Monopsony Makes Firms not only Small but also Unproductive: Why East Germany has not Converged

Preliminary: Current version

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June 26, 2021

Abstract

This paper documents that a steeper size-wage relationship, reflecting monopsony power, leads to aggregate productivity losses. We use this insight to understand the persistent labor productivity differences between West and East Germany. We employ high-quality administrative data to show that productivity differences between East and West Germany are related to a compressed plant-size distribution in East Germany. What is more, we show that the plant-size distribution is more compressed in those sectors where the size-wage relationship is steeper. Using a model of plant entry and customer accumulation, we show that differences in the size-wage relationships explain 10 percentage points lower labor productivity in the East German private sector, that is, approximately one third of its total labor productivity difference.

Keywords: productivity differences, size distortions, size-wage relationship, monopsony

JEL: E20, E23, E24, J20, J42, O11

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1 Introduction

Thirty years after the German reunification, labor productivity and wages remain more than 20% lower in East relative to West Germany. This is particularly striking in light of the fact that both regions have the same legal and cultural institutions. However, there does exist one important difference: In the West, wages are more likely to be collectively bargained in small and large plants alike, whereas collective wage bargaining in the East is more concentrated in large plants.¹ As a result, the size-wage relationship for plants, i.e., larger plants paying higher wages, is steeper in the East than in the West. That means growing large is particularly painful for plants in the East. We argue in this paper that, consequently, East Germany has lower aggregate labor productivity than West Germany.

At first glance, this is surprising because a steeper size-wage relationship is akin to more monopsony power for plants in the East, and the standard model of monopsony predicts lower wages, lower employment, and thus, higher labor productivity. However, the steeper size-wage relationship in the East leads to "missing" large plants in that region of Germany and economic activity taking place relatively more at smaller and relatively unproductive plants which each have a small customer base. These small customer bases, in a world where variety matters for production efficiency, further reduce aggregate productivity in East Germany. The intuition from the standard monopsony model, thus, fails to take into account firm entry, firm heterogeneity, and customer accumulation.

Of course, in 1991, when centrally planned East Germany reunited with West Germany and became a market economy, other factors depressing labor productivity played an important role. Capital was in short supply, machines were outdated, and political pressure had plants over-employ labor in the East. Consequently, labor productivity did not even reach 50% of the West German level in 1991 (see the first panel in Figure 1). During the first couple of years after reunification, labor productivity and wages grew quickly. However, this process ended soon, in about

¹In communist economies, trade unions did not have the role to represent workers' interests, because the idea was that these were taken care of by the government already, even though nominally almost everyone was a member of the single socialist union. As a consequence, after reunification, union membership and employer membership in bargaining associations fell dramatically.





Notes: The figure displays yearly log output per worker, log output per hour, and log average labor compensation in East and West Germany. The top panel displays it for the whole economy, the bottom panel for the private, non-primary sector. Calculations are based on national accounts (VGR). The data is available by region and sector only since 2008, which is why the lower panel starts only in that year. Similarly, data on hours worked by region starts in 2000.

1995. Since then, convergence in relative labor productivity and wages has almost come to a halt.² What is more, as the bottom panel of Figure 1 shows, the East-West productivity difference is with 32% even larger in the private (non-primary) sector.

Employing high-quality administrative data, we first show that differences in labor productivity are systematically related to the absence of large plants in East Germany. Sectors with fewer large plants in the East relative to the West are also those sectors with the largest differences in labor productivity. Importantly, in the aggregate, the share of employment at large plants is smaller in the East, too. For example, the share of employment at plants with more than 249 employees is

 $^{^{2}}$ We use output per worker as our baseline measure of labor productivity. As the figure shows, differences in output per hour are even somewhat larger than those in output per worker.

almost twice as large in the West. We argue in this paper that these missing large plants in the East are an important contributor to the overall lower productivity in that region of Germany.

What is more, we relate the phenomenon of missing large plants to differences in labor market power. The relationship between plant size and wages is 20% steeper in East Germany relative to West Germany on average across all industries. Exploiting differences across industry, we show that those industries with steeper size-wage relationships in the East are also those industries with particularly many missing large plants. The steeper size-wage relationship in the East can be traced back to the fact that workers at small plants in the East are more likely to have individually and not collectively bargained wages compared to their Western counterparts.

To understand the mechanism behind the relationship of differences in labor market power, distorted plant size distributions, and depressed aggregate productivity in East Germany, we develop a heterogeneous plant model, where plants have both product market and labor market power and not only decide about entry but also, through customer accumulation, about their optimal size. The model is static and therefore allows closed-form solutions, but, within period, plants face the following three-stage decision problem.³ First, plants decide about market entry. After market entry, they choose how many customers to accumulate, trading off additional sales and marketing expenses. This customer-base choice also takes into account that a larger customer base requires hiring additional workers which drives up wages in line with the upward-sloping size-wage relationship present in the data. Finally, plants decide on prices charged to each individual customer.

This structure leads plants to accumulate fewer customers the steeper their sizewage relationship is, i.e., the larger their labor market power. Indeed, we show that, in the data, marketing expenses are particularly small in those industries in the East which have a comparably steeper size-wage relationship relative to their Western counterparts. This has two effects on aggregate productivity: First, as plants on average have an incentive to remain small and search little for customers, the average customer knows fewer suppliers. This makes the economy less efficient.

 $^{^{3}}$ Our model is inspired by Sedláček and Sterk (2017) which does not feature monopsony power but is more explicitly dynamic with numerical solutions.

Second, compared to a situation with less labor market power, the employment distribution across plants is compressed, and labor is reallocated from more to less productive plants. Again, the result is an aggregate productivity loss.

We calibrate the model to the average plant size and the share of large plants in West Germany. Imposing, in the model, the steeper size-wage relationship from East Germany explains a 10 percentage points lower productivity in that region. Moreover, the model replicates the plant-size distribution in East Germany. That is, it matches the smaller average plant size and the relatively small number of large plants. Taking into account that the East-West difference in the sizewage relationship is heterogeneous across sectors, we also calibrate the model to the manufacturing sector, instead of the entire private sector. In the former, differences in the size-wage relationship are particularly pronounced and again explain differences in the plant-size distributions between the regions as well as 18 percentage points of the lower productivity in East Germany.

Lastly, we also consider alternative explanations for persistent productivity differences between the two regions. One might worry that low productivity in East Germany is a result from a more sclerotic labor market.⁴ However, it turns out that East Germany is the more dynamic economy with more job and worker reallocation and more plant entry. This seems broadly consistent with the lower economic significance of unions in East Germany. Another potential explanation for lower labor productivity are persistent differences in industry structures. However, we show that the industry structure has converged considerably throughout the period. More importantly, labor productivity differences are prevailing within almost all sectors. Finally, we consider differences in physical input factors. In turns out, however, that the capital intensity is only 5% lower in East Germany, but of a more recent vintage on average.⁵ Also in terms of human capital, workers in East Germany have a similar quality compared to those in the West. Hence, even within a country, we confirm the well-known finding from Hall and Jones (1999) that differences in TFP explain a large fraction of dispersion in labor productivity

 $^{^{4}}$ The importance of job reallocation for transition economies is stressed by Boeri and Terrell (2002).

⁵For example, with a constant returns to scale Cobb-Douglas production function and a standard capital share of 30% this difference in capital intensity would explain 1.5 percentage points of labor productivity differences.

across geographical units.

Literature First, our paper is related to the literature that explains aggregate productivity losses as a result of too little employment at the most productive plants. For example, Hsieh and Klenow (2014) take the relatively slow growth of manufacturing plants in India and Mexico as evidence of high (implicit) taxes for large plants and use this insight to quantify the resulting productivity loss relative to the U.S. Braguinsky et al. (2011) find that Portugal's firm size distribution has shifted to the left over time and interpret this finding as the result of a labor tax that has become steeper in firm size over time. More recently the literature, like this paper, starts from existing institutions and links them to aggregate productivity losses caused by their effects on the plant size distribution. Examples are Garicano et al. (2016) and Cingano et al. (2016). The former show that the additional regulation of plants with more than 50 employees in France decreases output. The latter show that additional employment protection for plants with more than 15 employees decreases productivity at Italian plants. This paper highlights a new force behind regional productivity differences that is rooted in distortions of plant size: monopsony power in the labor market and regional differences therein. In this, the German case is particularly interesting because government policies (and their enforcement) are basically constant across regions. The differences in labor market power are rather a result of the historical development of non-governmental labor market institutions.

Second, our paper relates to the large literature on productivity (non-)convergence between countries in general (see Johnson and Papageorgiou, 2020, for a recent survey), as well as former socialist countries in particular (see Svejnar, 2002, for a survey). We study non-convergence within a country and thus non-convergence within the same legal framework.⁶ This is different from the early difficulties of some other former socialist countries with building good legal institutions. Studying non-convergence within a country has the additional advantage that we can

⁶Non-convergence can also be found within many other countries (Italy's "Mezzogiorno", the US' "Rust-belt", etc.). What makes the German case of regional non-convergence particularly interesting is that there is a well-defined starting date from which on we should expect convergence (October 3, 1990), instead of observing a process of drifting apart, a point made by Uhlig (2006).

use high-quality micro data with common measures of factor inputs across the regions.

The particular case of non-convergence within Germany has also drawn some previous attention. Regarding convergence in labor productivity, Burda (2006) emphasizes the role of capital accumulation frictions for slow convergence between the two regions. Similarly, we also find that capital accumulation has played an important role in the convergence in the initial years after reunification. However, it cannot explain the persistent differences between the regions. Uhlig (2006)shows that initial conditions, i.e., at reunification, may be self-perpetuating when agglomeration effects in production networks are important. We also find that differences in production networks play a role, however, these arise endogenously from different size-wage relationships and resulting marketing choices in our framework instead of initial conditions. Using cross-boarder worker mobility, Fuchs-Schündeln and Izem (2012) find that job, in contrast to worker characteristics, explain lower wages in East Germany. Using matcher employer employee data, Heise and Porzio (2021) also find plant productivity differences driving the majority of wage differences between the two regions but worker differences contribute up to 10 percentage points to lower wages in the East. We see agglomeration effects and differences in worker skills as complementary to our theory which, after all, leaves two third of the productivity differences between the two regions for other factors.

Lastly, in terms of the model, our paper borrows from the literature that explains size heterogeneity of plants by demand accumulation (see Arkolakis (2010), Drozd and Nosal (2012), Gourio and Rudanko (2014), and Sedláček and Sterk (2017)). We provide micro-evidence that links heterogeneity in marketing expenses and plant sizes to heterogeneity in size-wage relationships. Moreover, we show that introducing an upward sloping size-wage relationship into such a model leads to aggregate output losses.

The remainder of the paper is organized as follows: Section 2 presents the data sets we use. In Section 3, we show that output differences are linked to missing large plants in East Germany and that these are related to a steeper size-wage relationship in the East. Section 4 introduces our model, and Section 5 discusses its quantitative implications. Finally, in Section 6, we show that explanations for the non-convergence of East Germany based on physical input factors, either their quantity or their reallocation, appear to be less plausible explanations for the persistent difference in labor productivity and wages. The last section concludes; an appendix follows.

2 Data

For our analysis, we use publicly available aggregate, sectoral and regional data and two administrative micro data sets. We focus on the private, non-primary sector (industries 10 to 82 in the German WZ2008 industry classification system). Specifically, we use German national income and product accounts data, *Volkswirtschaftliche Gesamtrechnung (VGR)*, to compute labor productivity at the national sectoral and regional level, as e.g. displayed in Figure 1. The micro data sets are, respectively, the Structure of Earnings Survey, *Verdienststrukturerhebung* (*VSE*), and the Administrative Wage and Labor Market Flow Panel (AWFP).

2.1 Structure of Earnings Survey (VSE)

The VSE is a cross sectional matched employer-employee data set maintained by the German statistical agency (*Statistisches Bundesamt*). The VSE is carried out every four years. The German statistical agency randomly samples plants and, by law, these plants are required to provide detailed information on their employees and their employees' monthly working hours and earnings. It contains the number of employees at a plant as well as regional information and industry classification. The sample is representative for the universe of all German plants with at least ten employees.⁷

For our analysis, we employ the 2006, 2010, and 2014 sample, which we pool for most empirical analysis. We drop all civil servants from our sample as well as all plants where at least 50% of employees are public servants. Moreover, we restrict the sample to full-time employees. The final sample contains 2,364,862 worker-plant observations. The 2006 sample uses a different industry classification than the later two samples. As a result, we have to merge some industries to have

 $^{^7\}mathrm{The}$ restriction on ten or more employees is meant to reduce administrative burden on small enterprises.

a consistent classification. Table A1 in the Appendix A provides a crosswalk for this merger and shows how it relates to the sectors from the national accounts.

2.2 Administrative Wage and Labor Market Flow Panel (AWFP)

The AWFP is a quarterly plant-level data set that covers the universe of private German plants and is available for both West and East Germany after 1993 until 2014 (see Stüber and Seth, 2017; Bachmann et al., 2021). The AWFP's data source is the Employment History (*Beschäftigten Historik*, BeH) of the German Institute for Employment Research (IAB). The BeH is an individual-level data set covering all workers in Germany subject to social security.⁸ The information in the BeH originates from the notification procedure for social security. Essentially, this procedure requires employers to keep the social security agencies informed about their employees by reporting any start and end date of employment and by annually confirming existing employment relationships. The AWFP aggregates this individual worker data to the plant level. We use the AWFP on occasion because it covers a longer time period than the SES and provides supplementary information about the plants, but its wage data are inferior to the SES.⁹

3 Size Distortions

The *VSE* data allows us to establish that the lower labor productivity in East Germany is related to missing large plants in the East which itself is related to a steeper size-wage relationship there. We start by showing that, at the aggregate level, East Germany has fewer large plants than West Germany. Next, we show

⁸Marginal part-time workers (*geringfügig Beschäftigte*) have been covered since 1999. The main types of employees not covered by the BeH are civil servants (*Beamte*), military personnel, and the self-employed. East German employees were integrated with the West-German social security administration only after 1992.

⁹To ensure consistency over time, most variables in the AWFP—and all variables used in this paper—are calculated on a 'regular worker' basis. In the AWFP, a person is defined as a 'regular worker' when she is employed full-time and belongs to one of the following person groups: 'employees subject to social security without special features', 'seamen' or 'maritime pilots.' Therefore (marginal) part-time employees, employees in partial retirement, interns, etc., are not counted as regular workers.

that productivity differences between East and West are particularly pronounced in sectors with more missing large plants in the East. We then document a novel size distortion: a relatively steeper size-wage relationship in East Germany. Using more detailed industry data, we show that a steeper size-wage relationship in an industry in the East predicts more missing large plants in that industry. This steeper size-wage relationship itself relates to the fact that workers at small plants in the East are less likely to be paid according to a collective bargaining agreement.

3.1 Missing Large Plants in East Germany



Figure 2: Plant-Size Distributions in East and West Germany, 2014

Notes: The figure displays the employment weighted plant size distribution in East and West Germany. The top panels display, respectively, an estimated density function (by a Gaussian kernel smoother) in the total private, non-primary sector and in the manufacturing sector. The bottom panels display, for different survey years, the empirical CDF of employment over plant log-employment for the total private non-primary sector. Data source: *VSE*.

That East Germany has fewer large plants than West Germany both in the private sector overall and in the large manufacturing sector in particular can be seen from Figure 2. The top panels show this in terms of the (employment-weighted) density of plants over log employment for the pooled samples. The bottom panels show this in terms of the CDF of employment over (log) plant sizes for each survey year. In all these years, employment at large plants is much more prevalent in the West. In this paper, we refer to large plants as those with more than 249 employees. In the West, close to 40% of employees are employed at such large plants in 2014, as the rightmost lower panel shows. The same number for East Germany is only around 25%. In Appendix C we show that the main result extends to earlier time periods and is not driven by differences in urbanization between East and West Germany or plant-age effects.

Comparing the two top panels in Figure 2, one can also see that the East-West differences in the plant size distribution are not uniform across sectors. Here, they are much stronger in the manufacturing sector, where in the West, 55% of all employees work at plants with more than 249 employees, while in the East it is only 31%. Figure 3 makes this comparison systematically across all sectors and relates it to sectoral productivity differences. The left panel uses the share of employment at plants with more than 249 employees to compare the plant size distribution. The right panel uses the standard deviation of log-employment, $\sigma_{\log e}^W - \sigma_{\log e}^E$, instead. The employment-weighted correlation between the two measures is 0.72 for the left panel and 0.70 for the right panel. Both scatter plots show that those sectors where productivity is particularly low in the East are also the sectors where particularly fewer workers are employed at large plants in East Germany relative to West Germany.

3.2 Size-Wage Relationships and Missing Large Plants

These differences in the plant-size distribution are in turn related to differences in the size-wage relationship that plants face. To show this, we use the VSE data to estimate the following reduced-form relationship between individuals' log wages, $\ln w_{it}$, and the log employment at their plant, $\ln E_{it}$:

$$\ln w_{it} = \beta_0 + \beta_E East_i + \hat{\omega}_W \ln E_{it} + (\hat{\omega}_E - \hat{\omega}_W) East_i \ln E_{it} + \beta x_{it} + e_{it}, \quad (1)$$

where $East_i$ is a dummy that is one when the employer is located in East Germany and x_{it} are other observable plant or worker characteristics. The coefficient of



Figure 3: Productivity Differences and Large Plants by Sector

Note: The figures relate 2014 log differences in output per worker between West and East Germany within major sectors to the share of employment at plants with more than 249 employees and the standard deviation of log plant employment. The lines show weighted-least squares regressions. MFG: Manufacturing, UTL: Utilities, CON: Construction, TRD: Wholesale and Retail, TRA: Transportation, TUR: Tourism, FIN: Finance, TPS: Technical professional services, OPS: Other professional services, see Appendix A. Data sources: VSE and VGR.

interest is the difference in the size-wage slope $\hat{\omega}_E - \hat{\omega}_W$, the interaction term. In our baseline specification, we non-parametrically control for a workers' age and sex by a full set of interaction dummies and for time and industry fixed effects. For robustness, we consider a second specification where we fully interact age, sex, and occupation dummies (in addition to time and industry fixed effects) to allow for differences in occupational patterns within industries between the two regions.

The top panel of Table 1 displays the results. It first shows that large plants pay higher average wages in both regions as $\hat{\omega}_{W,E} > 0$. Importantly, the size premium is larger in East Germany. In the West, increasing employment by 1% increases wages by 0.078%. The corresponding number for the East is 0.094%. For example, if a plant wants to increase its employment from 50 to 100 (log difference 0.69) it has to pay 5.6% higher wages in the West, while in the East, the same size increase comes with a wage increase of 6.7%. The last column of Table 1 shows that the difference between the two regions becomes yet slightly larger when we control additionally for age and sex specific occupational patterns.¹⁰ For manufacturing,

¹⁰We consider two additional robustness analysis which both slightly increase the difference between West and East Germany. First, we include part-time workers into our sample. Second, we allow the size-wage relationship to be non-linear by including a common second-order polynomial into the regression.

Table 1: Size-Wage Relationships

	Non-primary private sector		
	Baseline	Adding Occupation	
Wage-size elasticity, West, $\hat{\omega}_W$	7.8(0.1)	6.3(0.1)	
Difference in elasticities, $\hat{\omega}_E - \hat{\omega}_W$	1.6(0.3)	2.1(0.2)	
Implied elasticity, East, $\hat{\omega}_E$	9.4	8.4	
	Manufacturing sector		
	Baseline	Adding Occupation	
Wage-size elasticity, West, $\hat{\omega}_W$	8.8(0.2) $7.3(0.1)$		
Difference in elasticities, $\hat{\omega}_E - \hat{\omega}_W$	4.3(0.4)	5.0(0.3)	
Implied elasticity, East, $\hat{\omega}_E$	13.1	12.3	
	Type of Bargaining		
	Non-collective	Collective	
Wage-size elasticity, West, $\hat{\omega}_W$	7.7(0.2)	5.8(0.2)	
Difference in elasticities, $\hat{\omega}_E - \hat{\omega}_W$	-0.3(0.4) $-0.3(0.4)$		
Implied elasticity, East, $\hat{\omega}_E$	7.4	5.5	

Note: The table displays the estimated size-wage relationships for the non-primary private (manufacturing) sector in West and East Germany. Standard errors are in parentheses. The top panel is for all workers. The bottom panel splits the sample (non-primary private sector) by whether the worker is covered by a collective bargaining agreement or not. All coefficients are multiplied by 100 for better readability. *Baseline*: Controls for a workers' age and sex by a full set of dummy-interactions, plus time and industry fixed effects. *Adding Occupation*: Controls for a workers' age, sex, and occupation by a full set of dummy-interactions, plus time and industry fixed effects. Data source: *VSE*.

the difference in the size-wage relationship between East and West is even more pronounced.

In fact, that the East-West difference in the size-wage relationship is not uniform across industries generalizes. Importantly, it is also systematically related to industry variation in the prevalence of large plants, as Figure 4 shows. Industries with many missing large plants in the East have also a steeper size-wage relationship in the East.

Concretely, we estimate Equation (1) for 21 individual industries. We plot the the difference $\hat{\omega}_E - \hat{\omega}_W$ against (a) the difference in the share of employment at large plants and (b) the difference in the standard deviation of log employment for each industry. Here we can go beyond sectoral disaggregation as we do not need



Figure 4: The Share of Large Plants, the Size-Wage Relationship, and Collective Bargaining

Note: The top panel relates differences between West and East Germany in the share of employment at large plants and the standard deviation of log plant employment to differences in size-wage relationships. The bottom panel relates differences between West and East Germany in the share of employment at large plants and the standard deviation of log plant employment to the following double difference: $\log P(C|L, W) - \log P(C|S, W) - [\log P(C|L, E) - \log P(C|S, E)]$, where $P(C|\cdot)$ is the conditional probability of a worker being subject to collective bargaining in our sample in (L)arge (>249 employees) or (S)mall (≤ 249 employees) plants in the (E)ast and (W)est. The lines show weighted-least square regressions. MFT: Food and textile manufacturing, MPW: Paper and wood manufacturing, MCP: Chemical and plastic manufacturing, MTL: Utilities, CON: Construction, COP: Construction preparations, WHC: Wholesale and car retail, RTO: Other retail, TRA: Transportation, STO: Storage, TUR: Tourism, BAN: Banking, INS: Insurance, RNS: Research services, TES: Technical services, RES: Rental services, BAC: Building and area care, OTS: Other services, see Appendix A. Data sources: Calculations using the VSE.

to rely on regional VGR data (as we needed to calculate productivity in Figure 3).¹¹ We find a positive relationship between steeper size-wage relationships in the East and a larger difference in the share of employment at large plants (industry-size weighted correlation of 0.3). The industry-size weighted correlation for the standard deviation of log plant employment is 0.34.

What lies behind these differences in the steepness of the size-wage relationship? We highlight the role of collective wage bargaining and the differences in the role of unions rooted in the different historical developments before 1990. We find that, once we condition on whether individual employment contracts are subject to collective bargaining, the size-wage relationship in West and East Germany is basically identical (see the bottom panel of Table 1). Since collectively bargained wages are in general higher,¹² the fact that the size-wage relationship is flatter for collectively bargained wages (e.g. 5.8 vs. 7.7 in the West) means that collective bargaining in particular raises wages at small plants.¹³ One way to interpret this is that unions reduce a plant's monopsony power.¹⁴ Putting together the lack of a difference in the size-wage relationship conditional on collective bargaining and the overall higher collectively bargained wages means that the overall steeper size-wage relationship in the East is driven by composition differences between small and large plants regarding the prevalence of collective bargaining. Workers at small plants in the East have a particularly low probability to be covered by a collective bargaining agreement relative to their West German counterparts, as we will show next.

The bottom panels of Figure 4 show on the x-axes, for each industry, a double difference in the prevalence of collectively bargained wage contracts between large and small plants and between East and West. For the majority of industries this double difference is negative. This means that the fraction of collectively bargained

¹¹Table A1 in Appendix A shows the mapping between the two classifications.

¹²For all plant sizes collective bargained wages are higher in our sample.

¹³The size-wage relationship for collectively bargained wages is not completely flat for at least two reasons. First, firms can negotiate firm-specific agreements that are collective in the sense that they hold for their entire workforce. Second, the typical industry-wide collective bargaining agreement in Germany establishes a wage floor for all plants bound by the agreement, but allows to pay an individual worker better, e.g., through bonuses.

¹⁴It has been documented for the U.S. and the U.K., too, that collective bargaining makes the size-wage relationship flatter (see Stewart, 1987; Brown and Medoff, 1989; Blanchflower et al., 1990; Green et al., 1996).

wage contracts increases indeed more in plant size in the East than it does in the West. This double difference is plotted against our two measures of East-West differences in the plant size distribution: the share of employment at large plants (left panel) and the standard deviation of log plant-level employment (right panel). The relationship between collective-bargaining prevalence differences and plant-size differences is negative with an employment-weighted correlation of -.3 and -.4, respectively. Industries in which the prevalence of collectively bargained wages increases relatively more in plant size in the East are also those industries where, compared to the West, large plants are particularly missing in the East.

In summary, the data suggests that plants in East Germany face a stronger trade-off between growing large and paying low wages. This stronger trade-off appears to originate from the relative concentration of collective bargaining in East Germany at large plants. Most importantly, across industries/sectors the stronger size-wage trade-off in the East correlates with missing large plants and lower productivity.

4 A Model of Missing Large Plants

To understand why a stronger size-wage trade-off leads to missing large plants and lower productivity in East Germany, we introduce labor market power into a heterogeneous plant-size model with endogenous demand (customer) accumulation. We thereby draw on a recent and growing literature that puts a form of customer accumulation at the center stage next to productivity differences for understanding plant size heterogeneity (see Arkolakis, 2010; Drozd and Nosal, 2012; Gourio and Rudanko, 2014; Sedláček and Sterk, 2017). In these models, in order to grow, plants have to make potential customers aware of their products through marketing. We highlight that this decision naturally interacts with labor-market power: firms that face a higher size-wage trade-off will tend to accumulate less customers. Indeed, we see this prediction to be borne out by the data: Figure 5 shows that East-West differences in marketing expenditures are systematically related to the size-wage trade-off at the industry level. Industries with particularly steep size-wage trade-offs in the East spend, relative to West Germany, little on



Figure 5: Marketing Expenditures and $\hat{\omega}_E - \hat{\omega}_W$

Note: The figure relates differences between West and East Germany in the ratio of marketing expenditures relative to sales (West minus East in 2014) to differences in the size-wage relationship for those industries where marketing expenses are available. The line shows a weighted-least square regression. MFT: Food and textile manufacturing, MPW: Paper and wood manufacturing, MCP: Chemical and plastic manufacturing, MME: Metal manufacturing, MEL: Electronics manufacturing, MVE: Vehicle manufacturing, UTL: Utilities, CON: Construction, COP: Construction preparations, WHC: Wholesale and car retail, RTO: Other retail, TRA: Transportation, STO: Storage, TUR: Tourism, BAN: Banking, INS: Insurance, RNS: Research services, TES: Technical services, RES: Rental services, BAC: Building and area care, OTS: Other services, see Appendix A. Data sources: Calculations using the VSE and the Mannheimer Innovationspanel.

marketing (a size-weighted correlation of 0.71).¹⁵

Concretely, we introduce a size-wage trade-off into the following framework: There are intermediate good producers with heterogeneous productivities who can use labor to produce a differentiated good. First, these potential producers decide on market entry; second, conditional on entry, they learn their productivity and decide on marketing expenditures that are used to form production networks with final goods producers (bundlers). Third, intermediate good producers hire labor and produce, facing both a size-wage and an output-price trade-off. Finally, bundlers produce a perfectly substitutable consumption good under perfect

¹⁵Data for the ratio of marketing expenditures relative to sales at the industry level comes from the *Mannheimer Innovationspanel*. We are extremely grateful to the team at the ZEW, in particular Christian Rammer, who shared this data with us.

competition.¹⁶

4.1 Bundlers

There is a unit mass of bundlers who are indexed by j. Each produces a final consumption good, Y_j , using a Dixit-Stiglitz aggregator.

$$Y_j = \left(\int \gamma_i \theta_{ij} y_{ij}^{\frac{\eta-1}{\eta}} di\right)^{\frac{\eta}{\eta-1}}.$$
 (2)

They bundle differentiated goods, y_{ij} , of a continuum of potential intermediate good producers *i* (again of mass one).

A potential intermediate good producer may enter and be active, $\gamma_i = 1$, or not, $\gamma_i = 0$. Not all active intermediate good producers are known to each bundler, and producer *i* is known to bundler *j* only if $\theta_{ij} = 1$. A bundler can only buy an intermediate good from a producer that is both active and known to the bundler. This implies that the demand for producer *i*'s product by bundler *j* is given by

$$y_{ij} = \gamma_i^{\eta} \theta_{ij}^{\eta} \left(\frac{p_{ij}}{\bar{P}_j}\right)^{-\eta} Y_j, \tag{3}$$

where \bar{P}_j is the cost minimizing price at which bundler j sells its bundle, and p_{ij} is the price of the intermediate good charged by producer i to bundler j.

The cost minimizing price of bundler j is given by

$$\bar{P}_j = \left(\int (\gamma_i \theta_{ij})^\eta p_{ij}^{1-\eta} di\right)^{1/(1-\eta)},\tag{4}$$

which can be written as

$$\bar{P}_j = \left(\int (\gamma_i \theta_{ij})^\eta di\right)^{1/(1-\eta)} \left(\int p_{ij}^{1-\eta} di\right)^{1/(1-\eta)}$$
(5)

¹⁶We emphasize the interaction of customer accumulation and labor market power in shaping plant size and productivity, and, therefore, we abstract, for tractability reasons, from how interregional trade additionally influences this nexus. We thus model each East and West Germany as closed economies which is tantamount to assuming that the bundlers in both regions produce perfect substitutes.

because we assume that prices and γ and θ are independent. The latter reflects random matching, the former is tantamount to assuming, without loss of generality, that inactive producers set a price as if they were active and could sell (a weakly dominant strategy). What is more, random matching implies that the integral

$$\left(\int (\gamma_i \theta_{ij})^{\eta} di\right)^{1/(1-\eta)} \tag{6}$$

does not depend on the specific bundler j, and in turn all bundlers charge the same price:

$$\bar{P}_j = (\Gamma \bar{\Theta})^{1/(1-\eta)} \hat{P}_j, \tag{7}$$

where Γ is the mass of all active producers, $\overline{\Theta}$ is the average fraction of active producers known to a bundler, which by symmetry is also the average fraction of bundlers that an active producer sells to (and therefore has no *j* index), and

$$\hat{P}_j = \left(\int p_{ij}^{1-\eta} di\right)^{1/(1-\eta)} \tag{8}$$

is the average price charged by intermediate good producers. Because all bundlers j charge the same price, we focus on the symmetric equilibrium in which $Y_j = Y$, $\hat{P}_j = \hat{P}$, and $\bar{P}_j = \bar{P}$.

4.2 Intermediate Good Producers

Intermediate good producers operate a constant returns to scale production function that transforms l_i unit of labor into $y_i = z_i l_i$ units of the intermediate good, where z_i denotes idiosyncratic productivity. Because in the symmetric equilibrium $Y_j = Y$ and $\bar{P}_j = \bar{P}$ the intermediate goods producer supplies the same amount of goods to each bundler she knows, we can drop the subscript j and let y_i denote the representative quantity that an active producer supplies to each bundler she knows and l_i the number of workers that are needed to produce this representative quantity. The total number of employees of an intermediate good producer is $l_i\Theta_i$, where Θ_i is the number of bundlers known to that producer.

Moreover, an intermediate good producer faces monopsonistic competition in

the labor market, i.e., the wage is a function of its total number of employees. As in our empirical specification, Equation (1), we assume a constant elasticity:

$$w_i = \left(\frac{l_i \Theta_i}{\bar{l}\bar{\Theta}}\right)^{\hat{\omega}} W,\tag{9}$$

where we express size relative to the average producer size in the economy, $\overline{l}\Theta$, and W is a wage index, which we set to 1, making labor the numeraire.

Given this environment, we solve the decision problem of the intermediate good producers backward, starting with the optimal price-setting to one bundler. Thereafter, we solve for the optimal marketing policy given the downstream pricesetting decisions.

4.2.1 Price-Setting and Profits within a Single Market

Since intermediate good producers in each single (bundler/product) market face monopolistic competition for any bundler they are known to, they set prices as a mark-up over marginal costs, given by wages w_i relative to productivity z_i :¹⁷

$$p_i = \frac{\eta}{\eta - 1} \frac{w_i}{z_i}.$$
(10)

Hence, a producer who knows Θ_i bundlers has a total gross profit of:

$$\pi_i(\Theta_i) = \Theta_i \left(p_i y_i - y_i \frac{w_i}{z_i} \right) = \Theta_i \left(y_i \frac{1}{\eta - 1} \frac{w_i}{z_i} \right), \tag{11}$$

where the terms in brackets are the gross profits earned from commerce with an individual bundler.

Substituting into the gross profits the demand curve from an active market,

$$y_i = \left(\frac{p_i}{\bar{P}}\right)^{-\eta} Y,\tag{12}$$

as well as the optimal price, Equation (10), allows us to express gross profits as a

¹⁷The intermediate good producers' price-setting can ignore the fact that they are in monopsonistic competition in the labor market, as each bundler is infinitesimally small and, hence, a marginal increase in the quantity sold to a single bundler has only a second-order impact on the producer's total labor demand and is thus irrelevant for the producer's first-order condition.

function of known bundlers, the wage, and idiosyncratic productivity:

$$\pi(\Theta_i) = \Theta_i \left(\frac{w_i}{z_i}\right)^{1-\eta} \bar{P}^{\eta} Y \frac{(\eta-1)^{\eta-1}}{\eta^{\eta}}.$$
(13)

4.2.2 Optimal Marketing

The intermediate good producer maximizes gross profits net of marketing cost but takes into account wages as a function of the total number of employees. Therefore, we first need to express wages in (13) as a function of the number of bundlers the are known to the producer. To this end, we plug the number of workers, $\frac{y_i}{z_i}$, required to fulfill a producer's demand, (12), into the size-wage trade-off, (9):

$$w_i = \left(\frac{\left(\frac{p_i}{\bar{P}}\right)^{-\eta} Y \Theta_i}{z_i \bar{l}\bar{\Theta}}\right)^{\hat{\omega}}.$$
(14)

Next, substituting p_i with the optimal pricing decision (10), solving for the wage w_i , and redefining terms, we obtain wages as a function of the number of known bundlers as well as productivity and aggregates:

$$w_i = z_i^{\frac{(\eta-1)\hat{\omega}}{1+\eta\hat{\omega}}} \bar{w} \left(\frac{\Theta_i}{\bar{\Theta}}\right)^{\frac{\hat{\omega}}{1+\eta\hat{\omega}}},\tag{15}$$

where $\bar{w} = \left(\bar{P}^{\eta}Y\left(\frac{\eta}{\eta-1}\right)^{-\eta}/\bar{l}\right)^{\frac{\hat{\omega}}{1+\eta\hat{\omega}}}$ summarizes the aggregate terms that affect wages.

Given this reformulation of the size-wage trade-off, we are now ready to solve for the optimal marketing policy. To get to know one additional bundler, the intermediate good producer has to pay marketing expenditures, $\mu \bar{P}$ (μ measures costs in terms of the output good). The resulting operating profits are

$$\Pi_i = \pi(\Theta_i) - \mu \bar{P} \Theta_i. \tag{16}$$

Substituting in gross profits, (13), and the wage-size trade-off, (15), yields

$$\Pi_{i} = \Theta_{i} \left(\frac{\Theta_{i}}{\bar{\Theta}}\right)^{\frac{\hat{\omega}}{1+\eta\hat{\omega}}(1-\eta)} z_{i}^{-(1-\eta)\frac{\hat{\omega}+1}{1+\eta\hat{\omega}}} \bar{P}^{\eta}Y \frac{(\eta-1)^{\eta-1}}{\eta^{\eta}} \bar{w}^{1-\eta} - \mu \bar{P}\Theta_{i}.$$
 (17)

The optimal scope of producer *i* follows from the first order condition, $\frac{\partial \Pi_i}{\partial \Theta_i} = 0$, ignoring, for simplicity, that $\Theta_i \leq 1$:

$$\bar{P}^{\eta-1}\frac{Y}{\mu}\frac{(\eta-1)^{\eta-1}}{\eta^{\eta}}\bar{w}^{1-\eta}\frac{1+\hat{\omega}}{1+\eta\hat{\omega}}\left(\frac{\Theta_{i}}{\bar{\Theta}}\right)^{\frac{\tilde{\omega}}{1+\eta\hat{\omega}}(1-\eta)} = z_{i}^{(1-\eta)\frac{\tilde{\omega}+1}{1+\eta\hat{\omega}}},\qquad(18)$$

which, solving for Θ_i , simplifies to

$$\frac{\Theta_i}{\bar{\Theta}} = z_i^{\frac{1+\hat{\omega}}{\hat{\omega}}} \left[\frac{Y}{\mu} \frac{1+\hat{\omega}}{1+\eta\hat{\omega}} \frac{1}{\eta} \left(\frac{\bar{P}}{\bar{w}} / \frac{\eta}{\eta-1} \right)^{\eta-1} \right]^{\frac{1+\eta\hat{\omega}}{\hat{\omega}(\eta-1)}}.$$
(19)

This equation relates the optimal amount of known bundlers to a producer's idiosyncratic productivity, z_i . More productive producers find it optimal to accumulate more customers. A yet different way to think about the producers' optimal marketing decision is to use (15) and express (19) in terms of the real wage targeted by a producer:

$$\frac{w_i}{\bar{P}} = \frac{\eta - 1}{\eta} \left[\frac{1 + \hat{\omega}}{1 + \eta \hat{\omega}} \frac{Y}{\mu} \frac{1}{\eta} \right]^{\frac{1}{\eta - 1}} z_i.$$
(20)

The real wage is proportional to idiosyncratic technical productivity, z_i . Resulting from producers' product market power, workers receive only the inverse mark-up in the product market, $\frac{\eta-1}{\eta}$, of the producer's technical productivity. Additionally, producers pay a mark-down stemming from their monopsonistic power in the labor market, $\frac{1+\hat{\omega}}{1+\eta\hat{\omega}}$. The mark-down is applied to the additional amount of goods sold per producer for one unit of marketing expenses, Y/μ , multiplied by the profit margin per goods sold (in terms of goods), $1/\eta$.

To solve the model further, we need to make a functional form assumption about the distribution of idiosyncratic productivity, z_i . Assuming that z_i is lognormally distributed, $z_i \sim LN(\ln \bar{z}, \Sigma^2)$, (and learned after entry) allows us to solve the model analytically.¹⁸

Recall that for any log-normally distributed random variable $z \sim LN(\ln \bar{z}, \Sigma^2)$ and real number x:

$$E(z^x) = \overline{z}^x \phi^{x^2}$$
, with $\phi = \exp(0.5\Sigma^2)$.

Further, observe that, since $\overline{\Theta}$ is the expected value of Θ_i , we obtain from (19) after taking expectations:

$$\left[\frac{Y}{\mu}\frac{1+\hat{\omega}}{1+\eta\hat{\omega}}\frac{1}{\eta}\left(\frac{\bar{P}}{\bar{w}}/\frac{\eta}{\eta-1}\right)^{\eta-1}\right]^{-\frac{1+\eta\omega}{\hat{\omega}(\eta-1)}} = E\left(z_i^{\frac{1+\hat{\omega}}{\hat{\omega}}}\right) = \bar{z}^{\frac{1+\hat{\omega}}{\hat{\omega}}}\phi^{\left(\frac{1+\hat{\omega}}{\hat{\omega}}\right)^2} \tag{21}$$

Dividing Equation (19) by Equation (21) allows us to express individual marketing choices in a more compact form:

$$\frac{\Theta_i}{\bar{\Theta}} = \left(\frac{z_i}{\bar{z}\phi}\phi^{-\frac{1}{\bar{\omega}}}\right)^{\frac{1+\bar{\omega}}{\bar{\omega}}} \tag{22}$$

This equation highlights that the more a producer's productivity exceeds average productivity $(z_i > \bar{z}\phi)$ the more customers it accumulates relative to the average. Furthermore, we see from (22) that $\log \Theta_i$ is normally distributed and has a larger variance than $\log z_i$ because $\frac{1+\hat{\omega}}{\hat{\omega}} > 1$. This means that the distribution of networks, i.e., the distribution of Θ_i , which is log-normal, is more right skewed than the productivity distribution. In particular, a producer with average productivity knows fewer customers than the average producer by a factor of $\phi^{-(\frac{1+\hat{\omega}}{\hat{\omega}^2})} < 1$. This effect is the stronger the larger the variance of idiosyncratic productivity, ϕ . This means that the endogenous customer acquisition decision amplifies productivity heterogeneity. Furthermore, the difference between the productivity distribution and the distribution of networks becomes smaller as $\hat{\omega}$ increases. In the limit, $\hat{\omega} \to \infty$, productivity and customer accumulation are proportional. A stronger

¹⁸Strictly speaking, we solve an approximation that ignores the upper bound on Θ_i . The support of the log-normal distribution of z_i has no upper bound and, hence, there are always some firms for which (18) produces a $\Theta_i > 1$. However, as we later show in our calibration, that fraction is small and can be made arbitrarily small by choosing the marketing cost μ appropriately without changing the model results of interest.

size-wage trade-off renders the acquisition of additional customers less attractive because wages rise too fast.

Plugging Equation (22) into the size-wage trade-off, (15), yields that producerlevel wages are proportional to idiosyncratic productivity:

$$w_i = z_i \bar{w} \bar{z}^{-\frac{1+\hat{\omega}}{1+\eta\hat{\omega}}} \phi^{-\frac{(1+\hat{\omega})^2}{\hat{\omega}(1+\eta\hat{\omega})}},\tag{23}$$

so that marginal costs are constant across plants. Consequently, using (10), all producers charge the same price:

$$p_i = \frac{\eta}{\eta - 1} \bar{w} \bar{z}^{-\frac{1+\hat{\omega}}{1+\eta\hat{\omega}}} \phi^{-\frac{(1+\hat{\omega})^2}{\hat{\omega}(1+\eta\hat{\omega})}}.$$
(24)

This, in turn, implies that each producer sells the same quantity of the intermediate good to each bundler it knows. Given that idiosyncratic prices are constant, we have, using (7), that this quantity is:

$$l_i z_i = y_i = \left(\frac{p_i}{\bar{P}}\right)^{-\eta} Y = Y(\Gamma\bar{\Theta})^{\eta/(1-\eta)}.$$
(25)

In particular, this also means that the real price charged to a bundler is given by:

$$\frac{p_i}{\bar{P}} = \frac{\hat{P}}{\bar{P}} = (\Gamma \bar{\Theta})^{-1/(1-\eta)}, \qquad (26)$$

and, using (10), the real wage is given by:

$$\frac{w_i}{\bar{P}} = (\Gamma\bar{\Theta})^{-1/(1-\eta)} \frac{\eta-1}{\eta} z_i.$$
(27)

Finally, plugging

$$\frac{\bar{P}}{\bar{w}} = (\Gamma\bar{\Theta})^{1/(1-\eta)} \frac{\eta}{\eta-1} \bar{z}^{-\frac{1+\hat{\omega}}{1+\eta\hat{\omega}}} \phi^{-\frac{(1+\hat{\omega})^2}{\hat{\omega}(1+\eta\hat{\omega})}},\tag{28}$$

into Equation (21), we can derive the average network size:

$$\bar{\Theta} = \frac{Y/\Gamma}{\mu} \frac{1}{\eta} \frac{1+\hat{\omega}}{1+\eta\hat{\omega}}.$$
(29)

Importantly, the average network size depends negatively on the size-wage elasticity, $\hat{\omega}$, as higher monopsony power discourages customer accumulation. It depends positively on market size per producer gained by a unit of marketing costs, $\frac{Y/\Gamma}{\mu}$.

This concludes our discussion of the optimal marketing choice. Before we turn to the final producer decision, namely, market entry, we point out two properties of optimal producer size. Combining (22) and (25), producer size is given by:

$$l_i \Theta_i = z_i^{1/\hat{\omega}} Y(\Gamma \bar{\Theta})^{\eta/(1-\eta)} \bar{\Theta} \left(\frac{1}{\bar{z}\phi} \phi^{-\frac{1}{\hat{\omega}}}\right)^{\frac{1+\hat{\omega}}{\hat{\omega}}}$$
(30)

From this equation follows immediately that producer size is increasing in idiosyncratic productivity. We note that this holds despite the fact that workers per known bundler, l_i , decrease in idiosyncratic productivity given the independence of y_i from idiosyncratic productivity. This is because more productive producers choose to know more bundlers.

Secondly, from (30), we obtain an explicit solution for the standard deviation of log employment at the producer level:

$$std\left(\log(l_i\Theta_i)\right) = std\left(\frac{1}{\hat{\omega}}\log z_i\right) = \frac{1}{\hat{\omega}}\Sigma.$$
 (31)

That is, the distribution of log producer employment is, similar to the distribution of networks, normally distributed. Its dispersion depends positively on the dispersion of idiosyncratic productivities, Σ . Importantly, and consistent with the data in Figure 4, it depends negatively on the size-wage elasticity.¹⁹

¹⁹Specifically, we refer to the right-upper panel in Figure 4 which shows a positive relationship but only because the y-axis displays West-East differences, instead of East-West differences, in the standard deviation of log employment at the industry level.

4.2.3 Producer Entry

We assume free producer entry which implies that competition drives average producer profits to zero. We note that producers learn their idiosyncratic productivity level only after entry. Let $\lambda \bar{P}$ (λ is measured again in terms of the output good) be the costs to establish a producer. Given the marketing and downstream pricesetting behavior, we obtain that producers enter until average operating profits, (16), equal entry costs:

$$\int \Theta_i y_i (p_i - \frac{w_i}{z_i}) - \int \mu \bar{P} \Theta_i = \lambda \bar{P}$$
(32)

which implies, using Equations (25)-(27):

$$\lambda = \int_{V_{1}} \left[\Theta_{i} Y \left(\Gamma \bar{\Theta} \right)^{\frac{\eta}{1-\eta}} \left(\Gamma \bar{\Theta} \right)^{-\frac{1}{1-\eta}} \left(1 - \frac{\eta - 1}{\eta} \right) \right] di - \mu \int \Theta_{i} di$$
(33)

$$\lambda = \frac{Y}{\Gamma} \frac{1}{\eta} - \mu \bar{\Theta}. \tag{34}$$

This equation has an intuitive interpretation. The market entry costs in goods λ has to be equal to the goods sold per producer, Y/Γ , multiplied by the profit margin per goods sold (in terms of goods), $1/\eta$, net of expected marketing costs, $\mu\bar{\Theta}$.

4.3 Equilibrium

In equilibrium, the total amount of employment needs to equal aggregate labor supply. We abstract from agglomeration effects whereby a larger economy enjoys more product varieties and is, therefore, more productive. For this reason, we fix the aggregate labor supply at one unit.²⁰ Hence, labor demand of all active

²⁰If we analyzed only one geographical unit, for instance, West Germany, this would be an innocuous normalization. However, when we calibrate the model separately for East and West Germany, we make this abstraction for both regions, and, thus, disregard the possibility that East Germany is less productive simply because it is smaller.

producers, (30), integrated over all producers needs to be one:

$$\Gamma \int \Theta_i l_i di = \Gamma \int z_i^{\frac{1}{\omega}} Y(\Gamma \bar{\Theta})^{\eta/(1-\eta)} \bar{\Theta} \left(\frac{1}{\bar{z}\phi}\phi^{-\frac{1}{\bar{\omega}}}\right)^{\frac{1+\bar{\omega}}{\bar{\omega}}} di = 1$$
(35)

which solving for Y yields:

$$Y = \bar{z}\phi\underbrace{(\Gamma\bar{\Theta})^{\frac{1}{\eta-1}}}_{=\hat{P}/\bar{P}}\phi^{\frac{2}{\hat{\omega}}}.$$
(36)

This equation highlights key properties of the model: First, aggregate output increases not only with expected technical productivity, $\bar{z}\phi$, but also in the number of intermediate good producers known to the representative bundler, $\Gamma\bar{\Theta}$, through a love-of-variety effect. The effect can alternatively be expressed as the ratio of the average price charged to a bundler, \hat{P} , and the aggregate price index, \bar{P} . It reflects the fact that a larger variety of intermediate inputs used by the final goods producer increases its efficiency and, thus, lowers aggregate prices. Second, the last term, $\phi^{\frac{2}{\phi}}$, is a misallocation effect.²¹ There is a complementarity between technical productivity, z_i , and marketing expenses: More productive producers use less labor input for every good they produce, decide to know more bundlers and, thus, produce more goods. The larger the dispersion of technical productivity, ϕ , the more the economy is able to exploit this complementarity. Monopsony power, that is, a larger $\hat{\omega}$, limits the incentive to do so and, thus, reallocates workers from the most to less productive producers.

Ultimately, Equation (36) together with the average network size, (29), and producer entry, (34), determine the aggregate equilibrium in the economy. Normalizing average producer productivity $\bar{z}\phi$ to one and solving these equations for aggregate output, the average number of known bundlers, and the share of active

 $^{^{21}}$ It is similar to an Oi-Hartman-Abel effect (see Oi, 1961; Hartman, 1972; Abel, 1983) from the investment literature.

producers yields:

$$Y = \left(\frac{1}{\mu\eta} \frac{1+\hat{\omega}}{1+\eta\hat{\omega}}\right)^{\frac{1}{\eta-2}} \left(\phi^{\frac{2}{\hat{\omega}}}\right)^{\frac{1}{\eta-2}} \phi^{\frac{2}{\hat{\omega}}},\tag{37}$$

$$\bar{\Theta} = \frac{\lambda}{\mu} \left[\frac{1}{\eta - 1} \left(\frac{1 + \hat{\omega}}{\hat{\omega}} \right) \right],\tag{38}$$

$$\Gamma = \frac{1}{\lambda} \frac{\eta - 1}{\eta} \frac{\hat{\omega}}{1 + \eta \hat{\omega}} Y.$$
(39)

Equation (37) shows that output is the product of three terms that are all negatively affected by the size-wage trade off. The last term, $\phi^{\frac{2}{\omega}}$, is the aforementioned Oi-Hartman-Abel misallocation effect on output that would also be present in a monopsony model with heterogeneous producers but without product market power, as we show in Appendix B. The first two terms represent the aforementioned love-for-variety effect because a steeper size-wage trade off restricts the varieties available to bundlers. The first of the two, $\left(\frac{1}{\mu\eta}\frac{1+\hat{\omega}}{1+\eta\hat{\omega}}\right)^{\frac{1}{\eta-2}}$, would also be present in a model without producer heterogeneity, $\phi = 1$. The second of the two, $\left(\phi^{\frac{2}{\omega}}\right)^{\frac{1}{\eta-2}}$, captures the interaction of product market power, monopsony power, and producer heterogeneity.

From these equations also follows that aggregate labor compensation, which equals aggregate output minus entry and marketing costs, is proportional to aggregate output, where the proportionality factor is the inverse markup:

$$LC = Y - \Gamma(\lambda + \mu\bar{\Theta}) = Y \left[1 - \left(\frac{\eta - 1}{\eta} \frac{\hat{\omega}}{1 + \eta\hat{\omega}} + \frac{1}{\eta} \frac{1 + \hat{\omega}}{1 + \eta\hat{\omega}} \right) \right] = Y \frac{\eta - 1}{\eta}.$$
 (40)

This means that it is irrelevant whether we compare Y or LC differences across geographical units in what follows.

5 Numerical Implementation

5.1 Results

The set of model parameters are the standard deviation of productivity, Σ , the degree of product market power, η , the unit marketing costs, μ , the entry costs,

 λ , and the elasticity of wages with respect to employment, $\hat{\omega}$. Our strategy is to calibrate the model to the West German economy given the estimate of $\hat{\omega}_W = 0.078$ from Section 3.2.

Note from Equation (37) that, once we fix $\hat{\omega}$, the key parameters to understand the relative output between two regions, the main statistic of interest, are product market power, η , and the dispersion of idiosyncratic productivities, ϕ . Bundesbank (2017) finds an average price-cost margin of 1.4 in Germany, and, therefore, we set $\eta = 3.5$. We want to calibrate the dispersion for idiosyncratic productivities to match the share of employment at large plants. In the data, we identify a large plant as one that has more than 249 employees. In addition, given that the data is truncated at plants with at least 10 employees, we have to impose the same truncation in the calibration. For both reasons, we require a notion of plant size in the model. Therefore, we effectively calibrate ϕ and the entry costs, λ , jointly to match average plant size (62 employees) and the share of employment at large plants (39%) in the data (for West Germany).

Given this calibration, marketing costs μ do not affect relative productivities between East and West Germany, and, thus, different choices would only lead to a recalibration of λ . However, the marketing cost can be pinned down by the data we use in Figure 5, and we therefore set $\mu = 25$ to match an average West German ratio of marketing costs to sales of 1 percent.

To isolate and quantify the effect of a steeper size-wage trade-off in East Germany, we start from the parameters calibrated to West Germany and change exclusively $\hat{\omega}$, setting it to the value estimated in Section 3.2 for East Germany. Table 2 displays the results of this exercise, in the column entitled "*Model East*". For the private, non-primary sector (top panel), $\hat{\omega}_W$ is 0.078 and $\hat{\omega}_E$ is 0.094.

First and importantly, by varying only $\hat{\omega}$, the model matches the moments of the plant-size distribution that were targeted in West Germany extremely well in East Germany, where they were not targeted. That is, the average plant size decreases from 62 to 45 employees compared to 46 in the data, and the share of workers employed at large plants decreases from 39 to 22 percent compared to 21 percent in the data. Second, the model, through these effects of $\hat{\omega}$ on the plant size distribution, implies a substantial drop in productivity by 10 percentage points. In other words, the model explains a little more than a third of the output differences

Variable	Model West Model East		Data West	Data East	
	Private non-primary sector				
	$\hat{\omega}_W = 0.078 \text{ and } \hat{\omega}_E = 0.094$				
$1/\Gamma$	61.4	44.6	61.4	46.4	
$std(\log(\theta_i l_i))$	0.96	0.84	0.91	0.83	
Share $E > 249$	0.39	0.22	0.39	0.21	
Y_{east}/Y_{west}	0.9 0.72			72	
	Manufacturing sector				
	$\hat{\omega}_W = 0.088 \text{ and } \hat{\omega}_E = 0.131$				
$1/\Gamma$	98.5	57.1	98.5	64.2	
$std(ln(\theta_i l_i))$	1.11	0.90	1.05	0.94	
Share $E > 249$	0.55	0.24	0.55	0.31	
$Y_{east}/Y_{west}\%$	0.84		0.68		

Table 2: Size distortions and output losses: model vs. data

Notes: The table compares model simulated moments to data moments from the VSE and German national accounts for the private, non-primary sector (top panel) and manufacturing (bottom panel). $1/\Gamma$: Average plant size, $std(\log(\theta_i l_i))$: Standard deviation of log plant size. Share E > 249: Share of employment at plants with more than 249 employees. Y_{east}/Y_{west} : Output per worker in East relative to West Germany.

per worker between the two regions. From Equation (40) it follows that the model also rationalizes a 10 percent lower labor compensation in the East relative to the West.

Section 3.2 shows that differences in the size-wage trade-off are particularly large in manufacturing. To investigate the implications for productivity differences, we next, keeping the general calibration strategy constant, recalibrate our economy to the manufacturing sector in West Germany. The bottom panel of Table 2 shows that the average plant size in manufacturing is larger than in the total private, non-primary sector and that a larger share of workers is employed at large plants. Accordingly, we adjust the dispersion of idiosyncratic productivity, Σ , and entry costs, λ . Bundesbank (2017) finds that average price-cost margins in manufacturing are lower than in the private sector as a whole, implying $\eta = 6$.

The panel shows that also for the manufacturing sector the difference in the size-wage relationships alone is able to explain the smaller average plant size and the lower share of employment at large plants in East Germany. Importantly, and consistent with the data, the model produces output differences in manufacturing that are larger than in the private sector as a whole. The model predicts that output is 16 percent lower in East relative to West Germany, in the data the difference is 32 percent.

	Private non-primary	Manufacturing
Total productivity difference	10.3%	15.5%
OHA-misallocation effect, $\phi^{\frac{1}{\hat{\omega}}}$	5.2%	10.6%
Love of Variety (LoV), $\left(\frac{1}{\mu\eta}\frac{1+\hat{\omega}}{1+\eta\hat{\omega}}\right)^{\frac{1}{\eta-2}}$	1.9%	2.9%
Misallocation LoV interaction, $\phi^{\frac{1}{\hat{\omega}}\frac{1}{\eta-2}}$	3.5%	2.7%

Table 3: Decomposition of Output Loss

Notes: The table displays the relative output loss per worker in East relative to West Germany, $1 - Y_{east}/Y_{west}$ decomposed, to the first order, into the three channels highlighted in the discussion of Equation (37).

Table 3 now decomposes the predicted output losses into the three channels we have highlighted in Equation (37). In the private, non-primary sector, the Oi-Hartman-Abel misallocation effect that would also be present in a model without customer accumulation makes up roughly half of the total productivity loss. In manufacturing, the share of productivity losses attributed to this effect is somewhat larger.

Of the two terms representing the distortionary effect of monopsony power on network size, the interaction term is quantitatively larger than the pure loveof-variety effect that would also be present in a homogeneous producer model. In other words, the model implies that monopsony power is particularly costly, when it hinders the most productive producers to accumulate customers and grow, rendering the entire production network in the economy less efficient.

5.2 Policy Discussion

One policy tool often discussed in the context of helping distressed areas are entry cost subsidies. Equation (37) makes clear that this policy would fail to increase output per worker in our model. That is, increasing the number of active plants

by decreasing entry costs will fail to create larger networks because producers would simply accumulating fewer customers, (see Equation 38) and, hence, will leave the number of total bundlers known to producers, $\Gamma\bar{\Theta}$, unchanged. Instead, the model highlights the importance of creating large producers. One way for policymakers to increase the number of large producers is to subsidize marketing expenses. In fact, Equation (37) shows that output is directly related to the level of these expenses, $\left(\frac{1}{\mu}\right)^{1/(\eta-2)}$. Hence, to increase output by 10 percentage points, the policy would need to decrease marketing expenses by 15% through subsidies. Note, this channel would work exclusively through increasing networks, i.e., the variety of products known to different bundlers, which increases their productivity. It would not change the relative inefficient distribution of labor over intermediate good producers, as Equation (31) shows.

We identify collective bargaining, i.e., collective bargaining being concentrated at large plants, as the root of the relative size distortion. Table 1 shows that, in the context of our model, having collective bargaining representation throughout the plant size distribution would be the preferable cure to this problem rather than having no collective bargaining at all because collective bargaining depresses the size-wage relationship. That is, it raises wages most at the bottom of the size distribution which reduces plants' monopsony power. In fact, using the size-wage relationship from the workers covered by collective bargaining, $\hat{\omega} = 5.8$, increases labor productivity by 22% in West Germany in our model. However, such an institutional setting may well come at the cost of aggregate employment which the model abstracts from. Moreover, in a dynamic setting, small plants may at the same time be young plants that face borrowing limits and increasing their labor cost might depress their employment growth.

6 Differences in Physical Input Factors and Reallocation

This section considers alternative explanations for missing large plants in East Germany and resulting persistent productivity differences between the two regions. In particular, we consider whether a more sclerotic labor market in East Germany may fail to reallocate labor to large, productive plants, and whether plants in the East suffer from inferior input factors. We find that these factors are, indeed, important to understand the initial convergence after reunification but they are unlikely to be important factors in explaining the long run non-convergence.

6.1 Missing Reallocation



Figure 6: Job and Worker Turnover Rates

Notes: The first panel displays the job turnover rate (the sum of job creation and job destruction). The second panel displays the worker turnover rate (the sum of accessions and separations). The third panel displays the share of employment at plants entering in a quarter. Calculations are based on the *AWFP* data from the private, non-primary sector.

Productivity might be lower in East Germany because the economy has failed to reallocate labor from the former state-run, unproductive plants towards more productive plants. Boeri and Terrell (2002) stress that the associated job reallocation has been important for productivity growth in former Soviet Republic countries.²²

Using the AWFP, we study job and worker reallocation in detail. In the AWFP, a worker is considered to be working for a given plant in a given quarter when she is employed at this plant at the end of the quarter. From this definition follows the number of jobs at a plant *i* at the end of a quarter, E_{it} , the number of hires, H_{it} (a worker that was not working for that plant at the end of the previous quarter), as well as the number of separations, S_{it} (a worker that no longer works for a plant at the end of the quarter), and the net job flow at a plant, $JF_{it} = E_{it} - E_{it-1}$.

 $^{^{22}}$ Even for the US, the evidence suggests that much of long-run productivity growth is driven by the reallocation of jobs from less to more productive plants (see Foster et al. (2001)).

Figure 7: Industry Convergence



Notes: The figure displays the Kullback-Leibler divergence index between the West and East German employment distribution over 21 industries: $KL = \sum_{i=1}^{2} 1P(x_i) \log \frac{P(x_i)}{Q(x_i)}$, where $P(x_i)$ is the employment share of industry *i* in the West and $Q(x_i)$ is the corresponding share in the East. Calculations are based on the AWFP data from the private, non-primary sector.

When a plant decreases employment within a quarter $(JF_{it} < 0)$, we count this as job destruction, JD_{it} . When employment increases $(JF_{it} > 0)$, we count this as job creation, JC_{it} . As we are interested in longer-term trends, we seasonally adjust all data series using the X-12 ARIMA CENSUS procedure.

Next, we define flow rates, where we use the average of contemporaneous and lagged end-of-quarter employment as the denominator:²³

$$N_{it} = [E_{it} + E_{it-1}]/2.$$

For example, the job turnover rate is given by:

$$JTR_{it} = \frac{JC_{it} + JD_{it}}{N_{it}}.$$
(41)

Figure 6a displays the job turnover rate for East and West Germany. Job reallocation in the East has been relatively high following the years after reunification, likely contributing to the rapid productivity growth during these years,

 $^{^{23}}$ See Davis et al. (1996) for a thorough discussion of these rates.

Table 4: Differences in Output per Worker by Sector in 2014

	MF	UTL	CON	RTL	TR	TUR	FIN	RE	TPS	OPS
$\Delta \log(Y/N)$ %	39.2	8.1	19.3	29.4	23.8	17.8	44.4	32.8	43.6	41.6

Note: The table displays log differences in output per worker between West and East Germany by major sectors. MFG: Manufacturing, UTL: Utilities, CT: Construction, RTL: Retail, TR: Transportation, TUR: Tourism, FIN: Finance, TPS: Technical professional services, OPS: Other professional services. Calculations are based on German national accounts.

yet, missing reallocation does not appear to be the reason for the missing productivity convergence afterward. That is, job reallocation has remained higher in East than in West Germany throughout the sample period. In fact, the amount of job turnover in East Germany was sufficient to destroy and create every job 2.8 times since 1993. An economy may reallocate workers across plants also without reallocating jobs, for example, to increase match quality between existing jobs and workers. Figure 6b shows that the East also does not fall short in terms of worker reallocation relative to the West. In particular, worker reallocation has been particularly high after reunification in East Germany and has nearly converged to the West level afterward. Finally, the third panel considers one particular form of job reallocation, namely, that arising from new plant entry. It displays the share of total employment in a quarter that is due to employment at plant start-ups. Again, if any, the East is the more dynamic economy with a higher employment share at start-ups throughout the sample period.

Reallocation of input factors might be particularly slow across industries. The idea is that the industry composition has been significantly different in the East at reunification and that the East has failed to reallocate jobs to more promising industries. To better understand the role of different industry structures between the two regions, Figure 7 plots the Kullback-Leibler divergence index between the West and East German employment distribution over 21 industries. The industry distributions between the two regions have diverged initially following reunification as large, unproductive plants exited in East Germany.²⁴ Strikingly, when convergence in productivities started to slow down in 1995, convergence in the industry structures has taken off. The convergence in industries has markedly

²⁴Figure B7 displays the convergence for each of the 21 underlying industries.

slowed down since 2008, but the overall pattern is inconsistent with the idea that the industry structure present before reunification is still driving output differences today. Most importantly, Table 4 shows that differences in output per worker are as large within sectors as in the economy as a whole. The East is less productive in each sector, and differences range from 0.44 log differences in finance to 0.08 in electricity and water supply.

6.2 Capital and Labor Inputs

One possible explanation for differences in output per worker across regions are differences in their physical inputs. Burda (2006) puts forwards an explanation where capital and labor are imperfectly mobile across German regions and capital accumulation is subject to frictions. Since the East had a lower capital stock in 1992, convergence in labor productivity is slow as it takes time for the East to accumulate capital. Figure 8 compares the (net, i.e., after depreciation) capital stock per worker in East to West Germany. Though East Germany started with a significantly lower level, the capital stock per worker, different from output per worker, has almost converged by 2005. In 2019, the difference in the capital stock per worker is only 3%. Thus, with a constant returns to scale Cobb-Douglas production function and a standard capital share of 30% this difference in capital intensity would explain 1.5 percentage points of labor productivity differences.

We are particularly interested in differences in the non-primary private sector. Unfortunately, the German national accounts do not provide the capital stock by detailed industry and region. However, it provides data on the production sector (manufacturing plus mining). Figure 8 shows that East Germany has overtaken the West German economy in 1998 in capital intensity in that sector.

One possible hypothesis is that the capital stock is poorly measured and East German plants still produce with outdated capital from before reunification. Figure 8 displays the modernity of the capital stock, i.e., the difference between the net and gross capital stock. Consistent with the large catch-up in capital accumulation, the capital stock is of a younger vintage in East Germany suggesting that, if any, it is of relatively higher quality.

Besides differences in the capital stocks, differences in the quality of the labor





Notes: The left panel displays the capital stock (after depreciation) per worker in East and West Germany. It shows is for the total economy and the production sector (manufacturing plus mining). The right panel displays the modernity of the current capital stock (the difference between the net and gross capital stock). Calculations are based on national account data.

inputs may explain differences in output per worker. The AWFP has information on workers' age, formal education, and work task. To understand how changes in relative worker quality might have impacted convergence between East and West Germany, we proxy productivity by wages and map these quality measures into wage outcomes. To be specific, we estimate the following (employment-weighted) regression for each year

$$lnw_{jt} = \alpha_0 + East_j + F(age_{jt}, educ_{jt}, task_{jt}) + \epsilon_{jt}, \tag{42}$$

where lnw_{jt} is the log average wage at plant j in year t, $East_j$ is a dummy that is one when plant j is located in the East, and age_{jt} is the share of employment of workers across different age categories, $educ_{jt}$ is the share of employment across different education categories, and $task_{jt}$ is the share of employment across different task categories at the plant. We estimate two versions of the regression, one with the function F and one without it. In the latter, $East_t$ simply provides the employment-weighted log-wage differences between East and West Germany for each year. In the former, it provides the same but controlling for different skill distributions in East and West Germany.

Figure 9 compares the two regressions. It shows that differences between the

Figure 9: Worker Quality



Notes: The figure displays the predicted log wage effect of a plant being located in East Germany (*No controls*) and the predicted effect of a plant being located in East Germany when controlling for worker skills (*With controls*). Estimation is based on the non-primary, private sector from the AWFP.

mean difference in log wages and the mean difference in log wages after controlling for observable worker characteristics is never particularly large. The predicted wage difference between East and West Germany would have been 0.05 log points larger than the realized wage difference in 1993, if the distribution of worker qualities had been the same. The skill distributions converge over time, and the better distribution of worker qualities in West Germany explains 0.01 log points of the difference in wages between the two regions by 2014. Figure B6 in the Appendix displays the underlying relative employment shares of worker characteristics over time. It shows that the initial difference is mostly due to a more experienced and more educated workforce in the East. The convergence over time is mostly due to converging education shares and workers with management skills becoming relatively more abundant in the West.

The relative improvement of the West Germany skill distribution has in part resulted from an outflow of workers from East Germany, see Uhlig (2006). However, as just argued, this seems rather a process of convergence than divergence. Moreover, Figure 10 shows that net-outflows from the East to the West have converged to zero by 2013.

Figure 10: Net Migration



Notes: The figure displays the net migration from East to West Germany. The data is from the German statistical agency.

Finally, workers' selecting into the two regions may also be driven by selection on non-observable productivity. However, Fuchs-Schündeln and Izem (2012), using worker migration close to the boarder, finds that job effects instead of differences in human capital explain regional non-convergence in Germany. Heise and Porzio (2021), using matched plant-worker data, find that worker fixed effects may explain up to 10% of lower wages in the East. However, they also find that differences in plant fixed effects are the main driver behind wage differences.

7 Conclusion

Recent work by Hsieh and Klenow (2014) and Braguinsky et al. (2011) documents a positive relationship between countries' labor productivity and plant size. They rationalize such a relationship by differences in governmental policies that punish being large. Such policies reduce the optimal plant size and, thereby, reduce substantially aggregate productivity. However, large labor productivity differences also persist across regions where governmental policies (and legal institutions enforcing these) are almost identical. We consider the case of Germany where 23 years after reunification, the East German private, non-primary sector remains 32% less productive today than its West German counterpart. In this context, we show that differences in the institution of collective bargaining, despite identical policies governing this institution, lead to higher labor market monopsony power in East relative to West Germany because of historical reasons. We show that monopsony power leads to aggregate labor productivity losses by reducing optimal plant size and by distorting the distribution of employment over plants. The difference in monopsony power that we estimate explains a ten percentage point lower labor productivity in the East German private, non-primary sector.

A Industry Classifications

	VSE 2008	VSE 2003	National accounts
MFT	10 - 15	15	C (MFG)
MWP	16 - 18/31 - 32/58 - 60	20	C (MFG)
MCP	19 - 23	22/25 - 26	C (MFG)
MME	24 - 25/28	30	C (MFG)
MLE	26 - 27	32	C (MFG)
MVE	29-30	37	C (MFG)
UTL	35 - 39	36/43/90	D/E (UTL)
CON	41 - 42	45	F (CON)
COP	43	46/47	F (CON)
WHC	45 - 46	48	G (TRD)
RTO	47/33	51	G (TRD)
TRA	49 - 51/61 - 63	53 - 54	H (TRA)
STO	52 - 53	57	H (TRA)
TUR	55 - 56	52	I (TUR)
BAN	64	63	K (FIN)
INS	65 - 66	64	K (FIN)
RNS	68/72 - 75	71	M (TPS)
TES	69-71	72	M (TPS)
RES	77		N (OPS)
BAC	78-81	78	N (OPS)
OTS	82	93	N (OPS)

Table A1: Industry Classifications

Notes: The table provides a crosswalk that maps the 21 industries used in this paper into the industry classifications used by the VSE in 2008 and 2003 and the sectors from the national accounts. MFT: Food and textile manufacturing, MPW: Paper and wood manufacturing, MCP: Chemical and plastic manufacturing, MME: Metal manufacturing, MEL: Electronics manufacturing, MVE: Vehicle manufacturing, UTL: Utilities, CON: Construction, COP: Construction preparations, WHC: Wholesale and car retail, RTO: Other retail, TRA: Transportation, STO: Storage, TUR: Tourism, BAN: Banking, INS: Insurance, RNS: Research services, TES: Technical services, RES: Rental services, BAC: Building and area care, OTS: Other services.

Industry classifications have undergone several revisions since reunification. The AWFP data is organized by the so called WZ93 classification. The 2006 sample from the VSE uses the WZ03 classification. The 2010 and 2014 samples of the VSE use the WZ08 classification. Finally, national accounts are organized by sectors which are based on the WZ08 classification. Table A1 provides a cross-walk across the different classifications.

B A Simple Model of Monopsony Power

Consider the simplified version of our model in Section 4 without imperfect competition in the goods market, no customer accumulation, and no endogenous producer entry. Producers hire labor, l_i , and combine it with their idiosyncratic productivity, z_i , to produce a homogeneous output good, y_i . We assume again that a producer's wage is log-linear in its size, l_i :

$$w_i = \left(\frac{l_i}{\bar{l}}\right)^{\hat{\omega}}.\tag{A.1}$$

Hence, producers' profits are given by their revenues minus labor costs:

$$\Pi_i = P z_i l_i - l_i \left(\frac{l_i}{\bar{l}}\right)^{\hat{\omega}}.$$
(A.2)

Taking the first-order condition with respect to labor and rearranging gives a producer's optimal size as a function of its idiosyncratic productivity:

$$l_i = \bar{l} z_i^{\frac{1}{\bar{\omega}}} \left(\frac{P}{1+\omega}\right)^{\frac{1}{\bar{\omega}}}.$$
(A.3)

Labor market clearing implies that total labor demand is equal to the total labor supply of one. Hence, taking expectations of (A.3) where we assume again that z_i is log-normally distributed yields

$$\int l_i di = \bar{l} \bar{z}^{\frac{1}{\bar{\omega}}} \phi^{\frac{1}{\bar{\omega}^2}} \left(\frac{P}{1+\omega}\right)^{\frac{1}{\bar{\omega}}} = 1.$$
(A.4)

Dividing (A.3) by (A.4) and rearranging yields:

$$l_i = z_i^{\frac{1}{\hat{\omega}}} z^{-\frac{1}{\hat{\omega}}} \phi^{-\frac{1}{\hat{\omega}^2}}.$$
 (A.5)

Output of each producer is

$$y_i = z_i l_i = z_i^{\frac{1+\hat{\omega}}{\hat{\omega}}} z^{-\frac{1}{\hat{\omega}}} \phi^{-\frac{1}{\hat{\omega}^2}}.$$
 (A.6)

Finally, taking expectations and normalizing average productivity, $\bar{z}\phi$, to one yields for total output

$$Y = \int y_i di = \phi^{\frac{2}{\hat{\omega}}},\tag{A.7}$$

which is the counterpart to (37). The simple model highlights some key aspects of our baseline model. First, without customer search and endogenous entry, there is no output distortion resulting from the average producer size being too small as a result from monopsony power. Second, also in this simple model, the standard deviation of log producer-level employment is given by $\frac{\Sigma}{\hat{\omega}}$, i.e., monopsony power shrinks the producer-size dispersion by affecting most the employment choices of large producers. However, the effect on output is only $\phi^{\frac{2}{\hat{\omega}}}$ instead of $\phi^{\frac{2(\eta-1)}{\hat{\omega}(\eta-2)}}$ because the interaction with product market power is absent.

C Further Data on Plant Size Distributions in East and West Germany

Figure B1: Size Distribution AWFP



Notes: The figure displays the size distribution in East and West Germany. It displays the density function in the total private, non-primary sector in different years. Calculations are based on the AWFP data.

In this appendix, we show that differences in the plant-size distribution extend to earlier time periods and are not driven by differences in urbanization between East and West Germany or plant-age effects. To that end, we employ the AWFPdata which contains information going back to 1993, information on plants' locations at the German "Kreis" (county) level, and plant age.

Figure B1 displays the density of plants over log employment in East and West Germany starting in 1994. The size distribution diverged between 1994 and 2004 as large, unproductive plants exited the market in the East initially. Consistent with the *VSE* data, there is some, but very little, convergence in the size distribution between 2004 and 2014.

Figure B2 displays the plant size distribution conditional on a plant being located in a metropolitan area. To define these areas, we employ the the definition by Dijkstra et al. (2019). The figure shows that metropolitan areas have on average more large plants than non-metropolitan areas. Importantly, even within each area, the plant size distribution in East Germany is shifted to the left relative to West Germany and displays a less fat right tail.

One possible explanation for missing large plants in East Germany is that plants in the West are older on average, and the relatively young plants in the East may not yet have reached their desired size. Figure B3 shows, however, that



Notes: The figure displays the size distribution in East and West Germany. It displays the density function in the total private, non-primary sector conditional on plants being located in a metropolitan area. Metropolitan areas are defined by the OECD based on functional urban

areas. Calculations are based on the AWFP data.

Figure B3: Employment Share 250+ by Cohort



Age (quarters) Age Notes: The figure displays for different plant-entry cohorts the share of employment at plants with more than 249 employees over their life-cycles. Calculations are based on the *AWFP* data.

even within plant-entry cohorts, large plants are missing in East Germany. Already at entry, a cohort has fewer employment allocated at large plants in East Germany and a plant cohort in the East never catches up to its Western counterpart over its life-cycle.

D Analysis with Additional Regions in Germany

The *VSE* data allows us to distinguish between 5 regions within Germany: North, West, South-West, South, and East.²⁵. Our baseline analysis distinguishes only between two: the aggregate of West Germany and East Germany. This appendix extends the analysis and shows our empirical results when we distinguish the 4 regions within West Germany.





Note: The figures plot log differences in output per worker in 2014 against the share of employment at plants with more than 249 employees (left) and the standard deviation of log plant employment (right). Each dot represents a sector/region combination and displays the difference to the same sector in the northern region in Germany. The lines show weighted-least squares regressions.Data sources: VSE and VGR.

Figure B4 relates differences in output per worker to the phenomenon of missing large plants. It displays for each sector within each region the labor productivity gap and the gap in the share of large plants relative to the same sector in the northern region. Those sector/region combinations that have particularly low output per worker also have relatively few large plants operating in that sector/region.

Next, we use again data for 21 industries to show the relationship between the phenomenon of missing large plants and a steeper size-wage relationships. To that end, we estimate (1) for each region where we use the Northern region as base-line. The top panel of Figure B5 relates the resulting differences in the size-wage

²⁵North: Schleswig Holstein, Hamburg, Bremen, Berlin, and Lower Saxony; West: Northrhine-Westphalia; South-West: Hesse, Rhineland Palatinate, and Saarland; South: Baden-Württemberg and Bavaria; East: Thuringia, Saxony, Saxony-Anhalt, Mecklenburg Western Pomerania, and Brandenburg

relationship in a sector/region to the phenomenon of missing large plants. It displays for each sector within each region the difference in the size-wage relationship against the difference in the share of employment at large plants (left) and the difference in the standard deviation of log employment (right). Those sector/region combinations that have particularly steep size-wage curves also have relatively few large plants operating in that sector/region.

The bottom panels of Figure 4 show on the x-axes, for each industry, a double difference in the prevalence of collectively bargained wage contracts between large and small plants and between East and West. For the majority of industries this double difference is negative. This means that the fraction of collectively bargained wage contracts increases indeed more in plant size in the East than it does in the West. This double difference is plotted against our two measures of East-West differences in the plant size distribution: the share of employment at large plants (left panel) and the standard deviation of log plant-level employment (right panel). The relationship between collective-bargaining prevalence differences and plant-size differences is negative with an employment-weighted correlation of -.3 and -.4, respectively. Industries in which the prevalence of collectively bargained wages increases relatively more in plant size in the East are also those industries where, compared to the West, large plants are particularly missing in the East.

E Further Data on Differences between East and West Germany

This Appendix provides further data on differences in worker qualities and industry composition in East and West Germany. Figure B6 displays the employment share in East Germany relative to the employment share in West Germany for different measures of worker skills. The figure highlights that just after reunification, the East German workforce had a higher education level and workers performed more skilled tasks. Over time, the East German working population has become relatively older and relatively fewer workers work in management positions.

Figure B7 computes the log difference in employment shares of industries between East and West Germany (West-East). The left panel compares the relative

	East-West	East-West + finance dummy
> 249, Y/N	1.37	2.53
Std log, Y/N	1.37	2.53
$\omega, > 249$	1.37	2.53
ω , Std log	1.44	2.31
Collective, > 249	-1.2	-1.49
Collective, std log	-1.86	-2.06
	All regions	All regions + finance dummy
> 249, Y/N	6.2	6.11
Std log, Y/N	5.47	5.52
$\omega, > 249$	2.78	2.86
ω , Std log	2.62	2.85
Collective, > 249	-1.82	-1.52
Collective, std log	-1.84	-1.61

Table B1: T-statistics

employment distribution in 1996 to 1993, the middle panel compares 2006 to 1993, and the right panel compares 2014 to 1993. At reunification, the East has had relatively many workers employed in construction and few workers employed in manufacturing. The industry distribution changed little between 1993 and 1996, but convergence is visible afterward.



Figure B5: The Share of Large Plants, the Size-Wage Relationship, and Collective Bargaining

Note: The top panels plot the share of employment at plants with more than 249 employees (left) and the standard deviation of log plant employment (right) against the size-wage relationship. Each dot represents a sector/region combination and displays the difference to the same sector in the northern region in Germany. The bottom panel relates sectoral differences across regions in the share of employment at large plants and the standard deviation of log plant employment to the following double difference: $\log P(C|L, R_1) - \log P(C|S, R_1) - [\log P(C|L, R_i) - \log P(C|S, R_i)]$, where $P(C|\cdot)$ is the conditional probability of a worker being subject to collective bargaining in our sample in (L)arge (>249 employees) or (S)mall (\leq 249 employees) plants in region 1 and region *i*. The lines show weighted-least square regressions. Data sources: Calculations using the *VSE*.



Plant-Level Size-Wage Differences

Notes: The figure displays the difference in the size-wage slope between East and West Germany when the size-wage relationship is estimated using plant-level data. The dark gray bars are obtains the slopes of the size-wage relationship by regressing log average plant-level daily earnings on log plant-size. The light gray bars use plant-level fixed effects instead of earnings. Calculations are based on the *AWFP* data from the private, non-primary sector.

Figure B6: Employment Shares by Worker Observables



Notes: The figure displays employment shares in East Germany relative to employment shares in West Germany for different worker observables. The left panel displays relative employment shares by age groups. The center panel refers to formal education: *Low:* without any tertiary education, *Medium:* with professional training, *High:* academic tertiary education. The right panel refers to the work tasks of the employed: *Low:* Agricultural occupations, elementary manual occupations, elementary personal services occupations, elementary administrative occupations, *Medium:* Skilled manual occupations, skilled services occupations, skilled administrative occupations, *Semi-high:* Technicians, associate professionals, *High:* Professional occupations, managers (see Blossfeld (1987)). Calculations are based on the *AWFP* data from the private, non-primary sector.





Notes: The figure displays the difference in log employment shares (West-East) for 21 major industries between 1993 and 2014. Industries appearing from left to right: Food and textile manufacturing, Paper and wood manufacturing, Chemical and plastic manufacturing, Metal manufacturing, Electronics manufacturing, Vehicle manufacturing, Utilities, Construction, Construction preparations, Wholesale and car retail, Other retail, Transportation, Storage, Tourism, Banking, Insurance, Research services, Technical services, Rental services, Building and area care, Other services. Calculations are based on the *AWFP* data from the private, non-primary sector.

References

- ABEL, A. B. (1983): "Optimal Investment under Uncertainty," The American Economic Review, 73, 228–233.
- ARKOLAKIS, C. (2010): "Market Penetration Costs and the New Consumers Margin in International Trade," *Journal of Political Economy*, 118, 1151–1199.
- BACHMANN, R., C. BAYER, C. MERKL, S. SETH, H. STÜBER, AND F. WELLSCHMIED (2021): "Worker Churn in the Cross Section and Over Time: New Evidence from Germany," *Journal of Monetary Economics*, 117, 781–797.
- BERGER, D. W., K. F. HERKENHOFF, AND S. MONGEY (2019): "Labor market power," Tech. rep., National Bureau of Economic Research.
- BLANCHFLOWER, D. G., A. J. OSWALD, AND M. D. GARRETT (1990): "Insider Power in Wage Determination," *Economica*, 143–170.
- BLOSSFELD, H.-P. (1987): "Labor-Market Entry and the Sexual Segregation of Careers in the Federal Republic of Germany," *American Journal of Sociology*, 93, 89–118.
- BOERI, T. AND K. TERRELL (2002): "Institutional Determinants of Labor Reallocation in Transition," *Journal of Economic Perspectives*, 16, 51–76.
- BRAGUINSKY, S., L. G. BRANSTETTER, AND A. REGATEIRO (2011): "The Incredible Shrinking Portuguese Firm," Tech. rep., National Bureau of Economic Research.
- BROWN, C. AND J. MEDOFF (1989): "The Employer Size-Wage Effect," *Journal* of Political Economy, 97, 1027–1059.
- BUNDESBANK, D. (2017): "Mark-ups of Firms in Selected European Countries," Monthly Report, 53.
- BURDA, M. (2006): "Factor Reallocation in Eastern Germany after Reunification," American Economic Review (Papers and Proceedings), 96, 368–374.

- CINGANO, F., M. LEONARDI, J. MESSINA, AND G. PICA (2016): "Employment Protection Legislation, Capital Investment and Access to Credit: Evidence from Italy," *The Economic Journal*, 126, 1798–1822.
- DAVIS, S. J., J. C. HALTIWANGER, AND S. SCHUH (1996): Job Creation and Destruction, MIT Press.
- DIJKSTRA, L., H. POELMAN, AND P. VENERI (2019): "The EU-OECD Definition of a Functional Urban Area," Tech. rep., OECD Regional Development Working Papers.
- DROZD, L. A. AND J. B. NOSAL (2012): "Understanding International Prices: Customers as Capital," *American Economic Review*, 102, 364–95.
- FOSTER, L., J. C. HALTIWANGER, AND C. KRIZAN (2001): "Aggregate Productivity Growth, Lessons from Microeconomic Evidence," in *New Developments* in *Productivity Analysis*, University of Chicago Press.
- FUCHS-SCHÜNDELN, N. AND R. IZEM (2012): "Explaining the Low Labor Productivity in East Germany - A Spatial Analysis," *Journal of Comparative Economics*, 40, 1–21.
- GARICANO, L., C. LELARGE, AND J. VAN REENEN (2016): "Firm Size Distortions and the Productivity Distribution: Evidence from France," American Economic Review, 106, 3439–79.
- GOURIO, F. AND L. RUDANKO (2014): "Customer capital," *Review of Economic Studies*, 81, 1102–1136.
- GREEN, F., S. MACHIN, AND A. MANNING (1996): "The Employer Size-Wage Effect: Can Dynamic Monopsony Provide an Explanation?" Oxford Economic Papers, 48, 433–455.
- HALL, R. E. AND C. I. JONES (1999): "Why do some Countries Produce so much more Output per Worker than Other?" *Quarterly Journal of Economics*, 114, 83–116.

- HARTMAN, R. (1972): "The Effects of Price and Cost Uncertainty on Investment," Journal of economic theory, 5, 258–266.
- HEISE, S. AND T. PORZIO (2021): "The Aggregate and Distributional Effects of Spatial Frictions," .
- HSIEH, C.-T. AND P. J. KLENOW (2014): "The Life Cycle of Plants in India and Mexico," *The Quarterly Journal of Economics*, 129, 1035–1084.
- JOHNSON, P. AND C. PAPAGEORGIOU (2020): "What Remains of Cross-Country Convergence?" Journal of Economic Literature, 58, 129–75.
- OI, W. Y. (1961): "The Desirability of Price Instability under Perfect Competition," *Econometrica*, 58–64.
- SEDLÁČEK, P. AND V. STERK (2017): "The Growth Potential of Startups over the Business Cycle," American Economic Review, 107, 3182–3210.
- STEWART, M. B. (1987): "Collective Bargaining Arrangements, Closed Shops and Relative Pay," *The Economic Journal*, 97, 140–156.
- STÜBER, H. AND S. SETH (2017): "The Administrative Wages and Labor Market Flow Panel," FAU Discussion Papers in Economics, 1/2017, updated Dec. 2018.
- SVEJNAR, J. (2002): "Transition Economies: Performance and Challenges," Journal of Economic Perspectives, 16, 3–28.
- UHLIG, H. (2006): "Regional Labor Markets, Network Externalities and Migration: The Case of German Reunification," American Economic Review (Papers and Proceedings), 96, 368–374.