lambda(V, S)$ where V are total vacancies posted (note that these are exogenous, capturing between-firm frictions in the economy) and total searches S are

$$S = \sum_a S_a, \quad S_a = s_a^U m_a^U + \sum_i \int s_{ai}(w) dG_{ai}(w)$$

where G_{ai} is the distribution of (a,i)-workers. We will assume a simple matching function

$$\Lambda(V,S) = S^{\nu}V^{1-\nu}.$$

Let $\theta \equiv V/S$ (market tightness), and let the average rate at which workers find a posting $\lambda(\theta) \equiv \Lambda(V,S)/S$; Then a posting finds a worker at rate $\eta(\theta) = \lambda(\theta)/\theta$. A vacancy will find an age-a searcher at rates

$$\eta_a = \frac{\eta S_a}{S} = \theta^{-\nu}\frac{S_a}{S}.$$

In this setting, labor market institutions are captured by two simple parameters: the distribution of $v \sim C_q$ (exogenous bounds on firms' scale of operation) on the firm side, and ψ_a (cost of switching jobs) on the worker side. As can be seen in the matching function, a high correlation between (q,v) would make high q firms, who hire more workers per vacancy, even larger, thus raising aggregate productivity, since there are more workers in the more productive (high-q) firms. Conversely, a low correlation would make high q firms relatively smaller, leading to less employed workers in equilibrium. This also implies lower aggregate productivity. And clearly, high ψ_a will lead to less job filings on-the-job, leading to higher misallocation and again, lower aggregate productivity, since less workers will be able to climb the job-ladder, reaching the more productive (high-q) firms.

7.5 Flows and Steady State Equilibrium

Denote the distribution of offers:

$$dF(q) = \frac{\int^{q} v(\hat{q})dC_{\hat{q}}(v)dP(\hat{q})}{\int v(\hat{q})dC_{\hat{q}}(v)dP(\hat{q})} \tag{10}$$

where P is the distribution of firms over q and C_q the distribution of v conditional on q. The offer distribution also only depends on q since vacancies are exogenous, and firms choose wages to optimize profits per vacancy. Mass of workers per vacancy at firms of productivity q evolves as

$$\begin{aligned}
&\dot{l}_{ai}(q) + \left[\varphi_a + \delta_{ai} + s_{ai}(q)\lambda \int \mu_{ai}(q,q')dF_a(q')\right] l_{ai}(q) \\
&\qquad = \eta\omega_i \cdot \left[s_a^U \mu_a^U(q)\cdot m_a^U + \sum_{i'}\int s_{ai'}(q')\mu_{ai'}(q',q)d\tilde{G}_{ai'}(q')\right]/S + \varphi_{a-1}l_{a-1,i}(q).
\end{aligned}$$

Denote the rate of inflows per vacancy posting, and outflows per worker, respectively, as

$$\begin{aligned}
A_{ai}(q) &\equiv \eta\omega_i \cdot \left[s_a^U \mu_a^U(q)\cdot m_a^U + \sum_{i'}\int s_{ai'}(q')\mu_{ai'}(q',q)d\tilde{G}_{ai'}(q')\right]/S \\
B_{ai}(q) &\equiv \varphi_a + \delta_{ai} + s_{ai}(q)\lambda \int \mu_{ai}(q,q')dF(q')
\end{aligned}$$

Then in steady state,

$$l_{ai}(q) \equiv \frac{A_{ai}(q) + \varphi_{a-1} l_{a-1,i}(q)}{B_{ai}(q)} \tag{11}$$

and the equilibrium mass of workers must satisfy

$$\tilde{g}_{ai}(q) \equiv \int g_{ai}(q,v)dv = l_{ai}(q) \cdot \int^{q} v(\hat{q},v) dC_{\hat{q}}(v) dP(\hat{q}), \tag{12}$$

that is, $\tilde{g}$ is the mass of workers at a firm who posts wages $w(q)$, integrated over all such firms that may vary in the exogenously assumed vacancies. Since we assume that firms choose wages to maximize profits per vacancy, and we assume that v is exogenous, firm size need not be monotonic neither in w nor q.

The reservation wage must satisfy

$$W_{a\underline{i}}(R_a) = U_a$$

which means the lowest-type worker is indifferent between working or not. Note that since b_a is age-dependent, so will the the reservation wage. The flow of unemployment follows

$$\dot{m}_a^U = \sum_i \delta_{ai} m_{ai} - \left[\varphi_a + s_a^U \lambda \int \mu_a^U(q') dF(q') \right] m_a^U + \varphi_{a-1} m_{a-1}^U$$

In equilibrium it must also be that

$$n_a - m_a^U = \sum_i m_{ai}, \quad m_{ai} \equiv \int \tilde{g}_{ai}(q) dq \tag{13}$$

given a mass of age-a individuals n_a, so in steady state

$$m_a^U = \frac{\sum_i \delta_{ai} m_{ai} + \varphi_{a-1} m_{a-1}^U}{\varphi_a + s_a^U \lambda_a \int \mu_a^U(q') dF_a(q')} \tag{14}$$

except for age $\underline{a}$, for whom $\varphi_{a-1} m_{a-1}^U = n_0$.

A **steady state equilibrium** is defined as a set of worker allocations, search choices, job offer acceptances, firms' wage posting strategies and job offer arrival rates such that

1. Given worker allocations, firms' wage postings are optimal
2. Given firms' wage postings, workers' search efforts and acceptance probabilities are optimal
3. Job offer arrival rates are consistent with aggregate search decisions and (exogenous) vacancy postings
4. Distributions are stationary.

7.6 Transition

We first estimate a steady state of the model to the East Germany in the 2010s, which yields the search cost and exogenous vacancy distribution for the modern East. Then we change the search costs (ψ_a, ψ_a^U)'s, and between-firm distortions (the correlation between q and v), to a hypothetical GDR: The size of these labor market distortions captures the lack of a capitalist labor market. However, since we do not directly observe data for the GDR, we can only calibrate the size of these parameters along a transition path. That is, suppose that GDR was in a steady state with high distortions. Upon reunification, these distortions are lifted, and workers start flowing toward high-q firms since search is cheaper, while at the same time there are more high-q vacancies since the correlation between (q, v) becomes higher. Since we observe wages and worker flows post-1992, we match these moments to the data along a transition path.

To be sure, we also raise aggregate productivity (all firms' q) to match the overall rise in wages. Then, we can shutdown the effects of this exogenous productivity to counterfactually compute the effect of the removal of distortions on aggregate productivity.

How do institutions raise aggregate productivity and wages? For the former, since more workers will climb the ladder toward high-q firms and high-q firms post more vacancies, aggregate productivity must become endogenously larger. In addition, more workers will be in better matches as well. Workers will also gain more in terms of wages, since firms will need to compete more fiercely among themselves to attract more workers, who are now search more intensively.

Firm Production In a transition, we assume that firms exogenously "split" into two lines of production: Those that continue using jobs hired during the GDR regime (q_0, v_0), and those that hire new jobs according to their new productivity and vacancies (q_1, v_1). We assume that for the new jobs, firms post wages as if they are already in the new steady state: Theoretically, this is equivalent to assuming that firms have a discount rate converging to 0 with full commitment to wages, as in the standard BM case (and as we assume in steady state).

Since within the firm, there are two types of jobs along the transition path that pay different wages, numerically each firm would have $2n_q$ rather than n_q wages being paid out. In the benchmark case, we assume that firms only post wages for the new vacancies. We can also allow them to continue to post wages for old vacancies at some exogenously declining rate, which we do for robustness checks.

Define $l^0_{a,i}(q^0), l^1_{a,i}(q^1)$ to be labor per vacancy in the two steady states. Along the transition path at time t, firm output is

$$y = \frac{\left[q^{0\frac{1}{\gamma}} \cdot \sum_a h_a \sum_i z_i g^0_{ai}(q^0, v^0) + q^{1\frac{1}{\gamma}} \cdot \sum_a h_a \sum_i z_i g^1_{ai}(q^1, v^1)\right]^\gamma v(q)^{1-\gamma}}{\gamma}$$

$$v(q) = \frac{\sum_a \sum_i g^0_{ai}(q^0, v^0)}{\sum_a \sum_i l^0_{ai}(q^0)} + \frac{\sum_a \sum_i g^1_{ai}(q^1, v^1)}{\sum_a \sum_i l^1_{ai}(q^1)} = v^0(q) + v^1(q)$$

This formulation is implicitly assuming that labor per vacancy in each line of production is constant. Note that $v_0(q^0, q^1, v^0, v^1) = v^0$ when $t = 0$ and v^1 when $t \to \infty$. The formulation retains the production technology of the firm that we assumed, ensuring that the decreasing returns in worker-per-vacancy is applied "once" rather than separately on each line of production.

Worker Flows Workers are fully rational with perfect foresight. Many workers will have been stuck in undesirable jobs in the GDR regime, but now they realize they can search at a cheaper cost, that firms are posting new jobs with new wages, and that there are more high wages available since the correlation of q and v has gone up. Their search efforts will determine equilibrium market tightness, along with the new, exogenous vacancies.

In addition, we assume that some workers exogenously transit from the old production line to the new one, within the same firm. This assumption is require to match the fact that, many workers experience wage gains even within the firm in the data, and also that older workers are switching occupations within the firm at a higher rate than the young. Denote this rate by $\alpha(t)$, and suppose that this rate is logistic, so that the share of workers in a "new" job offered by the firm, S_t, evolves according to

$$\begin{aligned} &\dot{S} = \bar{\alpha}(1-S)S && \Rightarrow \quad \alpha(t) = \bar{\alpha}(1-S)dt \\ &S_t = \frac{S_0}{S_0 + (1-S_0)e^{-\bar{\alpha}t}} = \frac{1}{1+e^{-\bar{\alpha}(t-\mu)}} && \Rightarrow \quad \mu \equiv \frac{\log(1-S_0) - \log S_0}{\bar{\alpha}}. \end{aligned}$$

The two representations of the share is useful: the smaller the initial shock S_0 and the faster the maximum rate $\bar{\alpha}$, the later the inflection point. For example, if the shock is 10% on impact and the inflection point is 5 years, then since we assume periods are a quarter,

$$\bar{\alpha} = \frac{\log(0.9) - \log(0.1)}{20} \approx 11\%$$

is the maxmial transition rate of workers from old to new jobs.

Workers who are in a new line of production solve the same problem as above. However, workers in old lines of production solve

$$\begin{aligned} r\tilde{W}_{ai}(q,t) - \partial\tilde{W}_{ai}(q,t)/\partial t =& w(q,t)h_a z_i - \delta_{ai}\left[\tilde{W}_{ai}(q,t) - U_a(t)\right] \\ &+ \varphi_a[\tilde{W}_{a+1,i}(q,t) - \tilde{W}_{ai}(q,t)] + \frac{s_{ai}(q,t)(s_{ai}(q,t)/\psi_a)^{1/\psi_1}}{1+\psi_1} \\ &+ \alpha_t[W_{ai}(q,t) - \tilde{W}_{ai}(q,t)]. \end{aligned}$$

The masses of workers in the old and new jobs follow

$$\dot{g}^0_{ai}(q^0, v^0) = -B_{ai}(q^0)\cdot g^0_{ai}(q^0) + \varphi_{a-1} g^0_{a-1,i}(q^0) - \alpha g^0_{ai}(q^0, v^0) \tag{15a}$$

$$\dot{g}^1_{ai}(q^1, v^1) = -B_{ai}(q^1)\cdot g^1_{ai}(q^1) + \varphi_{a-1} g^1_{a-1,i}(q^1, v^1) + \alpha g^0_{ai}(q^0, v^0) + A_{ai}(q^1)\tilde{v}(q^1) \tag{15b}$$

8 Calibration and Algorithm

8.1 Calibration

Parameters

1. rw, rf, δ_{ai}: discount rates (let firms' be higher, to incorporate closures) and exogenous separations
2. Size of firm prod, q, and distribution $P(q)$. Follow Moscarini and Postel-Vinay to fit ex ante.
3. ω_i, z_i: share and productivity of ex-post match quality. Discretize a normal distribution with 5 states.
4. φ_a, h_a: stochastic aging. Age bins, only need 2. $\varphi_a = \varphi$ means uniform demographic structure.
5. ν: worker share in matching function, so $\lambda = \theta^{1-\nu}$ and $\lambda/\theta = \theta^{-\nu}$.
6. ψ_a, ψ_1: cost and curvature of search
7. c_a, χ_a: cost and curvature of hires: probably shouldn't vary across age
8. κ_a, σ_a: switching cost and EV variation.
9. b_a: unemployment benefit: set to 80% of lowest wage, at every iteration?

Extra Details:

1. Normalizations:

$$\begin{aligned}
\sigma &= \tilde{\sigma} \cdot U_a \\
\kappa_a^U &= \tilde{\kappa}_a^U \cdot \bar{W}_a(\underline{q}) \\
\kappa_a &= \tilde{\kappa}_a \cdot \bar{W}_a(\underline{q}) \\
\psi_a^U &= \left[\text{mean}(\bar{V}_a^U - U_a)\right]^{-\psi_1} \cdot \tilde{\psi}_a^U \\
\psi_a &= \left[\text{mean}(\bar{V}_{ai}(q, q') - W_{ai}(q))\right]^{-\psi_1} \cdot \tilde{\psi}_a
\end{aligned}$$

2. Reservation wage: In the calibration, fix R and assume b_a is set so that for all ages,

$$b_a \leq Rh_a z_{\underline{i}} + \frac{s_{a\underline{i}}(\underline{q})(s_{a\underline{i}}(\underline{q})/\psi_a)^{1/\psi_1}}{1+\psi_1} - \frac{s_a^U(s_a^U/\psi_a^U)^{1/\psi_1}}{1+\psi_1}.$$

   In the counterfactuals, assume that it binds only for one age.

   Targets/parameters for transition The goal is to use the transition between steady states to back out the extent of distortions in the GDR and thus quantify the contribution of the improvement in the labor market institutions to aggregate wage and productivity growth.

   The following parameters are allowed to vary between steady states:

(a) At the aggregate level, three core parameters change: i. the ability of workers to search on the job (ψ_a); ii. the correlation between vacancy cost and productivity; iii. the average level of productivity;

(b) The aggregate ii. and iii. above come from the fact that each firm draws a new vector of productivity and vacancy cost (q_1, v_1);

For the final steady state, only the first item above is relevant. However, along the transition path the speed at which firms transition from old to new productivity is relevant. Moreover, it is going to affect the measured excess reallocation.

We pick the following parameters

(a) Search intensity in the GDR

(b) Correlation in the GDR –> but then the problem is that

(c) Speed of convergence of q.

We target the following moments (brief discussion of identification), for estimation purposes, we only target the first 10 years after the reunification, since solving for every additional year requires

(a) the most parsimonious approach would be to target exactly the same moments we target in steady states

(b) however, we need to find a way to summarize the fit to do identification plots –> natural way to do this would be to do ex-post analysis given the fit.

(c) the additional steepness of the relationship between mobility and age naturally pins down the extent of limited "job-ladder" in the GDR. Notice that a key question is whether we know that this comes from workers rather than firm side. The key is that, it is true that old workers could be more likely to be at "bad firms", but we show that the patterns are not driven by the firm in which workers are at, but rather by their relative mobility.

(d)

Notes: - if q increases too much, then workers will "stay put" to wait for q to increase. This may lead to potential issues.

- maybe it is better to target the average firm size by wage rather than the other way around.

- something a bit problematic is that also the rho affects the allocation of workers over their life-cycle. If firms are misallocated, the ladder is distorted.

8.2 Algorithm

Steady State :

1. Guess $\tilde{g}_{ai}(q)$ on a (a, i, q)-grid. This also implies unemployment by age m_a^U.

   (a) Firm's problem:

i. Use $\tilde{g}$ guess and exogenous v to get $l_{ai}(q)$ from (12). Get $w(q)$ from (5), assuming that R is a parameter (rather than b).

ii. Use (10) to get $F(q)$.

(b) Worker's problem: Guess worker values (U, W) and market tightness, for each age. In the process, store acceptance probabilities $\mu_a^U, \mu_{ai}(q)$ in (6)-(7). Solve search problem using (8) which can be used for the recursion in (9).

(c) SS market clearing: Use (11) and (14) to update worker distribution, and new $l_{ai}(q)$ along with exogenous v to get new $\tilde{g}$ in (12). **Smooth-out kinks for approximation.**

2. Update g, m^U and iterate to convergence. Renormalize $\tilde{g}$ as necessary to be consistent with (13).

Transition: Guess a path for θ_t and numerically solve unemployed workers' problem and workers in new firms by backward induction. Let $t' \equiv t + dt$; Semi-implicit method:

$$\left[r_t + \frac{1}{dt}\right] W_{ai}(q,t) = \frac{1}{dt} W_{ai}(q,t') + w(q,t) h_a z_i - \delta_{ai} \left[W_{ai}(q,t') - U_a(t')\right] + \varphi_a [W_{a+1,i}(q,t') - W_{ai}(q,t')] + \frac{s_{ai}(q,t')(s_{ai}(q,t')/\psi_a)^{1/\psi_1}}{1+\psi_1}$$

for workers that have jumped, but if you haven't jumped:

$$\left[r_t + \frac{1}{dt}\right] \tilde{W}_{ai}(q,t) = \frac{1}{dt} \tilde{W}_{ai}(q,t') + w(q,t) h_a z_i - \delta_{ai} \left[\tilde{W}_{ai}(q,t') - U_a(t')\right] + \varphi_a [\tilde{W}_{a+1,i}(q,t') - \tilde{W}_{ai}(q,t')] + \frac{s_{ai}(q,t')(s_{ai}(q,t')/\psi_a)^{1/\psi_1}}{1+\psi_1} + \alpha(t)[W_{ai}(q,t') - \tilde{W}_{ai}(q,t')].$$

Given worker's solution s, can forward iterate (15) to obtain l's, and obtain the new, updated implied θ_t''s, and iterate to convergence. As a first guess, either just assume θ constant, or, just plug in empirical values of u. Note that we are ruling out v as an equilibrium variable since it is assumed to be exogenous.

9 Conclusion

How does the allocation of workers across plants and firms affect wage growth? And how do labor institutions, barriers to job mobility, and hiring/firing restrictions influence labor (mis)allocations? To tackle those questions we exploit the German Reunification, which abruptly superimposed West German institutions on the East.

Using matched employer-employee matched data, covering the universe of private sector employers, we first document large amounts of reallocation of workers across workplaces in East Germany. This "extra reallocation," compared to West Germany, rapidly de-

clines over time, all but disappearing by 1999. Reallocation was partly due to firm restructuring, but evidence shows that plants also actively swapped their workforce without changing size. These flows strongly correlate with a steep rise in East German wages relative to the West.

To establish evidence on the mechanisms behind the observed reallocation patterns, we exploit cross-cohort variation, which can be interpreted as the length of exposure to communist institutions. The working hypothesis is that upon liberalization of the labor market, worker flows across firms should be largest among older East German cohorts (relative to their western counterparts), reflecting the longer period of time they were unable to leave their firm in search of new jobs and also spared from plants restructuring. This is confirmed in the data, where one observes a strong reallocation-cohort gradient. This gradient exists even when comparing different cohorts within occupations, industries, and even plants. Moreover, it is only pre-existing East German plants that show high levels of job and excess worker reallocation, while newly-founded plants in the East behave almost identically to their Western counterparts.

We next decompose the East-West German wage gap into firm components and worker components, estimated by a wage regression that allows for time-varying firm effects. This is important for capturing German wage dynamics post-reunification. Consistent with the reallocation mechanism patterns, it is the older worker cohorts who gain the most from switching plants. Interestingly, this cannot be explained by directed mobility towards plants with larger pay premia. Instead the wages gains are realized by match specific effects.

Firm effects are almost solely responsible for the closing gap between East and West from 1992 to 1997. Around 55% of the relative growth of firm effects in East Germany is a uniform shift common to all plants. The second most important driver with a contribution of around 30% is a shuffling effect, capturing changes in the joint distribution of pay premia and size among East German firms. Further, shuffling is primarily coming from larger firms increasing their premia, as the size-wage gradient in the East approaches the West German one over time.

Our results strongly suggest that quick reallocation played a large role in East Germans' wage growth, but we did not quantify how much of it was a causal factor. Our empirical estimates up to this point also do not allow for meaningful counterfactuals, describing how the aggregate wage depends on different degrees of barriers to the allocation of workers across firms. In a model that features endogenous on-the-job search and exogenous vacancy frictions between firms, we find that these institutions can explain as much as half of aggregate productivity gains, suggesting that there are additional gains in productivity beyond what is indicated by the data.

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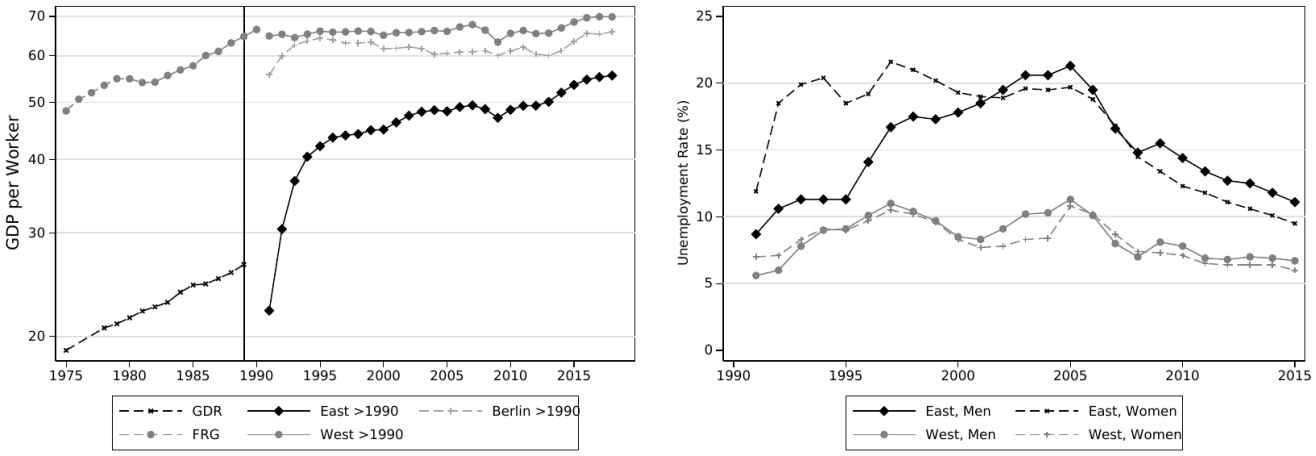
10 Figures

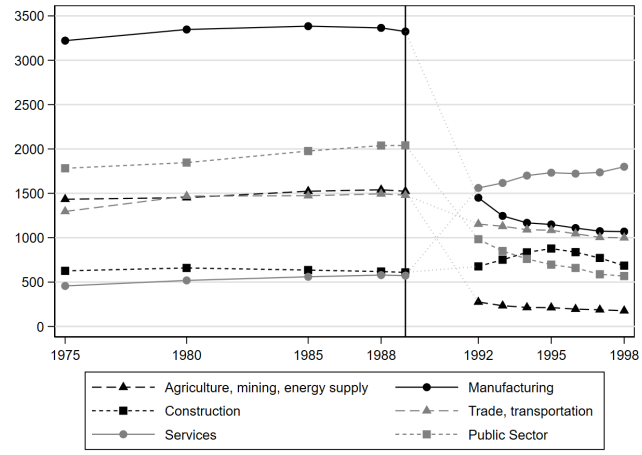


(a) East/West GDP before and after reunification

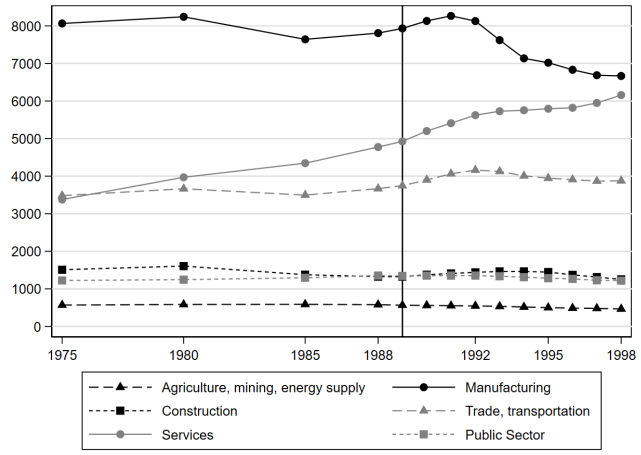
(b) East/West Unemployment by gender

Figure 1: GDP and Unemployment in East and West Germany

GDP per worker in one-thousand 2010 Euros. East includes Berlin. FRG (Federal Republic of Germany): West Germany before reunification. Official statistics do not exist for East Germany prior to 1991 and are based on retrospective accounting. *Source*: GDR GDP per worker from Heske (2009). FRG and East-West Germany GDP from the Federal Statistical Office (Statistisches Bundesamt) and unemployment from the Federal Employment Agency (Bundesagentur für Arbeit).



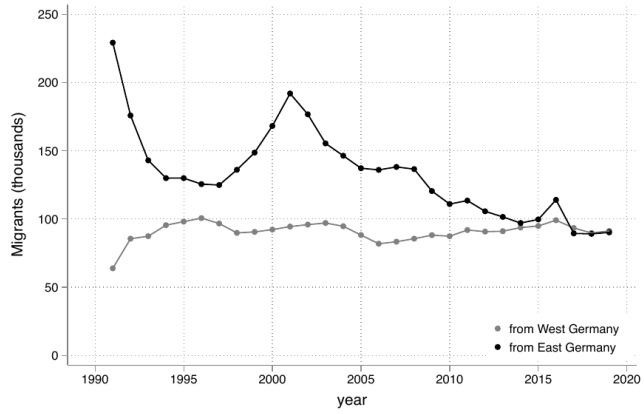
(a) East



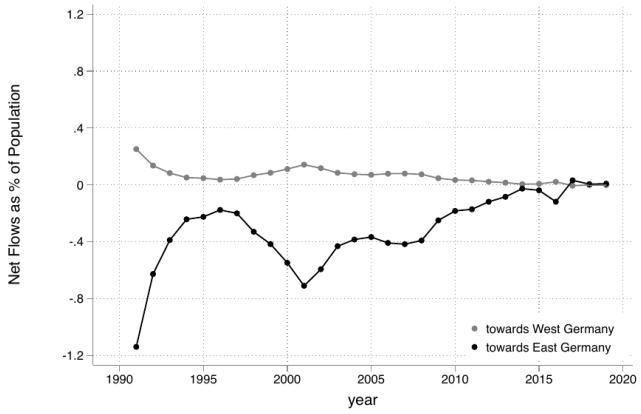
(b) West

Figure 2: Sectoral Employment in East and West Germany

Y-scale in thousands of workers. *Source*: GDR data from Fritz (2000). East from 1992 onward, and West data from IAB.



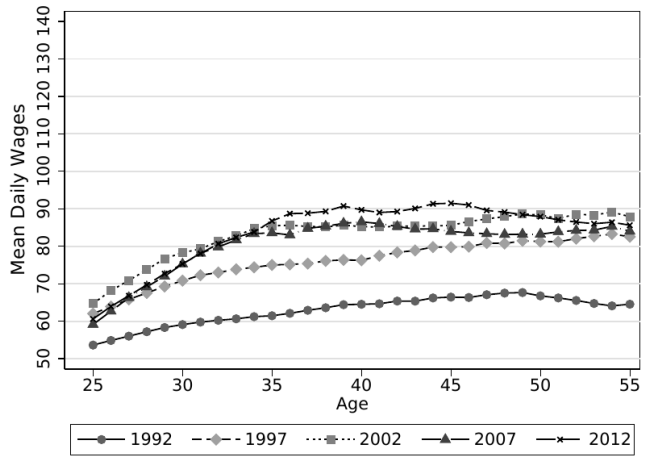
(a) East-West Migration Flows



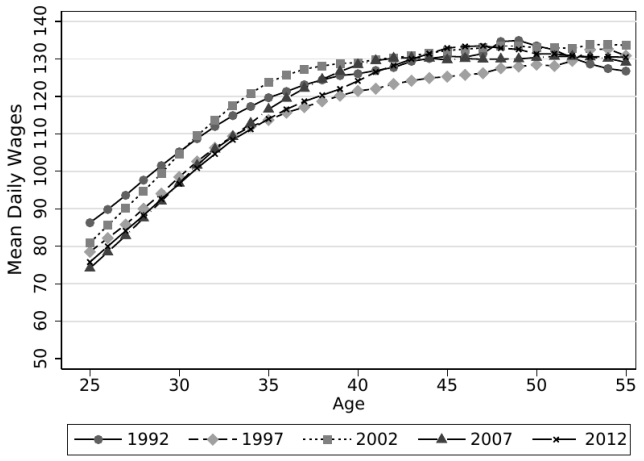
(b) Net Flows as a Percentage of Population

Figure 3: Migration Flows between Regions

Panel (b) shows net flows as a share of the population in the receiving region. *Source*: Federal Statistical Office.



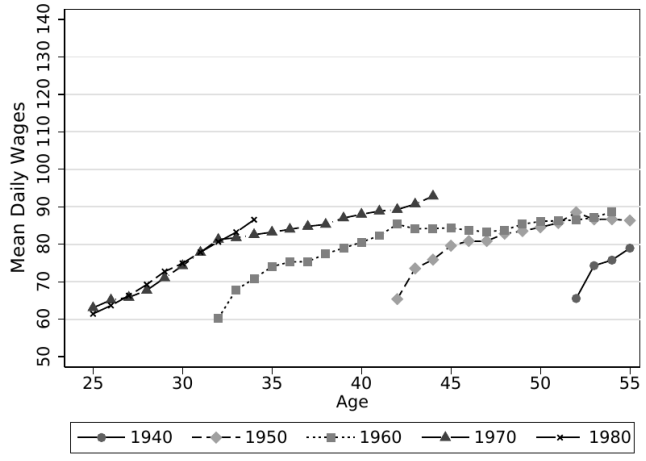
(a) East



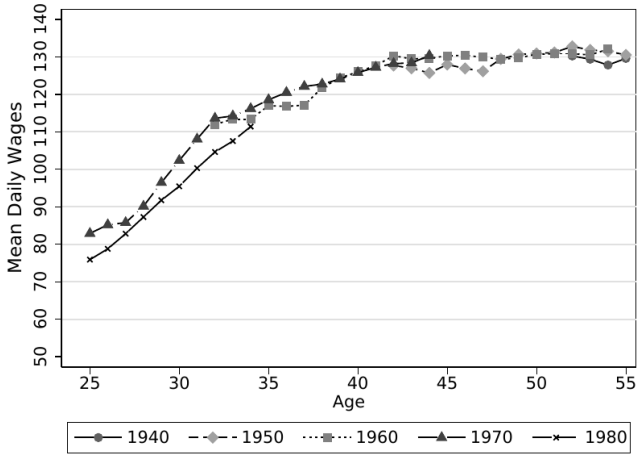
(b) West

Figure 4: Cross-Sectional Wage Profiles

In 2010 Euros. See Appendix Figure 5 for the corresponding age-wage profiles by cohort.



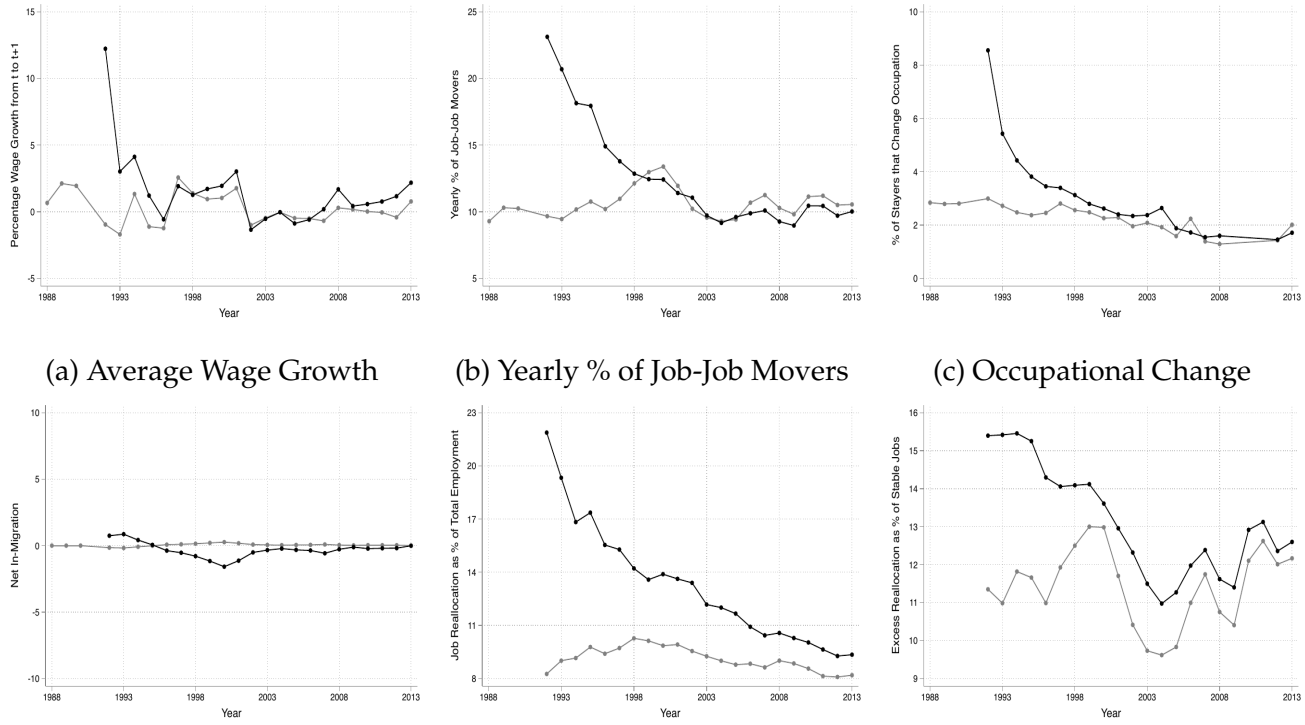
(a) East



(b) West

Figure 5: Age-Wage Profiles by Cohort

In 2010 Euros. See Figure 4 for the corresponding cross-sectional wage profiles.

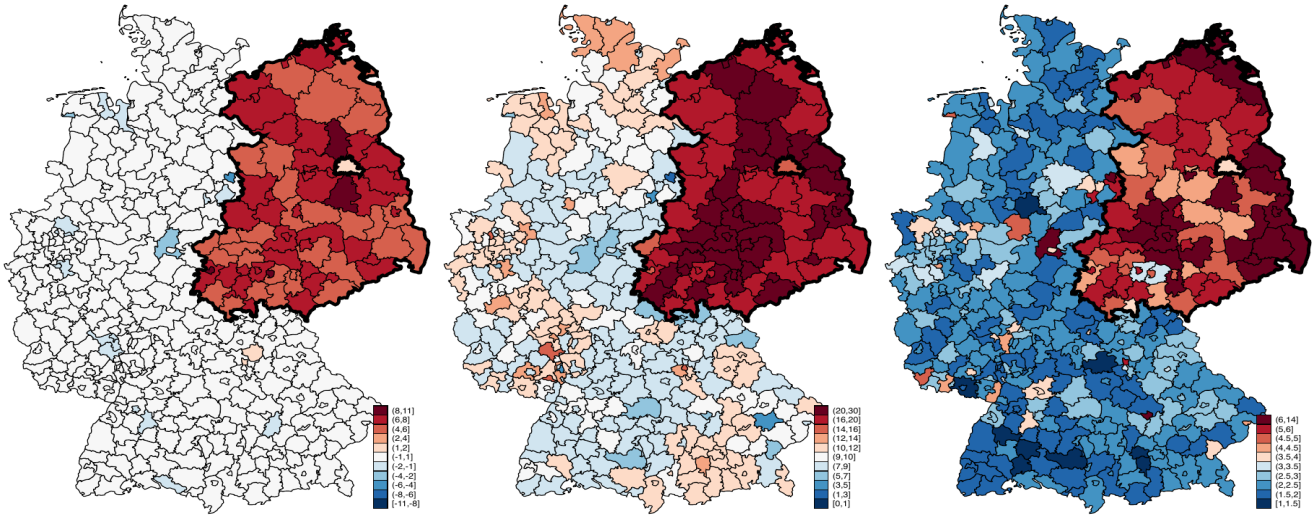


(a) Average Wage Growth (b) Yearly % of Job-Job Movers (c) Occupational Change

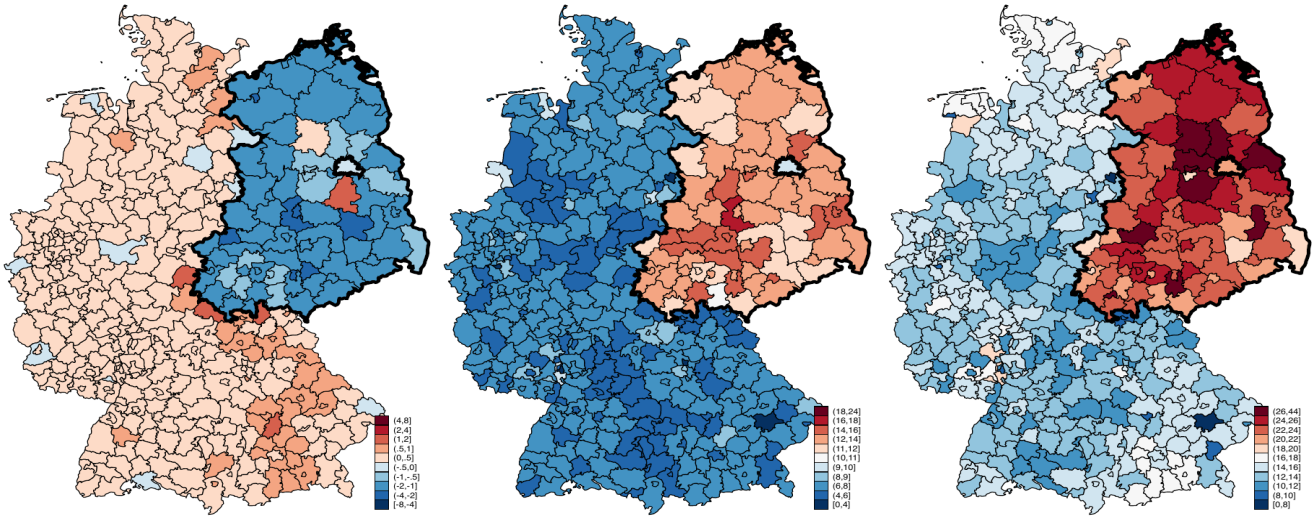
(d) Net Regional Migration (e) Job Reallocation (f) Excess Worker Reallocation

Figure 6: The German Labor Market from 1988 to 2013

Aggregate statistics over time, separately for East and and West Germany in black and gray, respectively. Panel (b) plots the share of job-job movers as a percentage of workers employed in both periods. Panel (c) plots the share of workers who switch occupation, as a percentage of all workers who remain in the same firm. See text for definition of net-migration and job and excess worker reallocation.



(a) Average Wage Growth (b) Yearly % of Job-Job Movers (c) Occupational Change



(d) Net Regional Migration (e) Job Reallocation (f) Excess Worker Reallocation

Figure 7: Germany from 1992 to 1995

Each cell in the map is a German Kreis. Former border of GDR highlighted in bold. Panel (b) plots the share of job-job movers as a percentage of workers employed in both periods. Panel (f) plots the share of workers who switch occupation, as a percentage of all workers who remain in the same firm. See text for definition of job and excess worker reallocation. All statistics are computed between years t and $t+1$ then averaged from $t = 1992$ to 1995.

(a) Average Wage Growth (b) Yearly % of Job-Job Movers (c) Occupational Change

(d) Net Regional Migration (e) Job Reallocation (f) Excess Worker Reallocation

Figure 8: Heterogeneous Effects by Distance to the Former Border

Each dot in the figure is a Kreis. In all panels, x-axis is the distance to the former border. Panel (b) plots the share of job-job movers as a percentage of workers employed in both periods. Panel (f) plots the share of workers who switch occupation, as a percentage of all workers who remain in the same firm. See text for definition of job and excess worker reallocation. All statistics are computed between years t and $t+1$ then averaged from $t = 1992$ to 1995.

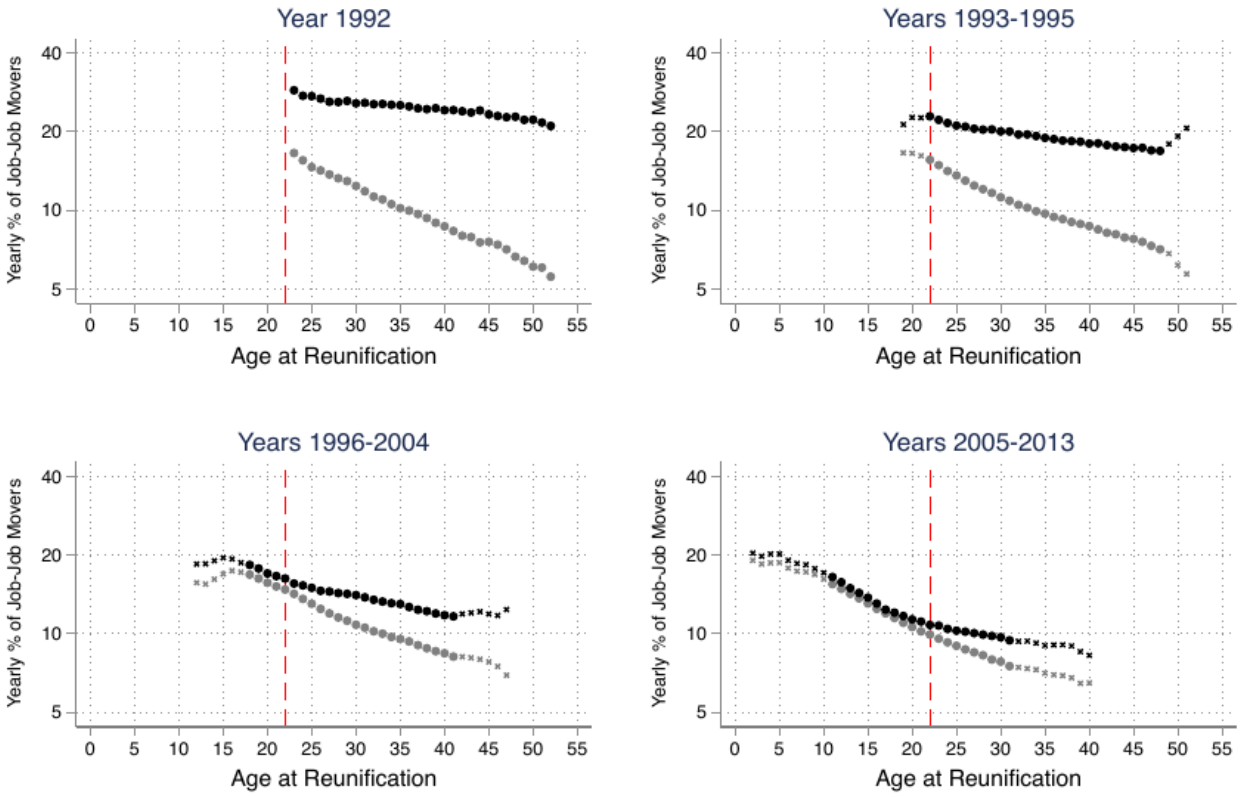


Figure 9: Reallocation of workers by cohort, East vs West

We divide the population by birth-region: black is for East Germany and gray for West Germany. For each cohort, we compute the % of job to job movers between any two years, among workers present in both periods. We then average across different time-periods and plot the % of job to job movers as a function of age at reunification. The cohorts that are in the data for only a subset of the periods are shown with crosses rather than dots. The red dotted line separates the birth-cohorts that entered the labor market before and after the reunification, assuming that, on average, individuals enter the labor market at age 22.

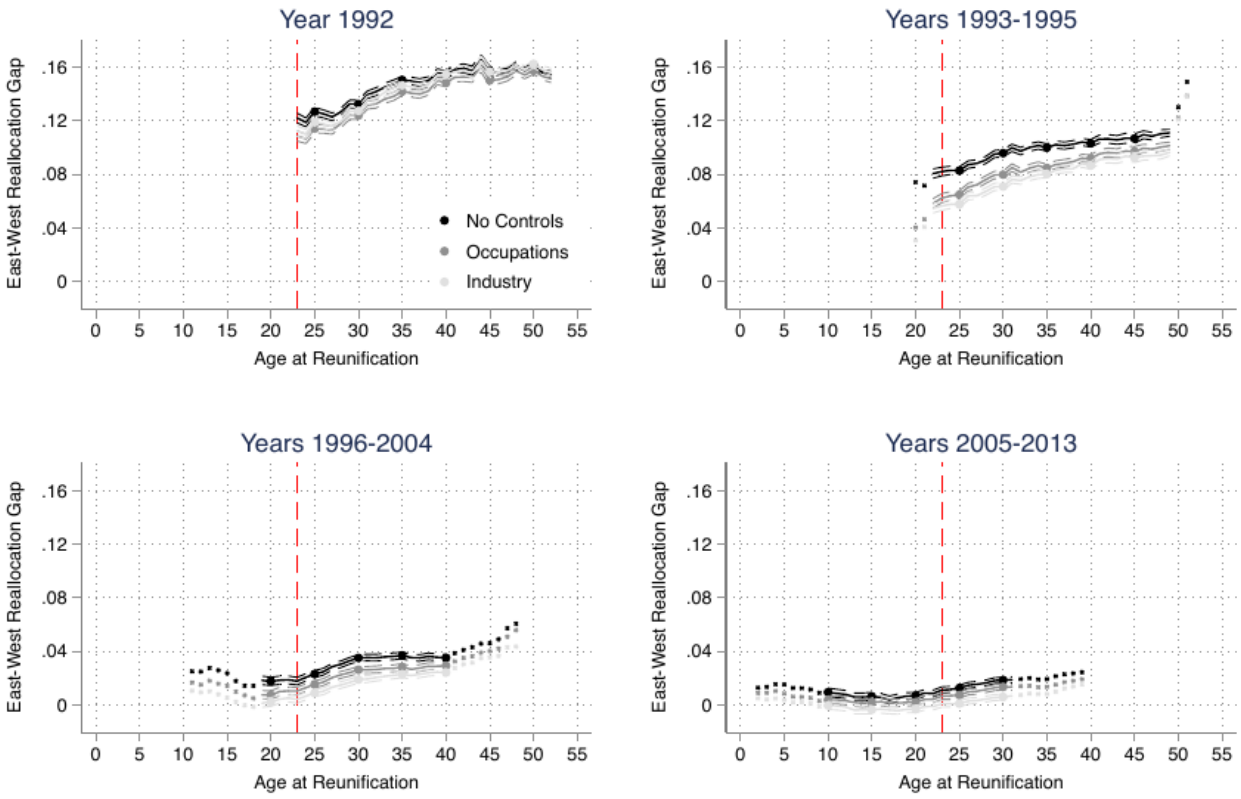


Figure 10: Reallocation of workers by cohort, East-West gap with controls

The figure shows the point estimates from specification 1, together with 90% confidence intervals. In each panel, we take a raw average of the point estimates over different time periods and plot them as a function of the age at reunification of each birth cohort. The cohorts that are in the data for only a subset of the periods are shown with crosses rather than dots. The red dotted line separates the birth-cohorts that entered the labor market before and after the reunification, assuming that, on average, individuals enter the labor market at age 22.

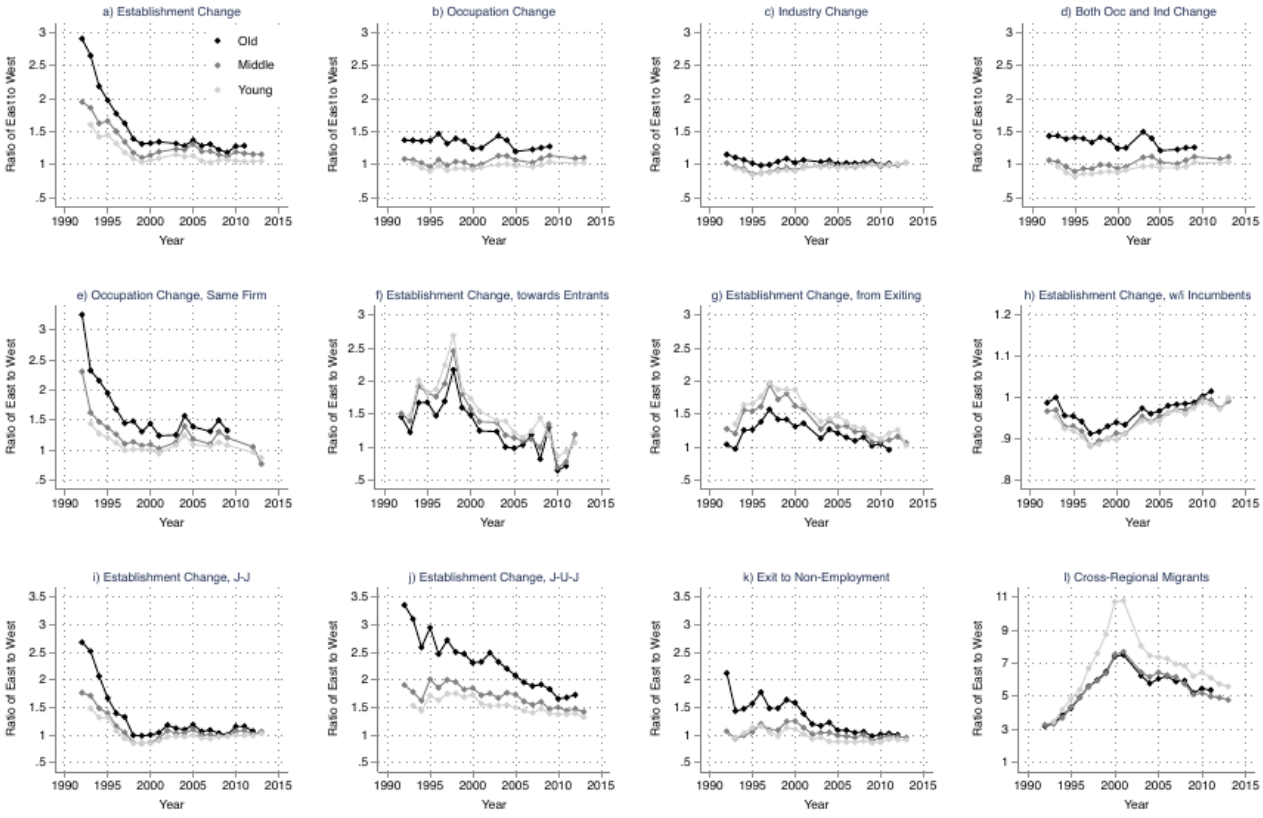


Figure 11: Unpacking Labor Mobility, East-West Comparison

The figure plots the ratios of several mobility statistics computed for East and West Germans and separately for three groups of cohorts: old (1937-1957), middle (1958-1967), and young (1968-1988). The 12 panels show: (a) share of workers present in both years that change their establishments; (b-d) share of workers, conditional on. changing establishment, that switch: their occupation, their industry, both their industry and occupation; (e) share of workers, among those staying in the same establishment that change their occupation; (f-h) share of workers, among those changing establishment within region, that move towards a just entered establishment, that move away from an establishment closing down, that move between incumbents; (i-j) share of workers present in both years that change establishment without and with a non-employment spell; (k) share of workers, among those employed in the first period, that exit to non-employment; (l) share of workers present in both periods that migrate across the former border. Statistics (i), (j), and (k) are computed using the 30% dataset that provides daily information on worker's status, as explained in Section 3.

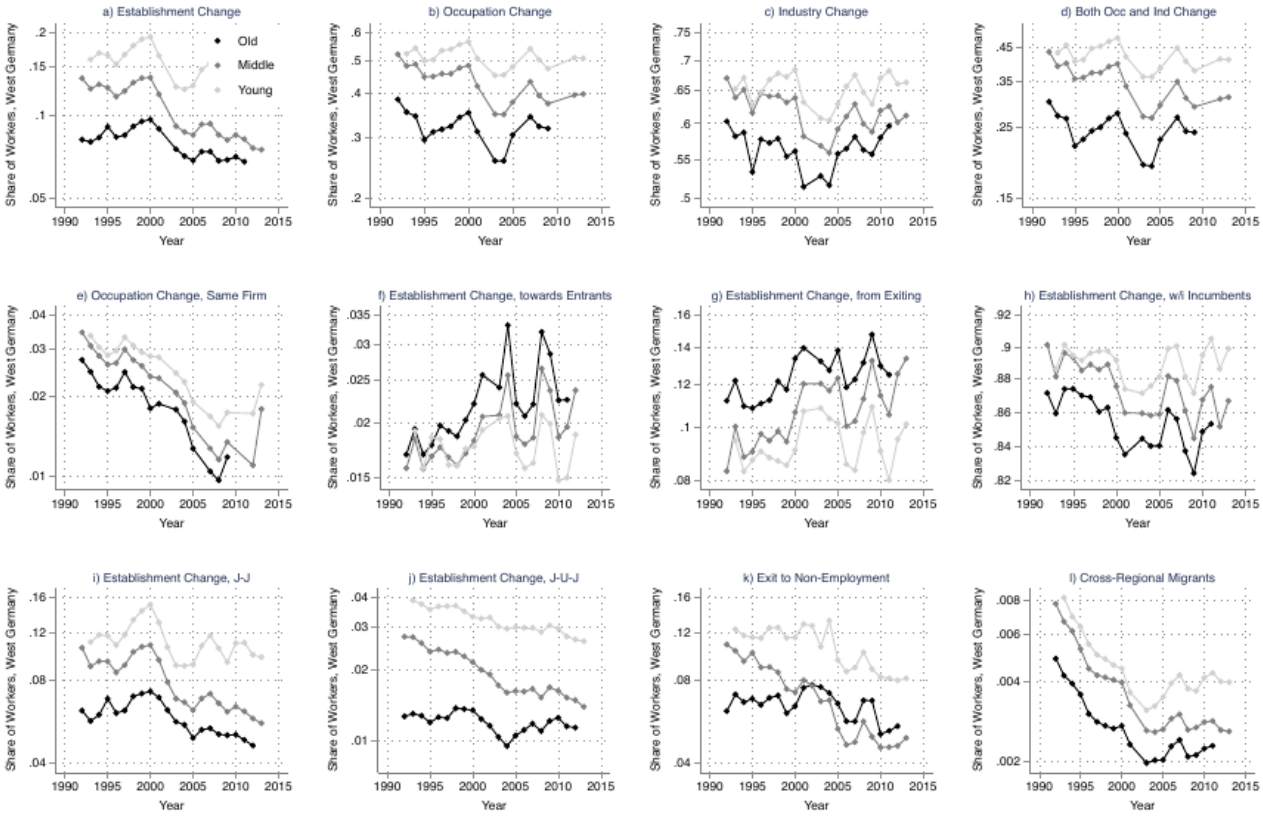


Figure 12: Unpacking Labor Mobility, West Germans

The figure shows the same twelve statistics described in the footnote of Figure 11 computed for West Germans only. The y-axis are in log scale.

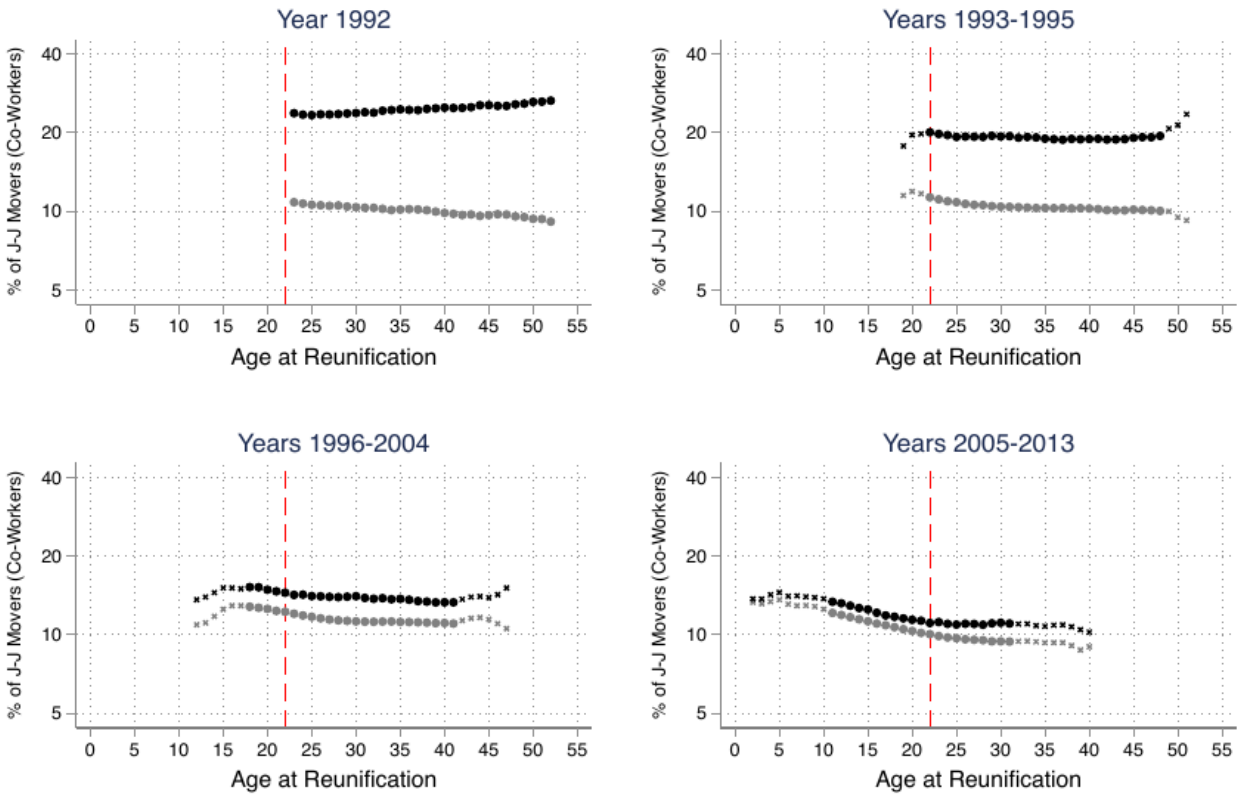


Figure 13: Reallocation of co-workers by cohort, East vs West

For each cohort and year, we compute the % of job to job movers among the workers that are employed in their same establishment and that are from different cohorts. We then average across different time-periods and plot the % of job to job movers as a function of age at reunification. The red dotted line separates the birth-cohorts that entered the labor market before and after the reunification, assuming that, on average, individuals enter the labor market at age 22.

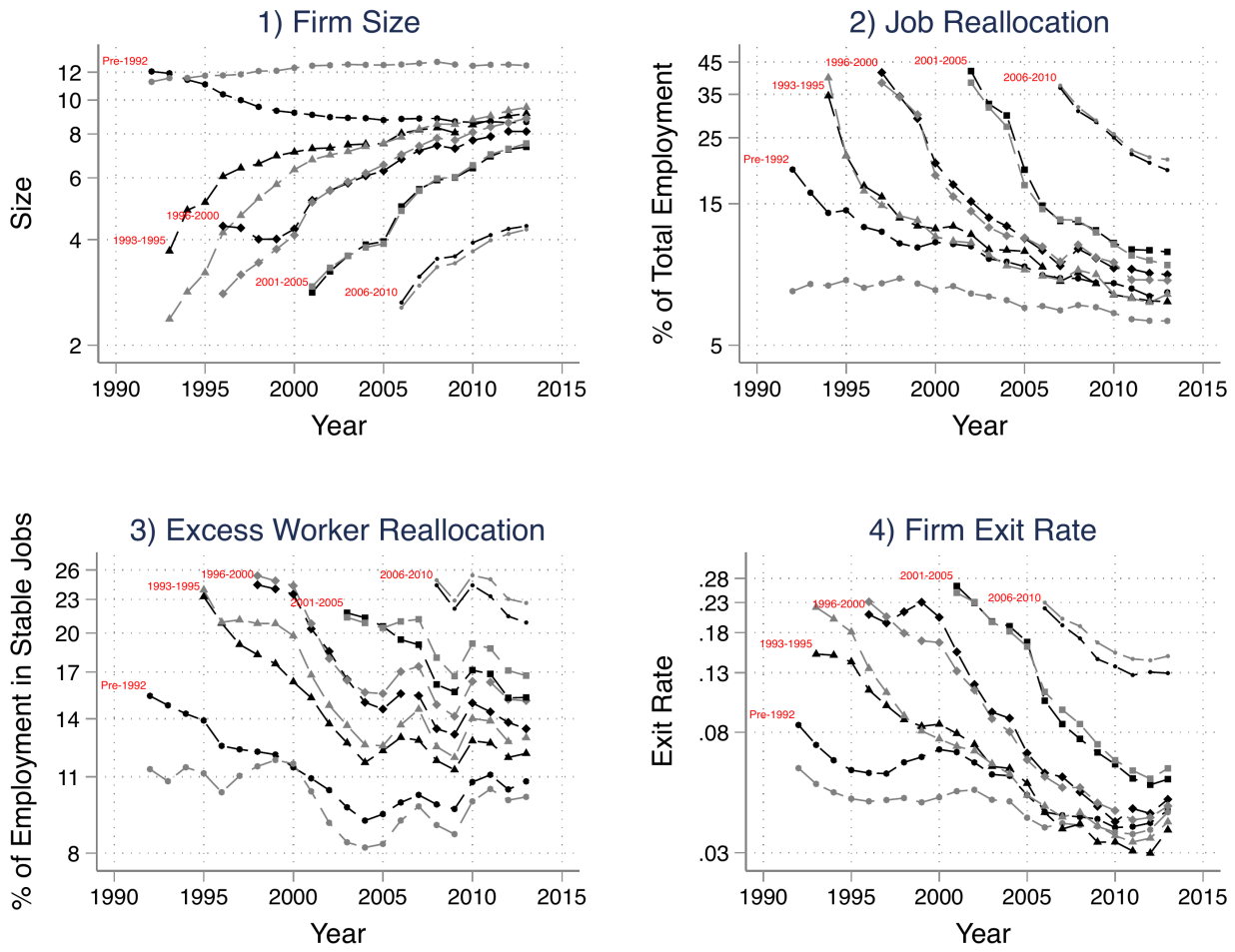


Figure 14: Heterogeneity by Firm Cohort

The figure shows four statistics calculated over time, separately for East and West-German firms, and for cohorts of firms that entered in five different time periods: i. before 1992, ii. between 1993 and 1995, iii. 1996-2000; iv. 2001-2005; v. 2006-2010. As usual, East is in black and West in gray. Cohorts of firms only appear in the figure after their entry time. For example, the cohort group iv. only appears in 2001. The four statistics are as follows: average firm size in the top-left panel; total net flows (computed as the sum of changes in firm sizes) as a share of total employment of all the active firms in that cohort in the top-right panel; total gross flows (computed as the sum of all new hires and fires) as a share of total firm employment in the bottom-left panel; and firm exit rate in the bottom-right panel.

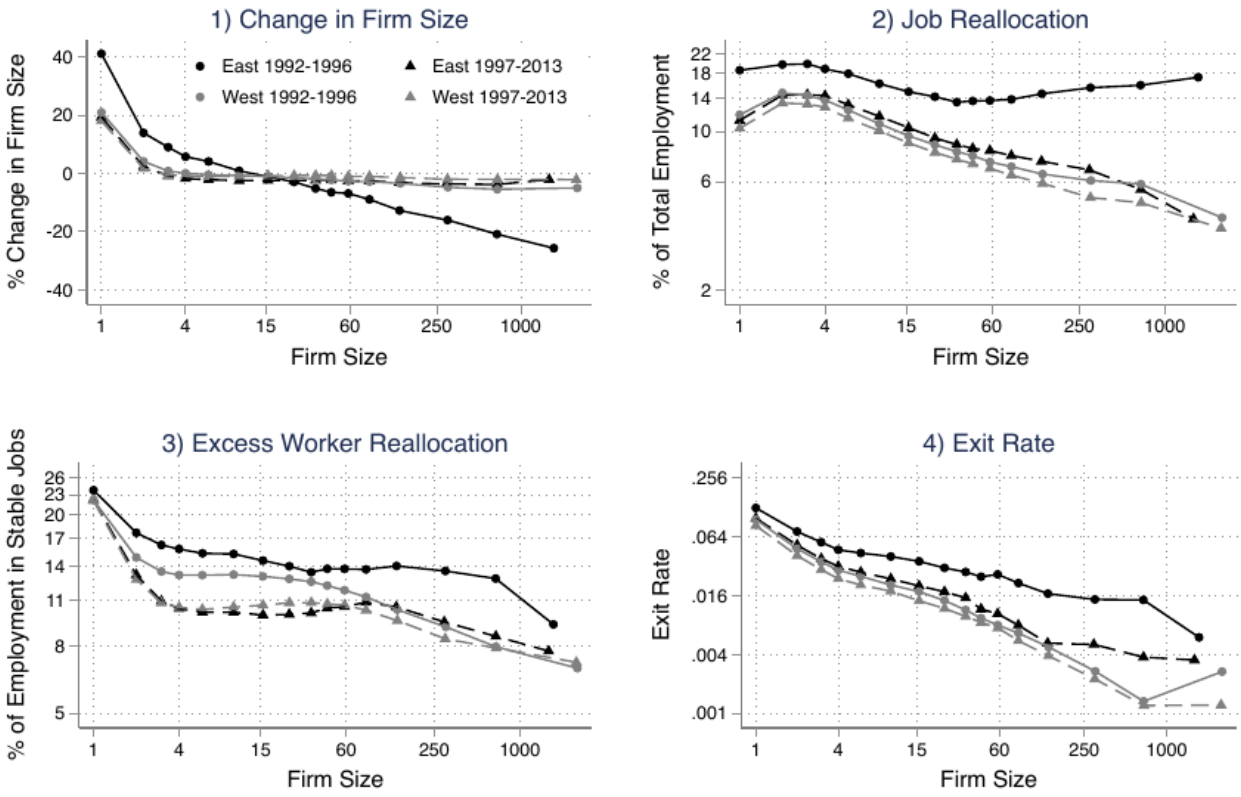


Figure 15: Heterogeneity by Firm Size, Cohorts pre-1992

The figure shows four statistics as a function of firm size, separately for East and West-German firms and for two time periods. The top-left panel shows the percentage change in firm size, computed as the overall decline in employment divided by the total employment (within the firms of that size group) at the previous year. The top-right and bottom-left panels show the total Jobs Reallocation and Excess Workers Reallocation, computed as explained in the text. Last, the bottom-right panel shows the exit rate calculated as the share of firms not present in the year after. All statistics are averaged over the relevant years: 1992 to 1996 for the solid lines, and 1997 to 2013 for the dotted ones. The figure is calculated using only firms already present in our dataset in the year 1992.

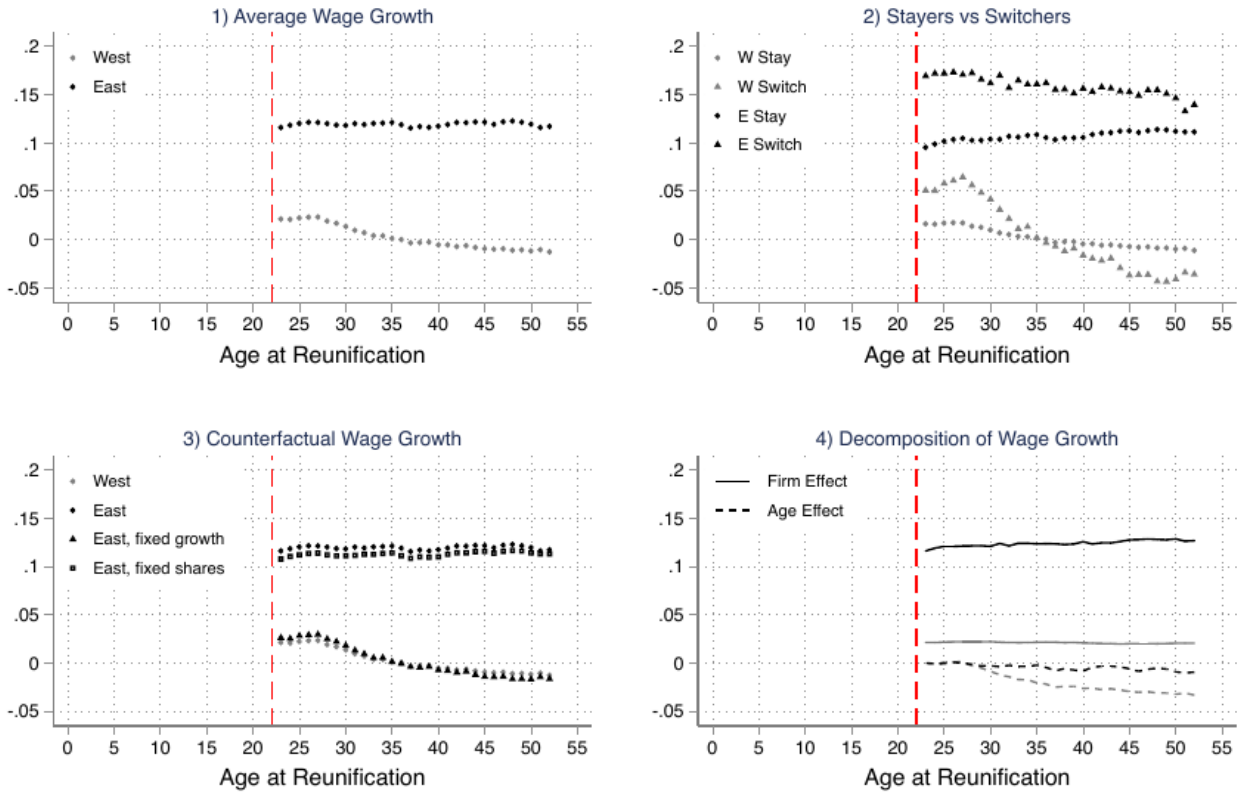


Figure 16: Wage Growth by Cohort in Year = 1992

For each cohort and for each year, we restrict the sample to workers that have positive earnings in our data in both 1992 and 1993, and we compute the wage growth between these two years. We then plot the wage growth as a function of age in 1990. The red dotted line separates the birth-cohorts that entered the labor market before and after the reunification, assuming that, on average, individuals enter the labor market at age 22. The top left panel shows the overall average wage growth. The top right panel distinguishes between workers that are employed in both periods at the same firm and those that change plant. The bottom left panel compares the overall wage growth with two counterfactuals described in the text. The bottom right panel decomposes the overall wage growth into firm and age effects.

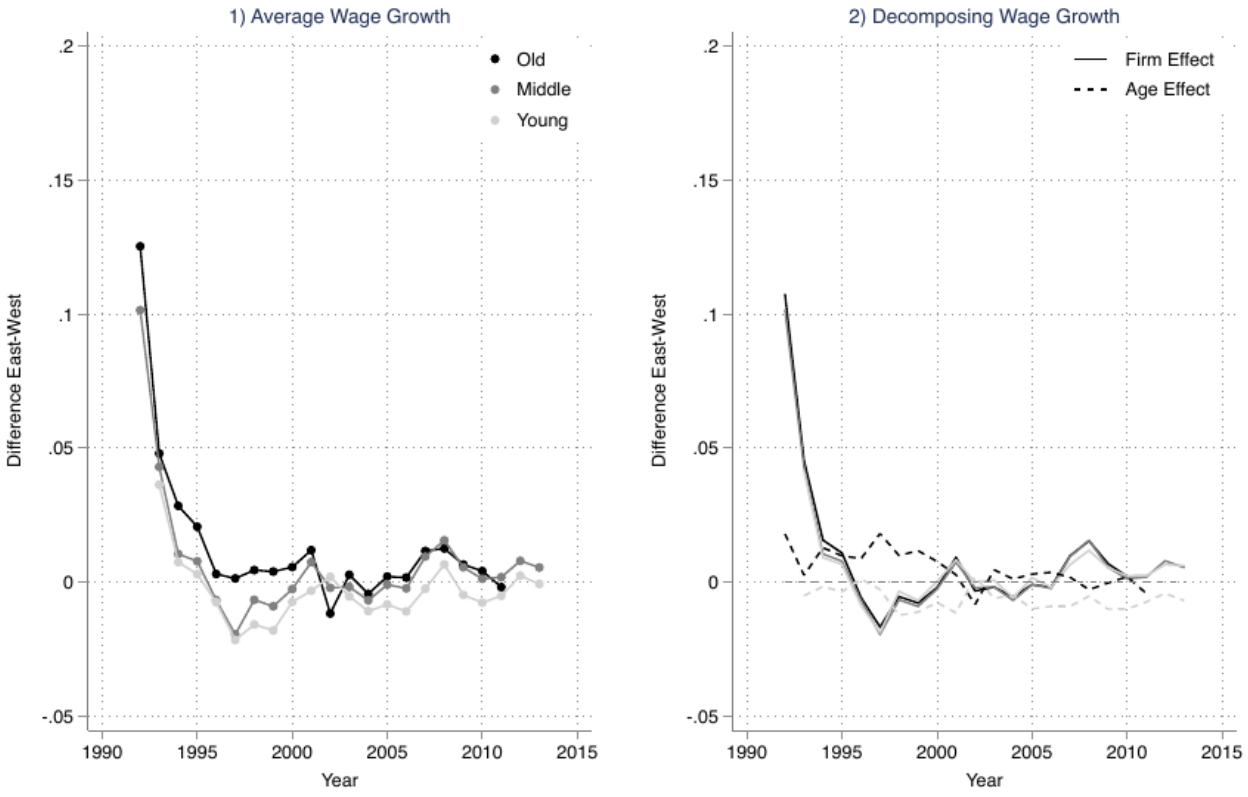


Figure 17: Wage Growth by Cohort, Difference between East and West over time

The figure shows the difference between the wage growth of East-born and West-born individuals over time. Before calculating the wage growth, we divide the individuals into three groups of cohorts, old (1937-1957), middle (1958-1967), and young (1968-1988). The left panel shows overall wage growth, while the right one distinguishes between growth coming from age and firm effects. Since the level of the age effects is not identified, we normalize it to zero in each year for the middle cohorts.

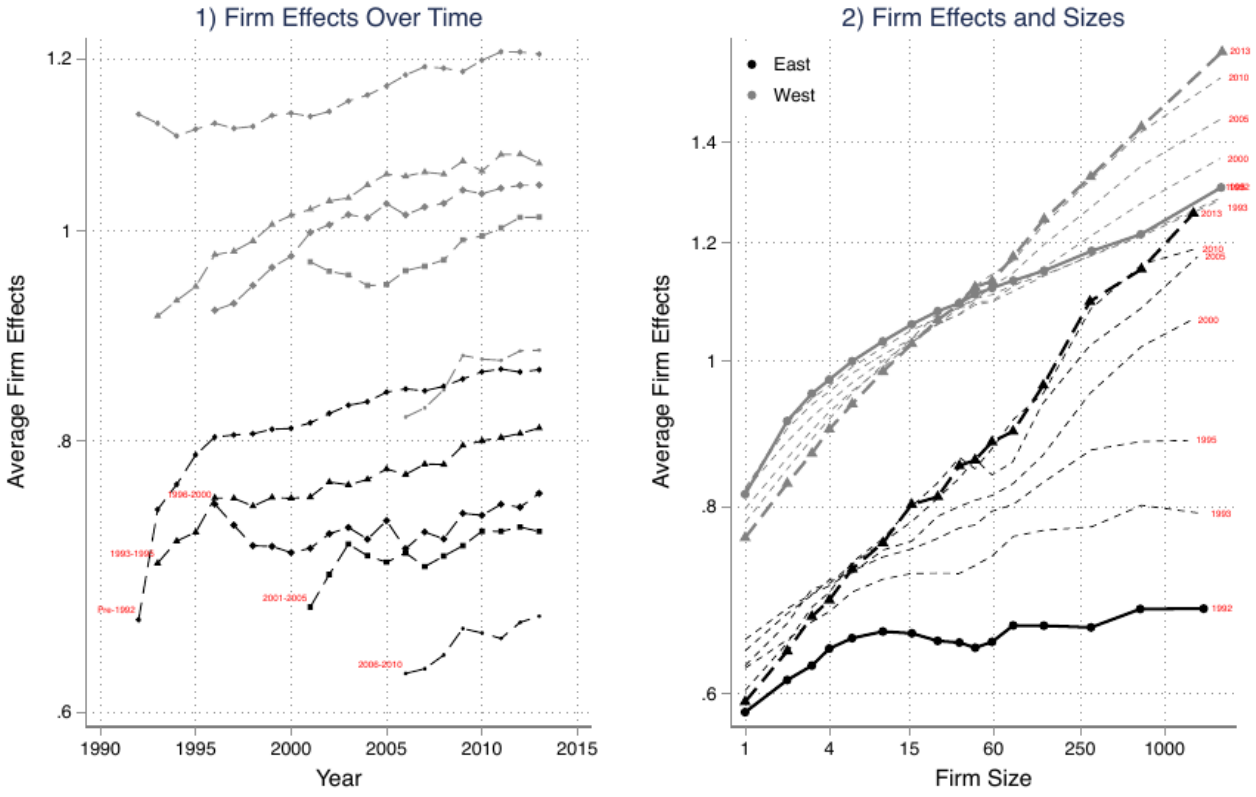


Figure 18: Firm Effects Over Time and by Firm Size

The left panel shows the average firm effect (θ) over time for firms of different cohorts and separately for East and West Germany. The right panel shows the average firm effect by firm size. We divide the firm size distribution into 16 bins, as described in the text, and for each bin we compute the average size and firm effect, separately for East and West Germany and by year. We then plot the relationships between firm effects and sizes.

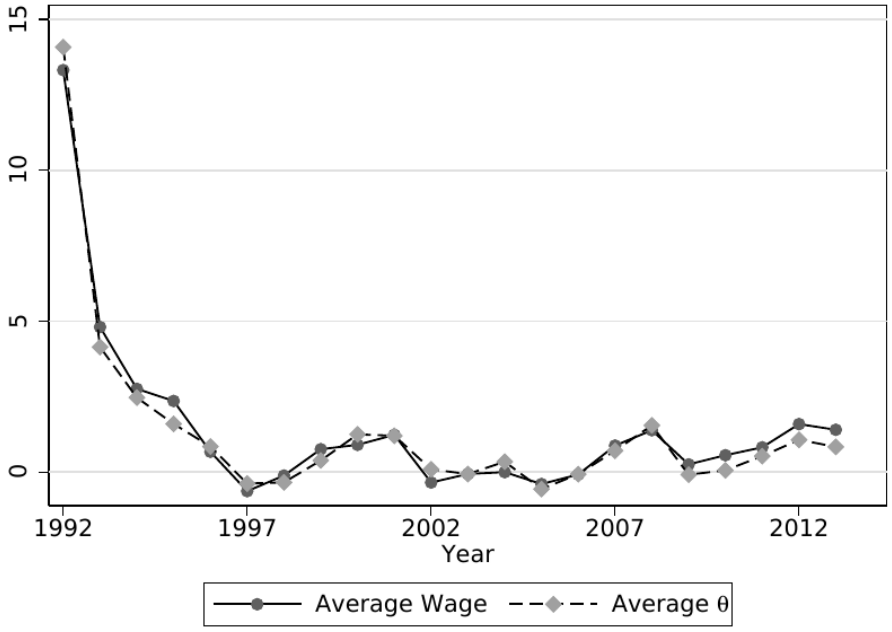
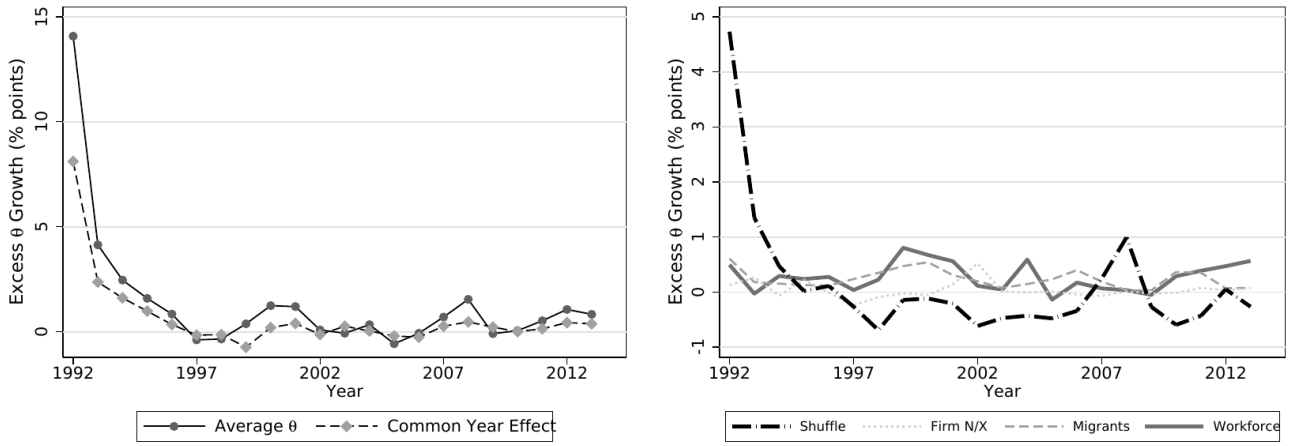


Figure 19: Extra Growth Decomposition of Average East-West Wages

In percentage points. Extra growth is defined as the annual growth rate of average East German wages subtracted by its West German counterpart. See text for definition of θ, the firm effect.

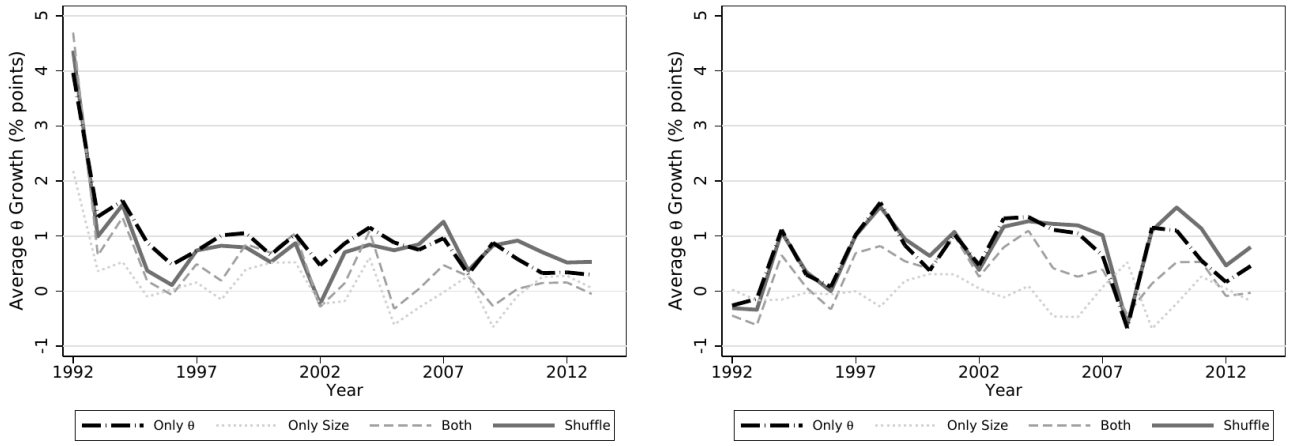


(a) Common Year Effect

(b) All Other Components

Figure 20: Extra Growth Decomposition of Average Firm Effects

In percentage points. Extra growth is defined as the annual growth rate of average East German wages subtracted by its West German counterpart. See text for definition of θ, and each of the subcomponents.



(a) East

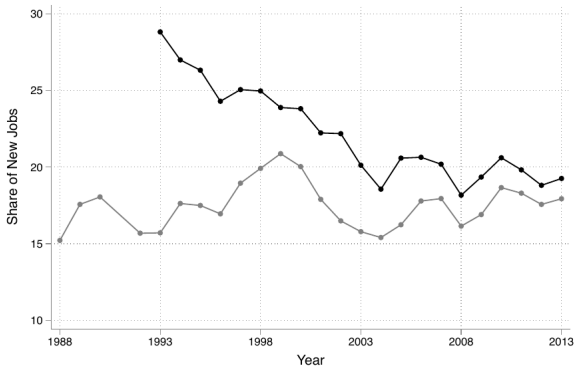
(b) West

Figure 21: Decomposition of Average θ Growth by size and θ-distribution(s)

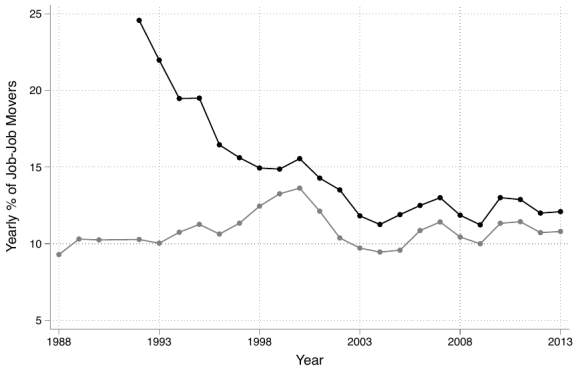
In percentage points. "Only θ" plots the growth rate of θ when the size distribution of firms is held constant from one year to the next. "Only Size" keeps the θ-distribution constant. The difference between "Both" and "Shuffle" is that the former includes workers who may cross the former border, or enter or exit our sample, from one year to the next. See text for definition of the firm effect, θ.

Appendices

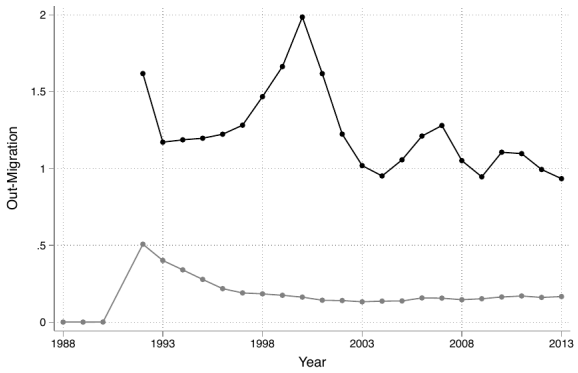
A Additional Figures



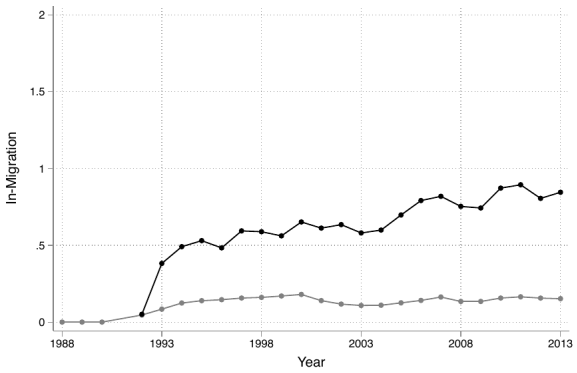
(a) Share of New Jobs



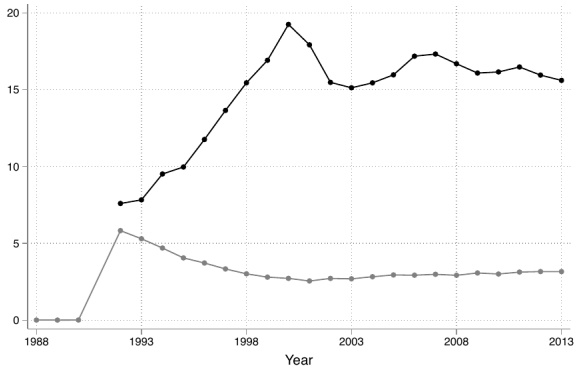
(b) % of Job-Job Movers, by Birth



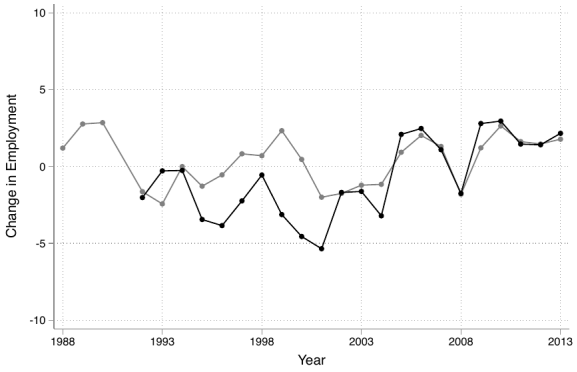
(c) Out Migration, by Birth



(d) Return Migration, by Birth



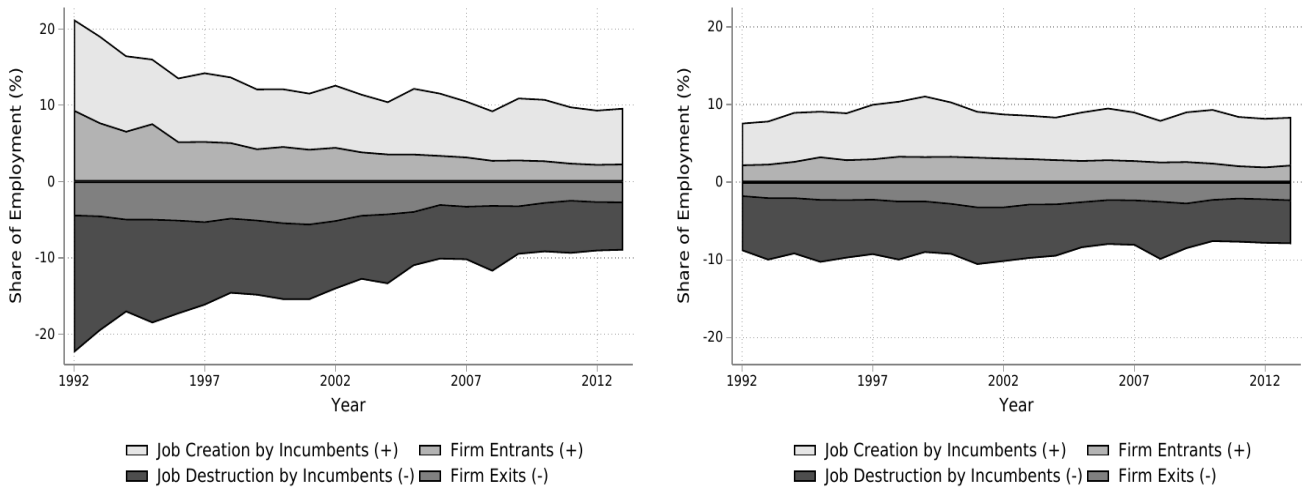
(e) Migrants Share of Job Movers, by birth



(f) % Change in Total Employment

Figure A1: The German Labor Market from 1988 to 2013

Aggregate statistics over time, separately for East and West Germany in black and gray, respectively. In Panel (a), new jobs are defined as jobs filled by a new worker (coming out of employment or from another establishment). Panel (b) plots the share of job-job movers as a percentage of workers employed in both periods, where we divide workers by their region of birth. Panel (c) shows the share of workers that move out of their birth-region. Panel (d) shows the share of workers that return to their birth-region. Panel (e) shows the share of job moves that involve crossing the former East-West border, by birth-region. Panel (f) shows the change in the total number of employed workers between two consecutive years.



(a) East

(b) West

Figure A2: Breakdown of Job Reallocation

Job reallocation is separated into job creation by incumbents and firm entrants, and job destruction by incumbents and firm exits, separately for East and West Germany. Job creation is shown as a positive percentage of employment in year $t+1$, and job destruction as a negative percentage of employment in year t.

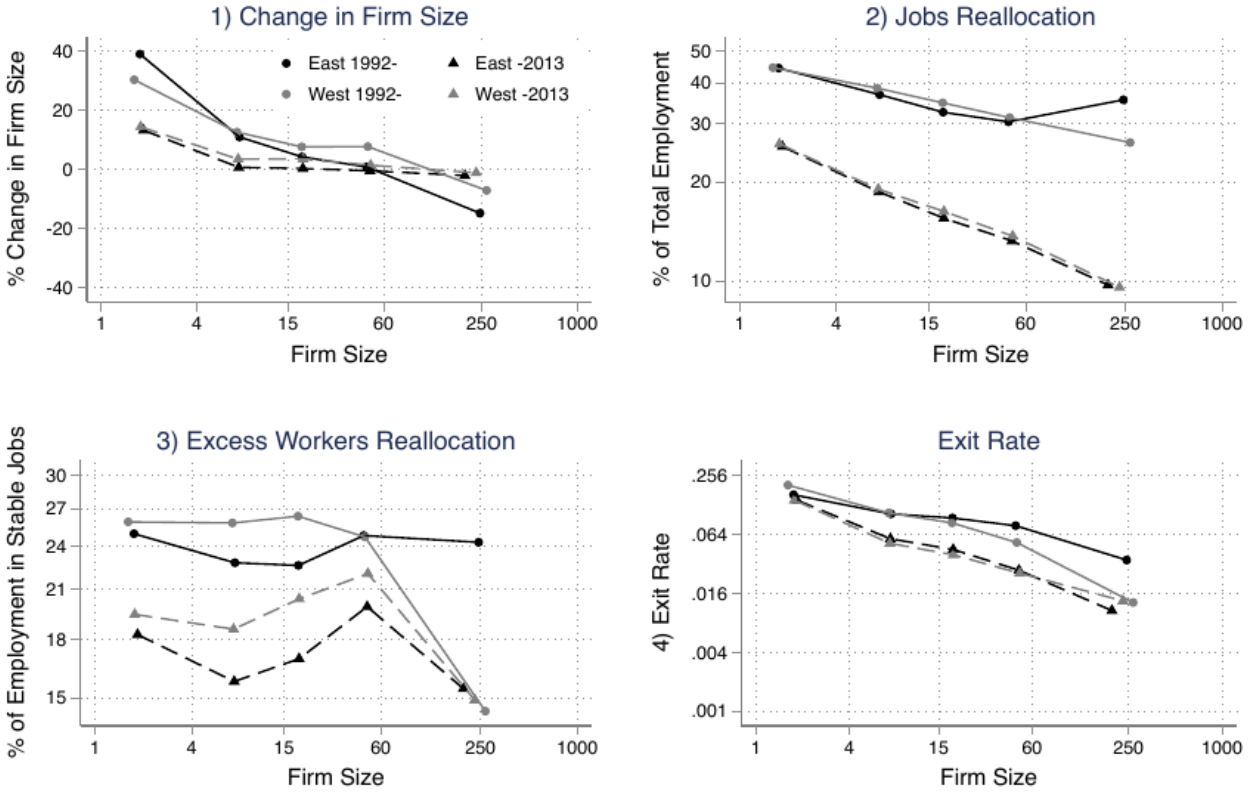


Figure A3: Heterogeneity by Firm Size, Cohorts post-1992

The figure includes the same statistics as Figure 15, but calculated for firms that entered our dataset after 1992.

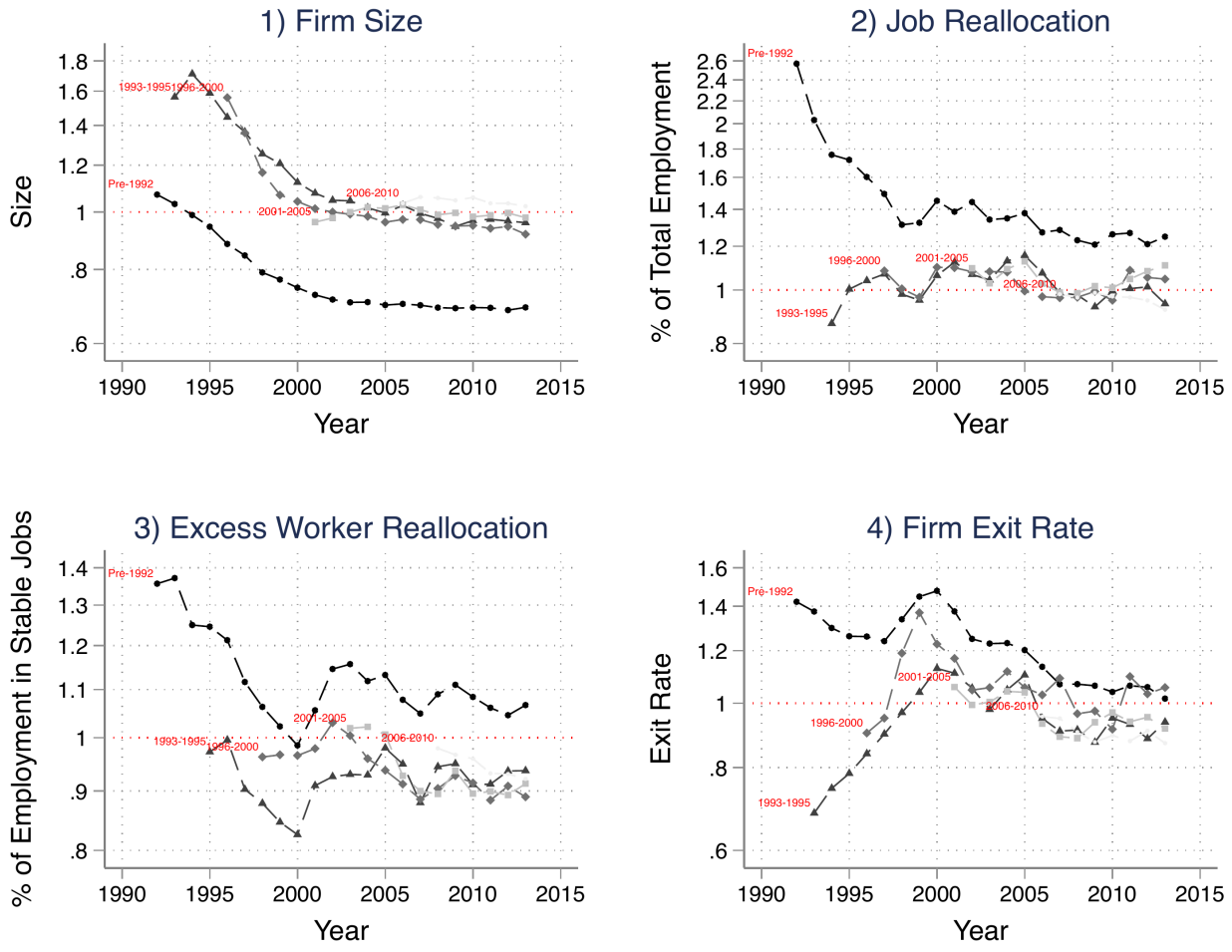
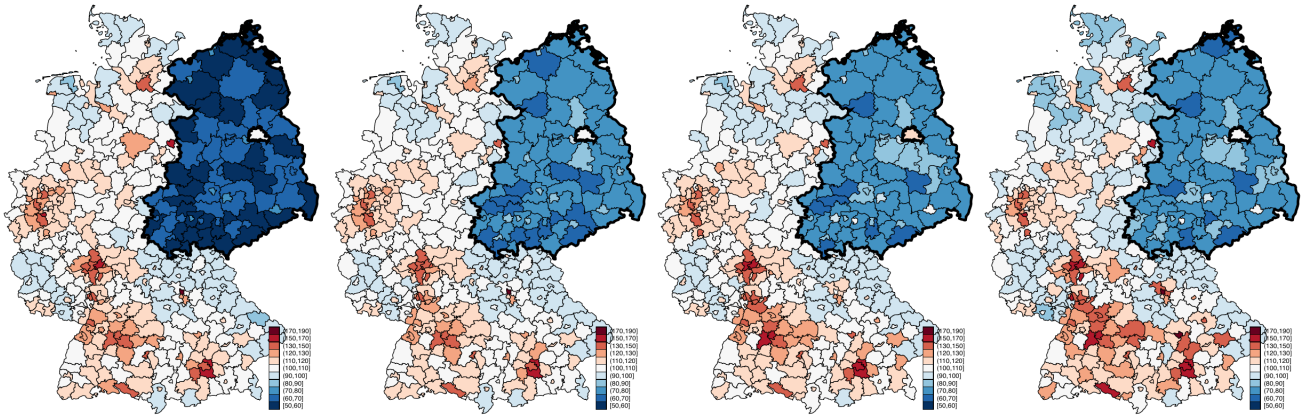


Figure A4: Heterogeneity by Firm Cohort, Gap East-West

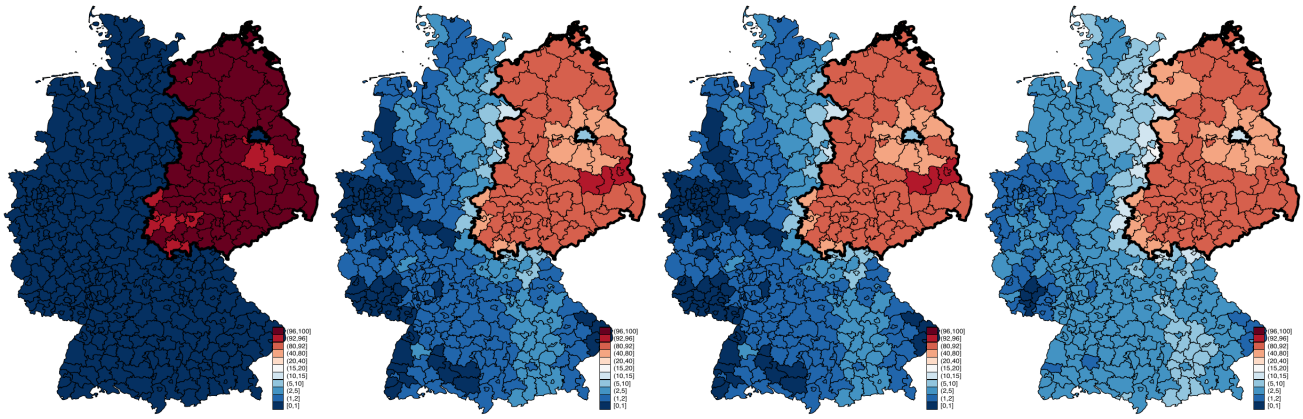
This figure shows the same data of Figure 14, but taking the ratio between the statistics computed for the East and West German firms.



(a) 1992 (b) 1995 (c) 2000 (d) 2014

Figure A5: Average wage heatmap over time

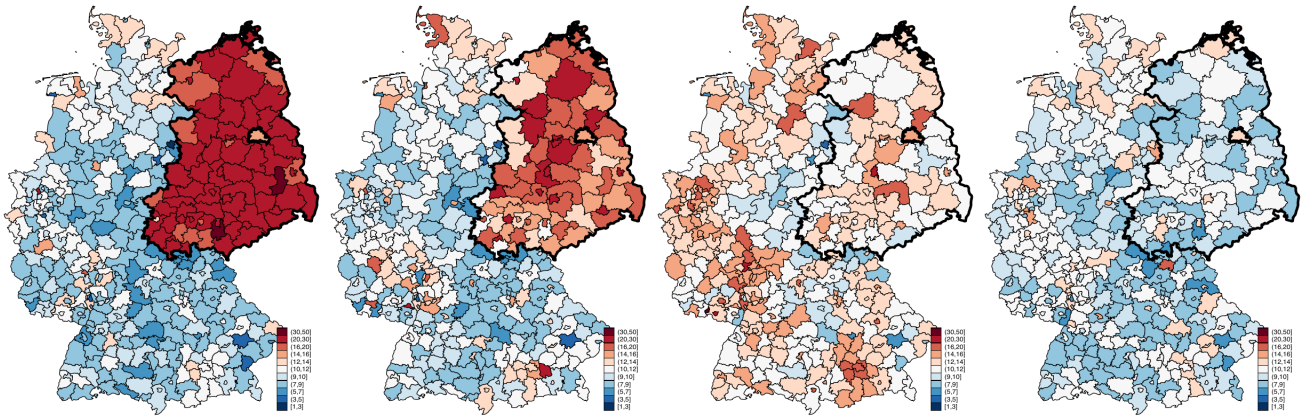
All wages are deflated to 2010 Euros. White represents the national average, and red and blue represent, respectively, higher and lower than the national average. There is barely any catchup post 1995, and a hard border still exists in 2014.



(a) 1992 (b) 1995 (c) 2000 (d) 2014

Figure A6: % of East-Born over time

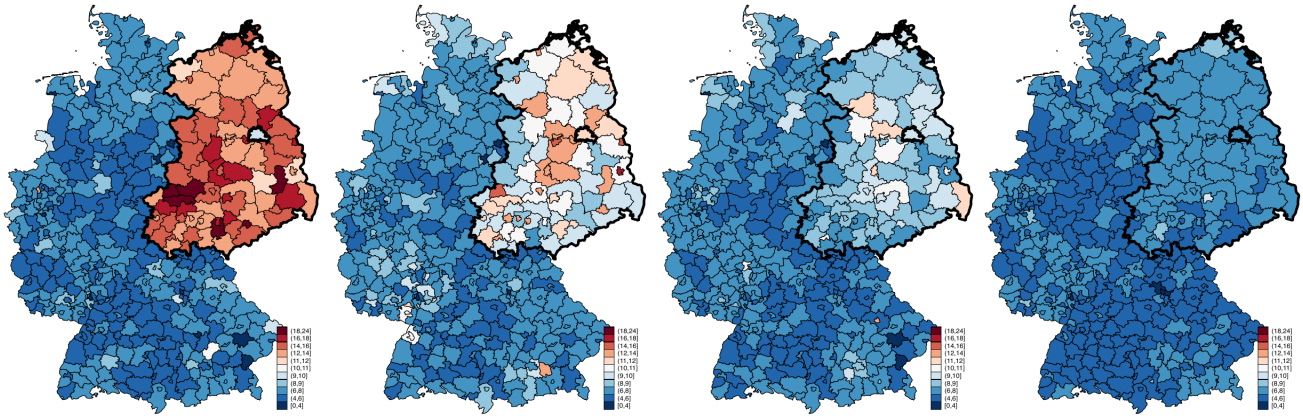
Origin is proxied by place of first appearance. For each Germany county, we compute the fraction of workers that were born in the East. White represents the national average (15%-20%). Note that migration flows are slow, and larger at the border.



(a) 1992 (b) 1995 (c) 2000 (d) 2014

Figure A7: % of Job-Job movers

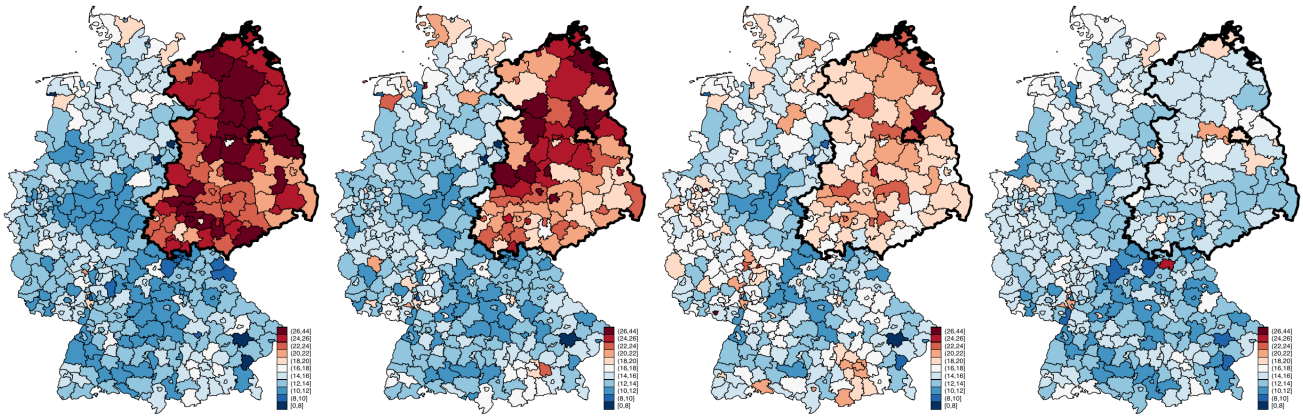
For each county, we compute the fraction of workers who switch firms *within* East or *within* West Germany. That is, we do not count workers who move to firms across the former border.



(a) 1992 (b) 1995 (c) 2000 (d) 2014

Figure A8: Job Reallocation

For each county, we compute the job reallocation, as defined in the text. We then plot job reallocation on the map, where red signals high and blue low job reallocation.



(a) 1992 (b) 1995 (c) 2000 (d) 2014

Figure A9: Excess Worker Reallocation

For each county, we compute the excess worker reallocation, as defined in the text. We then plot job reallocation on the map, where red signals high and blue low job reallocation.

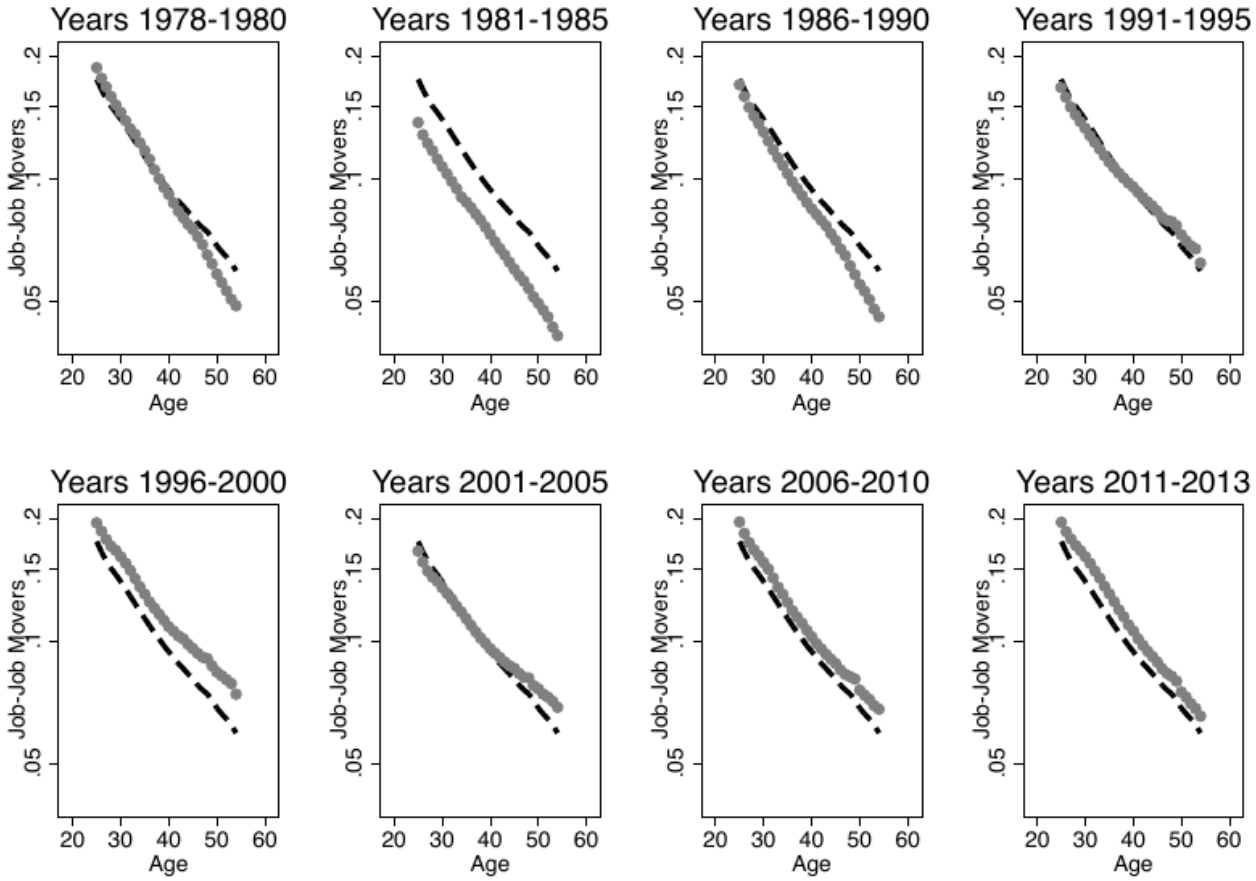


Figure A10: Job-job movers over time in West Germany

The thick dashed lines represent the average job transition rates by cohort for the entire sample period from 1978-2013. The gray dotted lines show the transition rates for each corresponding period. Transition rates display the same slope by age over time, and the patterns are consistent with the entire profile fluctuating around a long-run steady state.

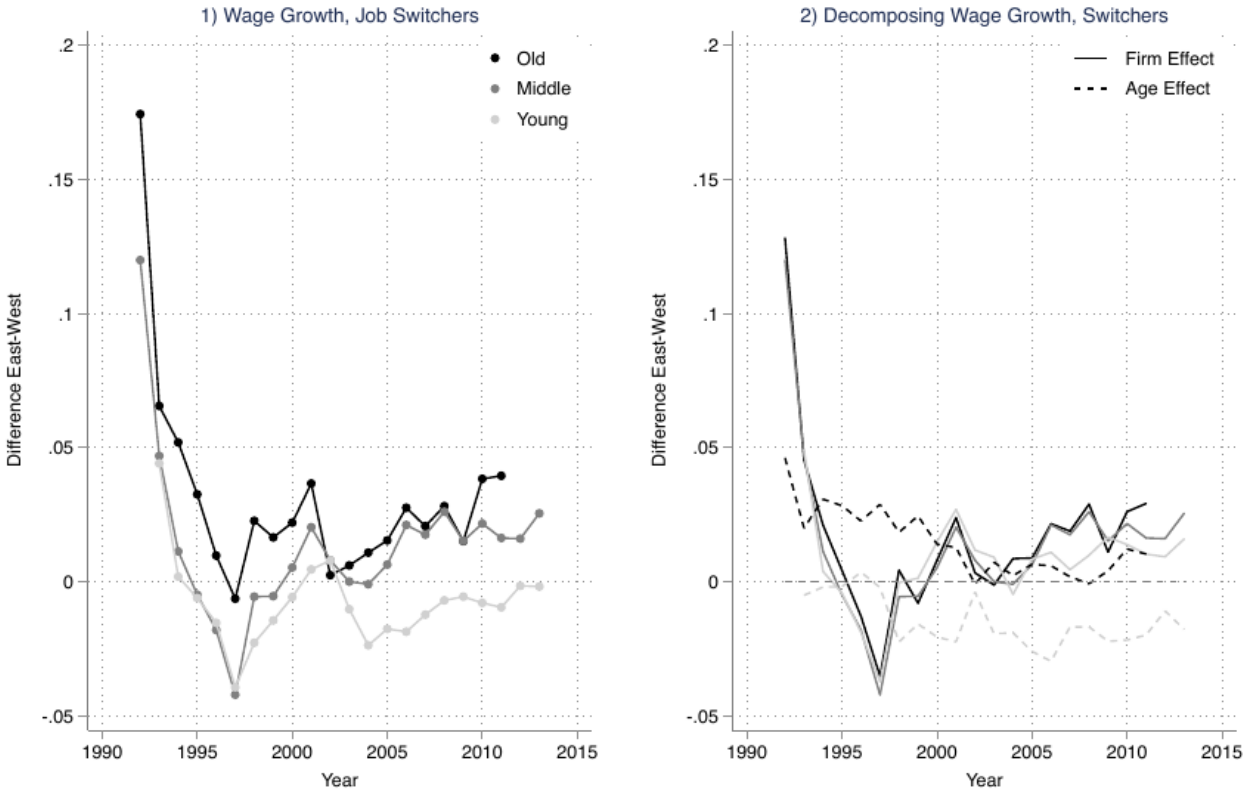


Figure A11: Wage Growth by Cohort for Switchers, Difference between East and West over time
The figure shows the difference between the wage growth of East-born and West-born individuals over time for the sample of workers that switch establishment. Before calculating the wage growth, we restrict the sample to job switchers and divide the individuals into three groups of cohorts, old (1937-1957), middle (1958-1967), and young (1968-1988). The left panel shows overall wage growth, while the right one distinguishes between growth coming from age and firm effects. Since the level of the age effects is not identified, we normalize it to zero in each year for the middle cohorts.

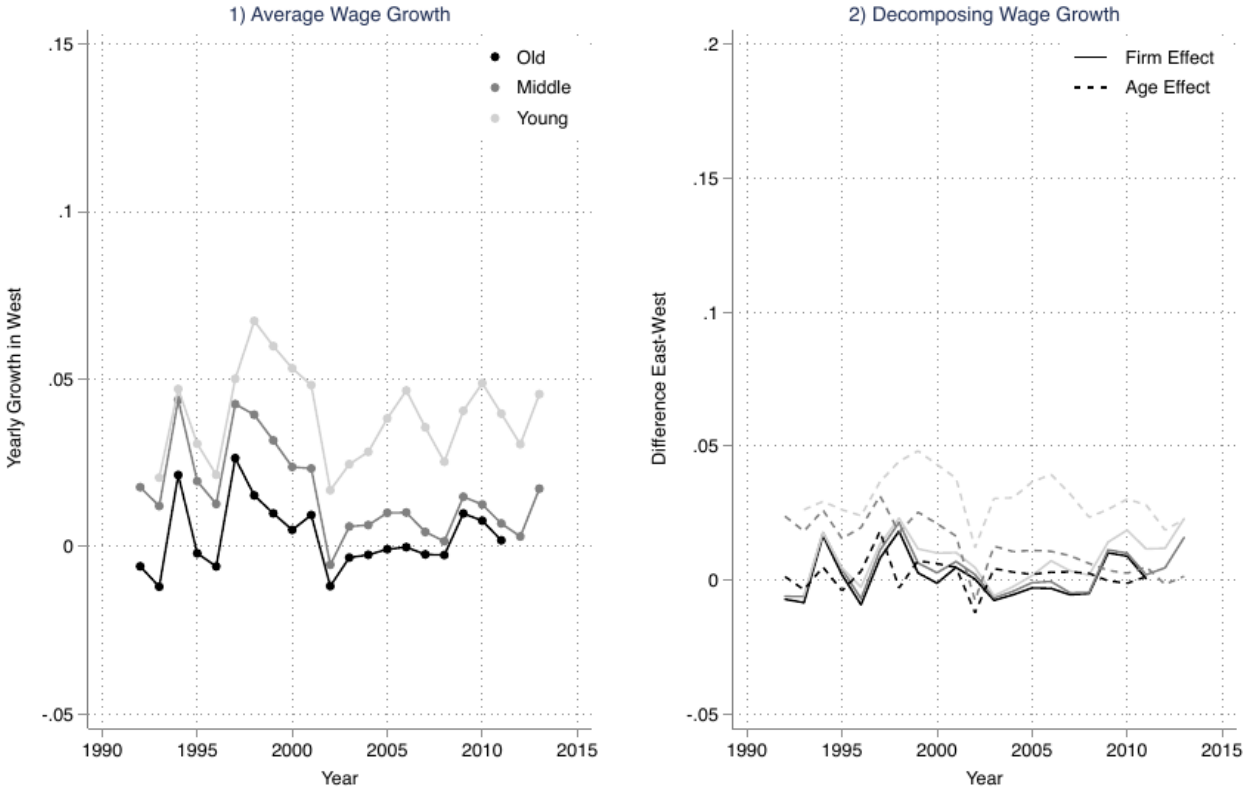


Figure A12: Wage Growth by Cohort, West Germany

The figure shows the wage growth of West-born individuals over time for. Before calculating the wage growth, we divide the individuals into three groups of cohorts, old (1937-1957), middle (1958-1967), and young (1968-1988). The left panel shows overall wage growth, while the right one distinguishes between growth coming from age and firm effects. Since the level of the age effects is not identified, we normalize it to zero in each year for the middle cohorts.

Figure A13: Wage Growth by Cohort for Switchers, West Germany

The figure shows the wage growth of West-born individuals over time for the sample of workers that switch establishment. Before calculating the wage growth, we restrict the sample to job switchers and divide the individuals into three groups of cohorts, old (1937-1957), middle (1958-1967), and young (1968-1988). The left panel shows overall wage growth, while the right one distinguishes between growth coming from age and firm effects. Since the level of the age effects is not identified, we normalize it to zero in each year for the middle cohorts.

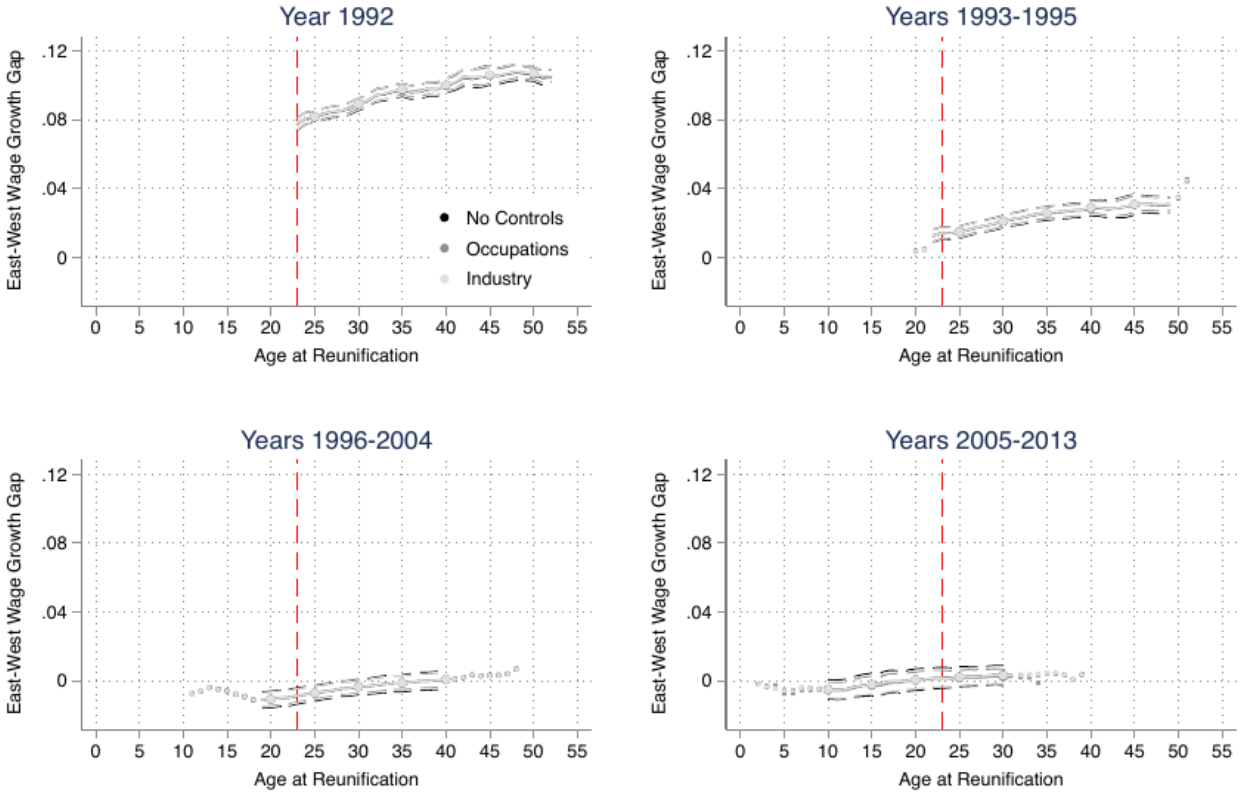


Figure A14: Wage Growth by Cohort with Controls, East-West Gap, Stayers Only

The figure shows the difference between wage growth for East and West-born individuals, for different birth-cohorts, over time, and changing the set of controls. We compute either raw differences (black) or control for occupations (dark gray) or industry (light gray). The results from the three specifications are almost identical, hence difficult to distinguish in the picture. In each panel, we take a raw average of the point estimates over different time periods and plot them as a function of the age at reunification of each birth cohort, together with the average standard error from the regressions. The cohorts that are in the data for only a subset of the periods are shown with smaller dots and without standard errors. The red dotted line separates the birth-cohorts that entered the labor market before and after the reunification, assuming that, on average, individuals enter the labor market at age 22.

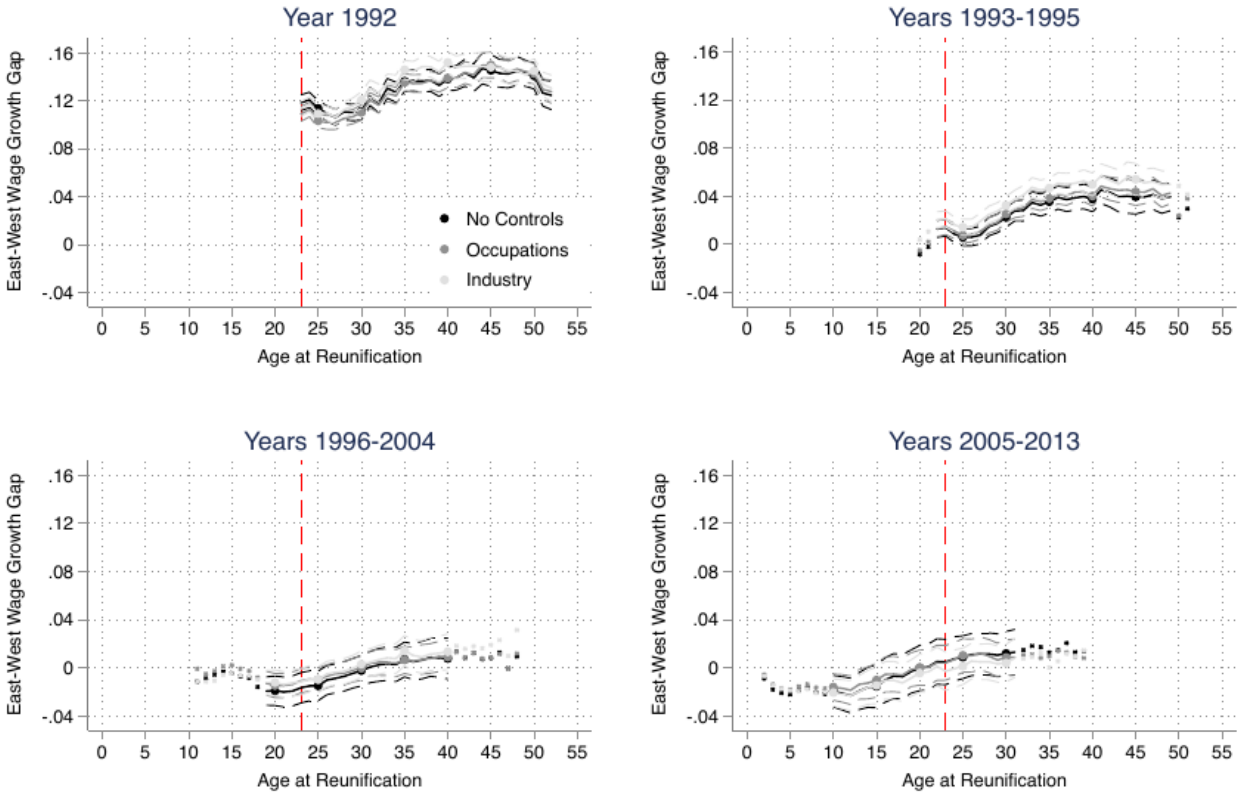


Figure A15: Wage Growth by Cohort with Controls, East-West Gap, Job Switchers

The figure shows the difference between wage growth for East and West-born individuals conditional on them making a job switch across establishments, and for different birth-cohorts, over time, and changing the set of controls. We first restrict the sample to job switchers, and then compute either raw differences (black) or control for occupations (dark gray) or industry (light gray). The results from the three specifications are almost identical, hence difficult to distinguish in the picture. In each panel, we take a raw average of the point estimates over different time periods and plot them as a function of the age at reunification of each birth cohort, together with the average standard error from the regressions. The cohorts that are in the data for only a subset of the periods are shown with smaller dots and without standard errors. The red dotted line separates the birth-cohorts that entered the labor market before and after the reunification, assuming that, on average, individuals enter the labor market at age 22.

Figure A16: Firm Wages Over Time and by Firm Size

The left panel shows the average firm wage over time for firms of different cohorts and separately for East and West Germany. The right panel shows the average firm wage by firm size. We divide the firm size distribution in 16 bins, as described in the text, and for each bin we compute the average size and wage, separately for East and West Germany and by year. We then plot the relationships between firm wages and sizes.

B Identification Interpretation

- Ignore skill and region subscript. For ease of notation, index cohorts by age at reunification, rather than birth year. Specifically, define $\tilde{\kappa}_{\tilde{c}} = \kappa_c$ if $\tilde{c} = 1990 - c$. Also index period by years since the beginning of our sample, so $\tilde{\alpha}_{\tilde{c},\tilde{t}} = \alpha_{c,t}$ if $\tilde{c} = 1990 - c$ and $\tilde{t} = t - 1992$.
- Cohorts age diagonally (redefined as age at RU):

Age	Year $1992+\tilde{t}$				
	0	1	2	$\cdots$	22
25	$\tilde{\kappa}_{23}$	$\tilde{\kappa}_{22}$	$\tilde{\kappa}_{21}$	$\cdots$	$\tilde{\kappa}_{1}$
26	$\tilde{\kappa}_{24}$	$\tilde{\kappa}_{23} + \alpha_{23,1}$	$\tilde{\kappa}_{22} + \tilde{\alpha}_{22,2}$	$\cdots$	$\tilde{\kappa}_{2} + \tilde{\alpha}_{2,22}$
27	$\tilde{\kappa}_{25}$	$\tilde{\kappa}_{24} + \tilde{\alpha}_{24,1}$	$\tilde{\kappa}_{23} + \tilde{\alpha}_{23,2}$	$\cdots$	$\kappa_{3} + \tilde{\alpha}_{3,22}$
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
54	$\tilde{\kappa}_{52}$	$\tilde{\kappa}_{51} + \tilde{\alpha}_{51,1}$	$\tilde{\kappa}_{50} + \tilde{\alpha}_{50,2}$	$\cdots$	$\tilde{\kappa}_{30} + \tilde{\alpha}_{30,22}$
55	**0**	$\tilde{\kappa}_{52} + \tilde{\alpha}_{52,1}$	$\tilde{\kappa}_{51} + \tilde{\alpha}_{51,2}$	$\cdots$	$\tilde{\kappa}_{31} + \tilde{\alpha}_{31,22}$

- κ_c has different meaning for cohorts $\tilde{c} = 1, \cdots, 22$ and $\tilde{c} = 23, \cdots, 52$
  1. $1 - 22$: lack of human capital due to pre-labor market exposure
  2. $23 - 52$: includes labor market exposure