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Misallocations go a long way: evidence from firm-level data

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Misallocations go a long way: evidence from firm-level data

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Abstract

We analyze the link between resource misallocation and subsequent long-run economic growth. We use two unique and novel sources of data for Poland and measure misallocation inherited from the period of central planning, i.e. period where input prices did not determine the use of inputs at firm, industry and country level. We assess sectoral, regional and cohort dimension of the inputs misallocation. We then show that undercapitalization was more prevalent that overcapitalization, and that it was due mostly to the firm and sector level variation in factor inputs. Given this insight, subsequent reallocation of the resources required shifting of inputs not only between firms, but also between sectors: a process which is relatively more prone to frictions due to specialization and information. When analyzing the link to the rate of growth once market mechanisms were reinstated, we find that regions with more misaligned firms (especially in terms of undercapitalization) experienced lower subsequent economic growth. This result proves highly robust, even three decades since the market mechanisms were reinstated.

Keywords:

misallocation, privatization, transition

JEL Classification

P31, D24, O47

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1 Introduction

The economic profession believes that firms optimize input choices given the expected level of output, in order to minimize costs and subject to technological constraints. In market economies, some distortions in pricing the inputs and or access to technology may prevail, as well as frictions resulting in misallocation of inputs, but essentially firms' focus on profits translates to their efficient use of inputs. Empirical evidence suggests that even with these aligned incentives, misallocation is prevalent and may explain the dampening of the TFP growth within countries (e.g. Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Busso et al. 2013) as well as generating differences between countries in GDP per capita (e.g. Song et al. 2011; Bollard et al. 2013; Bartelsman et al, 2013; Kalemli-Ozcan and Sørensen, 2016, Inklar et al, 2017).[1]

The literature on the consequences of misallocation when markets for inputs do not exist, i.e. allocation of inputs is not driven by their prices, is scarce (Restuccia and Rogerson, 2017). Some studies of the agricultural sector in developing countries show that constraints on transferring land lead to substantial inefficiencies in production[2], but to the best of our knowledge no such analysis was done for an economy as a whole. Against this background, consider an economy with heavily distorted prices of inputs and firms which do not optimize *per se*, rather they are focused on meeting ad hoc output targets. Optimization, if at all, involves maximizing output (rather than profits), whereas constraints are driven by availability of inputs and ability to access them, rather than prices. This was the setup for centrally planned economies.[3] In this study we evaluate the long-run consequences of resource misallocation using an example of one such economy, Poland.

Specifically, we analyze the role of resource misallocation at the start of transition in determining the subsequent economic performance. We analyze the role of both within-firm inappropriate capital-labor ratio and through hoarding resources in inefficient firms and sectors. This separation is important, because according to Hsieh and Klenow (2009) misallocations affect the size of firms (less efficient firms have disproportionate access to inputs), but appears to have no effect on the capital-labor ratio across firms in India and China. However, prior studies refer to countries with market mechanisms at play, whereas in central planning the prices of inputs and outputs alike were heavily distorted, yielding different type of departures from optimal allocation.

To this aim we explore two unique datasets. One is a novel firm-level dataset of all state-owned enterprises in Poland prior to the onset of transition. Another is a firm-level based

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[1] Song et al (2011) and Bollard et al (2013) attribute growth in the manufacturing sector in China and India, respectively, to the ability of firms in the sector to reallocate efficiently. According to Bartlesman et al (2013) faulty firm-level decisions on how to allocate capital and labor lead to distortions in aggregate performance on a country-wide basis. See also a recent meta-analysis showing how misallocation hinders total factor productivity growth by Restuccia and Rogerson (2013), a literature review of Hopenhayn (2014) as well as review of causes and costs of misallocation by Restuccia and Rogerson (2017).

[2] E.g. de Janvry et al, 2015 for Mexico; Chen et al, 2017 for Ethiopia; Adamopoulos et al., 2017 for China; Restuccia and Santaeulalia-Llopis, 2017 for Malawi.

[3] In fact, misallocation or TFP measures cannot be developed at all in such economy for policy or evaluation purposes, as it has no measure of value added, relying on Material Production System rather than System of National Accounts. State monopolies and distorted prices of final products make sales a particularly unreliable measure of productivity.

sector-regional dataset on economic performance for Poland over the period of 1993-2013. Using this data we provide an assessment of the degree of misallocation and its sectoral, regional and cohort dimension.

Poland is an interesting case for a number of reasons. First, among all of the Central and Eastern European (CEE) economies it has demonstrated the fastest catching up over the past three decades since the collapse of central planning (Piatkowski, 2018). Second, it had a relatively high level of human capital and witnessed an educational boom over this period (Rutkowski, 1996). Third, Poland has experienced a remarkable change in economic structure: between 1995 and 2015, the share of manufacturing in output declined from roughly 60% to roughly 30% of GDP, with a corresponding change of an opposite sign and similar magnitude in the service sector. Given such performance of the Polish economy, one should expect that the original misallocation due to skewed incentives under central planning had little or no effect on the current economic performance.

We find that both under-capitalization of firms and allocation of resources towards the inefficient firms have negatively affected subsequent economic growth once the price mechanisms have been reinstated. The effects of misallocation carry over for more than two decades. Our findings are robust to measurement of misallocation, period of analysis as well as model specification. From these results we conclude that a causality from misallocation to weaker economic performance is plausible, while correlations are robust to a variety of checks.

While it is not very frequent that political systems remove price mechanisms altogether, our results provide important policy insights. First, there still remain many spheres where prices mechanisms do not exist to provide incentives in the markets. One obvious example is the environment, but one can easily bring up examples of resource use that were not subject to market mechanisms and which became so with technological or political innovations (e.g. sharing economy, marketization of public goods in the digital age, etc.). Hence, our conclusions may have indeed broad applications.

The paper is structured as follows. We first discuss the political and economic mechanisms behind allocation of inputs under central planning, thus characterizing the origins of misallocation prior the onset of transition. In the next section we move to discussing the existing empirical research on misallocation, presenting the empirical strategies. Section 4 discusses the unique data used in this study and presents the methods employed. We document the extent of misallocation in section 5 and discuss its consequences for the subsequent economic growth in section 6. In the concluding remarks, we draw policy implications of this study.

2 Central planning and misallocation

The centrally planned economies suffered from several inefficiencies. First, input allocation was an outcome of the political process rather than economic optimization (see eg. Estrin, 1991 or Piesse and Thrittle, 2000). While planning was to some extent based on input-output models, the economy wide plans for development were determined mainly by political considerations with considerable pressure from the Soviet Union, which too, paid little or no attention to input prices in allocations (Grossman, 1959; Grosfeld, 1987). For example, large heavy industry projects tended to be prioritized at the cost of the development of the consumer-oriented sectors (Weitzman, 1970).

Second, capital was excessively scarce (Grossman, 1953). The damage to physical capital in the aftermath of world war II capital was substantial (over 60% in Poland, Gella, 1998). The Warsaw Pact countries were forced to decline war reparations from Germany and stay outside the Marshall plan, which eliminated the external financing of reconstruction, leading to further undercapitalization. In later decades, machinery and equipment were not adequately upgraded despite technological advances (Grossman, 1966; Brada, 1989). The limitations in access to capital have been coupled with a political narrative which essentially excluded unemployment, leading to severe overmanning of many firms and industries (Blanchard et al., 1991; Aghion et al., 1994).

Third, unlike in market economies, firms were subject to the so-called soft budget constraint, i.e. the profitability of production was not a target of the firms. Their outputs and inputs were subject to economy wide central plans and could be changed ad hoc for political reasons. Given the lack of market incentive schemes, the soft-budget constraints lead to severe shortages of inputs (Kornai, 1980; Maskin, 1999; Maskin and Xu, 1999). As the size of sectors and enterprises were determined politically and not driven by market clearing prices, inefficient companies could operate at a loss for decades and keep resources from potentially more efficient uses. This had an economy-wide effect, as mangers knew they could be bailed out and this lowered the incentives for managerial effort. At the same time, political alignment became a rational priority over economic efficiency. Moreover, while efficient firms were taxed and effectively financed the loss-making firms, the incentives for efficiency were further lowered (Svejnar, 1991).

Allocation decisions made under soft budget constrains led to inherently ineffective distribution of certain resources. Ericson (1991) shows that the nature of socialist governments of the Soviet Bloc led to conscious decisions to overcapitalize certain “flagship” sectors or firms, while leaving others understaffed or without adequate levels of capital. With the intention of rapid industrialization, resource mobilization was greatly favored for heavy industry and producer good industries (Sachs et al., 1994). Furthermore, Bicanic (1957) shows that allocation decisions made by the satellite states of the Soviet Bloc mirrored those of industries favored in the Soviet Union, in spite of different economic conditions.

A final type of distortions under central planning was related to firm size. Depending on the country, industry and period, private businesses were allowed, but their size was limited to either self-employment or small enterprises. The most lax legislation allowed up to 50 workers. With limitations on the potential size of the firm and facing limits in access to inputs as well as distorted input prices, even private enterprises operated outside the optimal allocation.[4]

The above considerations lead to two different types of misallocation. One is the inappropriate capital to labor ratio. Capital can be either too high whenever investment projects were over-financed for political considerations and propaganda-type reasons or too low either because of overemployment, insufficient financing or lack of access to sources of capital goods (e.g. modern technology). The second type of misallocation is channeling resources towards inefficient firms and sectors hindering the growth of efficient ones, e.g. by disregarding the growth of demand in certain firms, regions and sectors. While the anecdotal

[4] Peters (2018) shows the paramount importance of the entry for reducing misallocation and enhancing productivity of incumbents, using data from Indonesian small-scale manufacturing.

evidence on misallocation in centrally planned economies is ample, the actual empirical evidence is missing to the best of our knowledge. We bridge this gap providing an overview of misallocation in late 1980s in one of the centrally planned economies, Poland.

3 Measuring misallocation – insights from the literature

Restuccia and Rogerson (2017) propose an intuitive and useful method for categorizing the measurement of misallocation. The methods they name *direct* relies on identifying a specific source of misallocation (e.g. legislation) and then observing the consequences of this misallocation. Such methods generally have limited scope and cannot be applied in our case, where there are multiple confounding sources of inefficiency, as described earlier.

The methods that Restuccia and Rogerson (2017) name *indirect* base on the presumption that an efficient equilibrium is characterized by equal marginal products of all active producers. If one knows what these products should be or one can observe the structure for all the producers, one can measure the extent of deviation from the efficient equilibrium. An example of the former is the approach proposed by Hsieh and Klenow (2009), who analyze China and India benchmarking their manufacturing firms to the distributions obtained for the US.[5] The caveat with using this approach is that the identification strategy relies on the assumption that adjustment costs are identical and linear across countries (Asker et al, 2014), which is not likely to be the case, especially in catching up economies. An example of the former is taking a dynamic approach and observing if and to what extent more efficient firms increase their share in inputs. This method was proposed by Olley and Pakes (1996), with the so called covariance measure and its derivatives.[6]

Both of the indirect approaches have advantages and disadvantages. Benchmarking necessitates conditional interpretations, i.e. the measure of misallocation is *conditional* on a benchmark country distributions being applicable in the analyzed country. On the positive side, this approach allows to judge if the input combinations (e.g. capital-labor ratios) are "correct" in the analyzed country. Decompositions in the spirit of Olley and Pakes (1986, henceforth OP) provide information on whether more efficient firms have more resources at disposal, but cannot serve to answer if inputs are combined efficiently overall in a given economy.

Given that central planning was likely to exhibit in both types of inefficiencies – inappropriate combination of inputs and wrong allocation across sectors and firms – we use both these approaches. First, we use benchmarking to establish the "correctness" of the capital-labor ratios across firms. These measures help us to identify the extent of over- or under-capitalization across firms. Second, we compute the OP gaps, in order to address the size-efficiency links.

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[5] Using similar methodology Camacho and Conover (2010) cover the case of Colombia, and Leal (2016) analyzes Mexico, Gorodnichenko et al (2018) provide a comparative analysis for the EU countries.

[6] Innovationts to Olley-Pakes were provided by Melitz and Polanec (2015) as well as Maliranta and Maatanen (2015). The Olley-Pakes covariance has been used as the primary measure of allocation efficiency over time for country case studies, such as Bartelsman et al. (2013) for multiple countries, Repetto and Micco (2012) for Chile, Song and Wu (2015) for China, Meehan (2016) for New Zealand, as well as Melitz and Polanec (2015) for Slovenia. Comparatively, the OP measurement is also employed in Nishida et al (2017), for a comparison of India, the United States, Chile, Colombia and Slovenia and in Gamberoni et al. (2016) for the case of Belgium, France, Germany, Italy, and Spain. Similarly, Bellone and Mallen-Pisano (2013) compare levels of misallocation between France and the United States.

We characterize the extent of the misallocations in sectoral and regional context. The sectoral context reflects the previously discussed "political preferences" of the central planners. The regional context serves to complement this analysis for two main reasons. First, due to war destruction and the post-war changes of borders, vast majority of plants was established in the post-war period, i.e. in the command system. Their location reflected military and political considerations, not necessarily the natural comparative advantages of these regions, possibly generating additional source of inefficiency. Second, despite the command system, more densely populated and economically active areas may have been less conducive to persistent misallocations.[7]

4 Data and methods

We compiled several novel sources of data for this study. First, we use previously unknown registry of all state owned plants employing 50 or more workers (full-time equivalent), that were operational in 1988, i.e. in the last year prior to the economic transition. This registry contains information on industry, year of establishing, employment (in persons), as well as capital stock and assets. This data is unique in a sense that it was uncovered from the archives of the Central Planning Office and covers a universe of 50+ plants: the data is complete for 1,641 plants in total (in few cases data on employment or assets are missing and could not be recovered).[8] This data is sufficient for establishing the OP measure of misallocation.[9]

The OP measure can be briefly described as follows. Consider Φ_i to be the employment-weighted labor productivity measure of sector *i*:

$$\Phi_i = \sum_j s_{ij}\phi_{ij},$$

where s_{ij} is firm *j*'s share in overall employment of sector *I and* $\phi_{ij} = q_{ij}/l_{ij}$ is the firm *j's* labor productivity measured as a ratio of output and employment. Taking $\bar{\phi}_i$ as an average of firm productivies in sector *i*, the Olley-Pakes (1996) decomposition is as follows:

$$\Phi_i = \bar{\phi}_i + cov(s_{ij}, \phi_{ij}),$$

where the covariance term $cov(s_{ij}, \phi_{ij})$ is the measure of allocative efficiency, i.e. if it is positive, larger firms attract more resources and if it is negative, there are barriers to small efficient firms growth while the large incumbents remain inefficient. While the covariance itself has no easy interpretation and its level depends on the level of the two productivities, we normalize it with respect to Φ_i, so it is measured in percent of the weighted productivity

[7] Combes et al (2012) and Fontagne and Santoni (2016), for the US and France, respectively, show that firms are less likely to have capital or labor misallocation when they are located in densely populated regions.

[8] This data was originally published in a book by Karpinski et al. (2013). Having noticed some mistakes in this source, we reconstructed the data, by manual search, plant by plant. The complete data is available under the following link: http://grape.org.pl/project/privatization. The sectoral, regional and cohort breakdown of the sample is reported in Tables A1 and A2 in the Appendix. The cohorts are different with respect to their sectoral and regional composition, i.e. the communist regime developed some sectors in waves overlapping with the swings in political leadership. The early years of the centrally-planned economy were focused on heavy industry while the 1970s saw development in many export-oriented industries, including light industry as well as a rapid development of the śląskie voivodship. Tables A1-A2 in the Appendix show tabulations of the number of firms across sectors, regions and cohorts and illustrate these regularities.

[9] Brown et al (2016) discuss the limitations of relying on dispersion measures.

and therefore, comparable across sectors, i.e: $OPGAP_i = (\Phi_i - \bar{\phi}_\iota)/\Phi_i$. In the same fashion, we compute a regional version of this variable: $OPGAP_r$.

For measuring the adequacy of capital-labor ratio, the original plant level-data from 1988 was combined with Socio-Economic Accounts of the World Input Output Database. This dataset contains reliable information on capital stocks and employment by sector for major economies of the world and has been compiled according to rigorous methodology. To avoid making arbitrary choice about a benchmark economy, we use a variety of benchmarks: Germany, UK, Italy, France (the earliest available period in WIOD is 1995). All these four economies have substantial manufacturing sectors. We also use future allocations in the Polish economy as benchmark, to verify the sensitivity of the results to the choice of benchmark.

The measures of allocation of capital and labor are based on benchmark values for the four industrialized economies and future data from Poland. A challenge in comparing Polish 1988 capital stock values to the ones from other developed countries is the comparison of relative prices both across countries and across time. In order to overcome this problem, we base our calculations on values that are normalized to the aggregate nominal values for respective countries. We begin by calculating the sectoral capital stock deviations relative to the reference countries:

$$KLDEV_i^{REF} = \frac{KL_i^{POL}/KL^{POL}}{KL_i^{REF}/KL^{REF}}$$

which gives us a set of sectoral measure of misallocation (one for each reference country) and a target level of capital-labor ratio for Poland: $KLTAR_i^{REF} = \frac{KL_i^{POL}}{KLDEV_i^{REF}}$. Since this measure is sector-specific and our data has a sector-regional dimension, we differentiate it by region in two ways. First, we compute the percentage of firms in a given sector-region that are either below the target minus one standard deviation in the capital-labor ratio for that particular sector or above the target plus one respective standard deviation to obtain two measures: $\%undercapitalied_{ir}$ and $\%overcapitalized_{ir}$. Second, in order to capture the size of the deviation, we compute the average deviation from the target plus/minus one standard deviation of capital-labor ratio across all firms for every sector-region pair. This way, we obtain separate measures of the degree of overcapitalization and undercapitalization in each sector: $undercapitalization_{ir}$ and $overcapitalization_{ir}$.

To analyze the consequences of misallocation for the subsequent economic growth, we compile unique and novel time series of sectoral and regional real growth in output.[10] This data was obtained for the census of firms employing at least 10 workers, using microdata from the Central Statistical Office and is available from 1993 onwards.

We assess the degree of pre-transition misallocation on the future economic growth (before period *t*) using simple regression methods on a cross-section of sector-region data where all but one of our explanatory variables come from 1998 and the explained variable is the

[10] There are no reliable sectoral deflators for the analyzed years. Hence, we control for overall changes in prices by computing the cumulated growth-rates in sector-region revenue shares in total revenues instead of ordinary growth rates of revenues. We express the growth rates in the annualized form to assure comparability across time.

growth rate of output from subsequent transition and post-transition years (see later). Our estimating equation is:

$$growth_{ir}^{t} = \alpha_0 + \alpha_1 OPGAP_i + \alpha_2 OPGAP_r + \alpha_3\, undercapitalization_{ir} + \alpha_4\, overcapitalization_{ir} + \alpha_5 \Phi_i + \alpha_6 \Phi_r + \alpha_6 sq_{ir}^{t} + \varepsilon_{ir}^{t},$$

where apart from the misallocation measures we include the 1988 sector and region productivity level and sq_{ir}^{t} – the share of a sector-region pair in overall industry revenues for that particular period. This measure is included to take account of economic convergence between sectors-regions that when omitted could be a source of omitted variable bias.

Given the substantial changes in administrative and sectoral definitions over the period, the consistent time series for the complete 1989-2013 period cannot be compiled. First, as of 1999, massive legal reform changed the administrative organization of Poland, removing the layer of 49 regions (*wojewodztwo*) and introducing a layer of 380 subregions and a layer of 16 larger regions. We adjust our data accordingly. Our firm-level data from 1988 has the location of the firms, so we can match the original plants with both old and new regions. However, we cannot provide output time series for the whole period, as the location data for the census at the disposal of the Central Statistical Office does not permit the mapping. Second, the sectoral data at the Central Statistical Office is available in NACE rev. 1 sectoral classification prior to 2005 and in NACE rev. 2 thereafter. As is widely known, this change in NACE classification was of many-to-many character, hence we cannot reconstruct the consistent time series. Our firm-level data from 1988 has the detailed sector description, hence we assign both NACE classifications based on firm characteristics on the firm-by-firm basis.

Overall, the growth analysis is performed in three subperiods: 1993-1998 (due to the administrative change), 1999-2005 (due to revision of NACE) and finally 2005-2013. This split, though imposed by data limitations, is actually quite useful from the interpretational perspective. The 1993-1998 period is the relatively early stage of transition where many state-owned enterprises coexisted with newly established private ones and recently privatized SOEs. The 1999-2005 period is marked by the Russian crisis that forced a considerable shift of the economy towards the Western Europe and intensive trade liberalization related to the EU accession in 2004. The 2005-2013 period is the period directly following the accession of Poland to the European Union, when all of the rules and regulations were set in line with the EU rules and Poland was a member of the Single Market.

5 The extent of pre-transition misallocation

The allocation of resources across firms was not strongly correlated with plant performance, with the OP gap reaching -5.1, i.e. the difference between average productivity weighted by employment and the non-weighted one is negative but not very large. Overall, inefficient firms had too much resources at their disposal, but in the aggregate terms this difference is not large. It is highly heterogeneous across sectors, however, as displayed in Table 1. In fact, in few industries OP gap exceeded -30 and in some industries exceeded 30. This heterogeneity hints that the mechanisms allocating resources *between* industries were not

very efficient and in some cases some industries maintained relatively unconstrained access to resources despite poor performance.

Table 1 Sectoral misallocation measures

Sector	# of plants	OP gap	%over-capitalized	%under-capitalized	over-capitalization raw	under-capitalization raw	over-capitalization std	under-capitalization std
Overall	1641	-5.1	7.5	35.1	23.6	77.4	219.4	201.6
Mining and quarrying	72	-13.9	15.6	5.2	43.9	23.3	182.4	118.0
Food, beverages and tobacco	297	-15.1	5.7	0.0	23.9	24.8	301.2	0.0
Textiles	121	-21.8	1.9	76.9	3.1	158.1	112.4	219.5
Leather	25	-33.7	0.0	90.9	0.0	204.2	0.0	250.1
Wood and wood products	52	-15.6	8.5	57.4	21.7	80.0	129.7	138.3
Pulp, paper, publishing	33	3.0	10.0	0.0	28.7	40.3	239.8	0.0
Refined petroleum	7	18.2	60.0	0.0	117.1	0.0	184.6	0.0
Chemicals	47	-9.3	16.7	0.0	50.9	10.9	225.1	0.0
Rubber and plastic	17	-9.4	21.4	7.1	37.1	27.8	166.6	118.4
Non-metallic minerals	257	-17.8	13.3	8.0	39.0	35.8	199.6	113.7
Metals and metal products	90	27.9	9.5	4.1	30.1	34.6	218.1	106.9
Machinery and equipment	193	8.7	2.3	73.4	6.2	146.2	248.2	198.9
Electrical and optical equipment	190	5.8	1.9	86.6	7.1	147.3	320.8	200.6
Transport equipment	53	34.0	0.0	63.9	4.3	102.2	0.0	210.7
Manufacturing nec	60	-12.4	3.6	91.1	5.5	208.0	153.0	240.9
Electricity, gas and water supply	82	-36.9	18.8	0.0	74.4	0.0	247.8	0.0

Notes. Data come from plant level 1988 registry. Data for Germany is the benchmark. Figure A1 reports the %over-capitalized and %under-capitalized for alternative benchmark countries. The OP gap column shows the covariance term of the Olley-Pakes (1997) decomposition computed for a given industry. The OP gap shows the covariance between the share of a firm in employment and its labor productivity relative to the weighted average of productivity and this amounts to a percentage difference between the labor-weighted average labor productivity and simple average of labor productivity. %over-capitalized (%under-capitalized) columns show percentage of firms in a given aggregate with the capital-labor ratio above (below) the target capital labor ratio plus (minus) one standard deviation. The over-capitalization raw (under-capitalization raw) shows the average deviation from target form firms above (below) the target K/L. The over-capitalization std (under-capitalization std) columns shows average deviation from target capital-labor ratio for firms that are identified as over-capitalized (under-capitalized). Note that %under-capitalized and % over-capitalized do not have to add up to unity, as some plants may report K/L ratio within one standard deviation of the benchmark within the sector.

This interpretation matches the results on relative efficiency of allocation. Table 1 reports the measures of over- and under-capitalization across sectors when WIOD data for Germany are used as a benchmark. On average, about 35% of plants in Poland were undercapitalized and and the undercapitalization on average amounted to approx. 200% of the standard deviation in K/L ratio. Less than 8% of firms could be classified as over-capitalized. The sectors where firms are over-capitalized were scarce and firms with higher K/L ratio than in the benchmark economies do not exceed 25% (except one case of the petroleum sector). The prevalent under-capitalization comes out also in the regional analysis (Table A3 in the Appendices).

The sensitivity of results to benchmark is reported in Figure A1. This analysis shows that while the benchmark matters for the absolute values of under- or over-capitalization, it never affects classification of firms in the sector. In Figure A2 we report the standardized deviation in K/L ratio. The reason for standardization is of course the fact that the nominal value of capital in 1988, as expressed in local currency at the time, cannot be converted meaningfully

to 1995 foreign currency. Hence, we measure K/L ratios in our registry data from 1988 and in the benchmark data as deviation from averages. Although it appears that the over-capitalization or under-capitalization classification does not depend on the benchmark country, we could rely on one selected benchmark. However, the magnitude seems to vary across benchmark countries. Given these insights, in the remainder of this paper we present the results relative to these multiple benchmarks (either in the main text or referring the reader to the Appendices).

Many sectors with excessively low K/L ratios are characterized by negative covariance of employment and labor productivity, which means that the resources were hoarded away from efficient use. The only cohort where large firms are characterized by a higher labor productivity are the firms established in the 1960s. At the same time, this cohort is also characterized by the highest under-capitalization (see Table A4 in the Appendices).

The apparent regional, sectoral and cohort heterogeneity could hint that the firm-level variation in misallocation may be driven by these general trends. However, in fact typically more than 50% of firm-level misallocation remains unexplained by sectoral, regional and timing variation. In Table 2 we report the analysis of variance and show that the region and the cohort explain negligible part of the overall variation in misallocation. This conclusion holds across both absolute and relative misallocation measures. Sector is substantially more important for the K/L deviations from benchmark, but explains a small part of variation in OP gaps. Given that region is of minor importance in explaining variation in misallocation in 1988, the potential for reverse causality in the subsequent growth regressions is relatively low.

Table 2 Variance decomposition of misallocation measures

	OP gap		K/L deviation from benchmark				
dimension	dummy	contribution	DEU	FRA	GBR	ITA	POL
cohort	0.5	0.4	1.5	1.4	1.5	1.6	1.3
region	1.3	0.8	1.4	1.5	1.4	1.4	1.7
sector	8.0	20.8	40.8	44.1	41.7	38.0	49.8
all	**9.1**	**22.3**	**43.4**	**46.6**	**44.3**	**40.7**	**52.1**

Notes: Data come from plant level 1988 registry. Table shows the decomposition of overall variance of the firm-level misallocation measures when they are regressed on sectoral, regional and cohort dummies. We construct the firm-level contributions to the aggregate OPGAP measure in two ways: (i) we create a dummy variable if the firm-level component of the aggregate covariance between firms is positive (ie. the firm positively contributes to the aggregate covariance between size and productivity) and (ii) a continuous measure equal to this firm-level contribution normalized by firm productivity. The misallocation measures are: dummy – positive firm contribution to overall OP gap covariance term, contribution – the firm-level contribution to the covariance normalized by firm productivity, K/L deviation from target – firm-level deviation from sectoral target capital-labor ratio. For the over- and undercapitalized measures, the firm-level measure is a dummy that takes a value of 1 if firm is under(over) the under(over)capitalization threshold.

6 Misallocation and economic growth

Misallocation is robustly correlated with subsequent economic performance. Table 3 presents the results for the growth regressions with both the measures of the allocative efficiency measured by the OP gap as well as the appropriate K/L allocations with data from German economy as a benchmark. Table 6 reports the sensitivity check for the alternative

benchmarks. A positive OP gap represents efficient allocation, hence the results hint that the more efficient is the initial allocation in 1988, the better is the growth performance in subsequent periods. It is the sectoral OP gap rather than the regional OP gap that appear to carry to the future decades. These correlations are relatively large: 10 percentage point improvement in allocative efficiency is correlated with roughly 1 percentage point increase in the subsequent growth rate. Naturally, changing allocative efficiency by 10 percentage points would be a substantial reallocation already, but our results imply that 1 standard deviation in the sectoral OP gap translates to the annual growth rate of output in that sector higher by 1.4 to 2.0 percentage points depending on the period under consideration.

Table 3 Misallocation at plant level and subsequent production growth in sectors and regions

	(1)	(2)	(3)	(4)	(5)	(6)
	05-13	05-13	99-05	99-05	93-98	93-98
OP gap (sector)	0.0871***	0.0835***	0.154**	0.146**	0.108**	0.0918**
	(0.0302)	(0.0303)	(0.0681)	(0.0683)	(0.0416)	(0.0420)
OP gap (region)	0.0229	0.0257	0.0511	0.0585	-0.00285	-0.00311
	(0.0515)	(0.0518)	(0.0442)	(0.0446)	(0.0369)	(0.0353)
%overcapitalized	-0.000973		-0.0192		-0.00130	
(DEU, std)	(0.0252)		(0.0320)		(0.0329)	
%undercapitalized	-0.0290**		-0.0513***		-0.0605***	
(DEU, std)	(0.0135)		(0.0153)		(0.0152)	
overcapitalization		-0.00273		-0.00676		-0.0216*
(DEU, std)		(0.0102)		(0.0142)		(0.0115)
undercapitalization		-0.0143***		-0.0224***		-0.0278***
(DEU, std)		(0.00536)		(0.00586)		(0.00617)
Output share	Yes	Yes	Yes	Yes	Yes	Yes
Productivity (sector)	Yes	Yes	Yes	Yes	Yes	Yes
Productivity (region)	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0189	0.0233	0.0289	0.0342	0.0631**	0.0566**
	(0.0515)	(0.0516)	(0.0517)	(0.0525)	(0.0264)	(0.0249)
No of observations	266	266	241	241	340	340
R-squared	0.077	0.081	0.123	0.123	0.075	0.080

Notes: Reference country: Germany. Columns correspond to different time periods and measures of misallocation (see data section for explanation). The OP gap measures shows the covariance term of the Olley-Pakes (1997) decomposition computed for sectors and regions. %overcapitalized (%undercapitalized) variable shows percentage of firms in a region-sector cell with the capital-labor ratio above (below) the target capital labor ratio plus (minus) one standard deviation. The overcapitalization (undercapitalization) measure shows average deviation from benchmark capital-labor ratio for plants that were identified to be over- or under-capitalized. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

As far as the capital-labor ratios are concerned, output growth rates of sector-region pairs are negatively associated with the rate of under-capitalization in 1988. The 10 percentage point difference in the share of undercapitalized firms across the sector-region pairs translates to roughly 0.3 and 0.6 percentage point difference in the output growth rates. It is not only the very fact of under-capitalization but also the magnitude that matter. The difference in average deviation in capital-labor ratio by 10 percentage points across sector-region pairs is associated with a difference in growth rates of between 0.1 and 0.3 percentage points. While these effects are significant in all the observed periods, the size of

the coefficient appears to decline over time (though the differences between respective columns are not statistically significant). In Table 5 we report that these results are consistent across benchmark economies. The differences between point coefficients across benchmark economies are not different in a statistically significant way, they all have the same sign and are significant.

In Table 5 we perform further sensitivity checks with respect to the choice of the capital-labor misallocation measure. First, we take the average deviation from target capital-labor ratio (with respect to Germany) without the one standard deviation threshold (first column for each period) separately for negative and positive deviation. The estimates are roughly the same as the ones with the threshold with similar regression diagnostics. In the subsequent column, instead of two variables for over- and under-capitalization, we include the average deviation from target capital-labor (that now can be either negative and positive) and the same variable squared. Only the latter turns out to be positive, suggesting that there indeed is a non-linear correlation between 1988 deviation from target (both the negative deviation and positive deviation) and subsequent economic growth. The nonlinearity suggests that both negative and positive substantial deviation from benchmark capital-labor ratio is associated with lower economic growth. As a last step, we introduce a raw average capital-labor ratio in the regression instead of the deviation to find whether it is important for growth without the link with reference levels and it is in general not significant.

Table 4 Links between misallocation and subsequent growth: sensitivity to the choice of benchmark country

		(1)	(2)	(3)	(4)	(5)
VARIABLE	Period	DEU	ITA	GBR	FRA	POL
%under-capitalized	05-13	-0.0290**	-0.0242*	-0.0256*	-0.0302**	-0.0247*
		(0.0135)	(0.0135)	(0.0139)	(0.0133)	(0.0133)
	99-05	-0.0513***	-0.0436***	-0.0434**	-0.0539***	-0.0473***
		(0.0153)	(0.0162)	(0.0169)	(0.0153)	(0.0154)
	93-98	-0.0605***	-0.0528***	-0.0530***	-0.0583***	-0.0536***
		(0.0152)	(0.0150)	(0.0159)	(0.0153)	(0.0154)
under-capitalization	05-13	-0.0143***	-0.0126**	-0.0128**	-0.0143***	-0.0115**
		(0.00536)	(0.00519)	(0.00513)	(0.00498)	(0.00447)
	99-05	-0.0224***	-0.0205***	-0.0191***	-0.0221***	-0.0161***
		(0.00586)	(0.00601)	(0.00595)	(0.00560)	(0.00585)
	93-98	-0.0278***	-0.0246***	-0.0245***	-0.0276***	-0.0219***
		(0.00617)	(0.00593)	(0.00596)	(0.00590)	(0.00565)

Notes: The numbers in the table show the regression coefficient for the *%under-capitalized* and variable from a regression of the same form as in columns 1, 3 and 5 of Table 3 but for different benchmark countries. Analogously, for *under-capitalization*, we report coefficient from a specification from columns and 2, 4 and 6 of Table 3 but for alternative benchmark countries. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The above results suggest that sector-region pairs with better initial allocation according to both analyzed dimensions exhibited better growth performance than those where allocation was not as efficient. This has two important implications: (i) more efficient sectors-regions grew faster and potentially became even more efficient over time while the gap from non-efficient sector-regions widened, and (ii) the potential gains of improving allocation in relatively inefficient sector-regions were not exploited. While the misallocation literature suggests that there may be growth effects from improving allocation, one could expect that relatively misallocated sector-regions could gain from reduction of misallocation on top of

other gains from the liberalization of the economy and they could grow faster that initially more aligned sector-regions. One could in principle expect an immediate effect of economic liberalization in highly misaligned sectors due to an immediate reallocation of resources (i.e. through foreign and domestic firm entry and exit) and therefore a positive relationship between pre-transition misallocation and subsequent growth. We show the opposite pattern. In fact, high misallocation associated with lower economic growth over transition.

It could have been, naturally, that the benefits of reducing misallocation have been realized immediately with the abrupt shock-therapy of 1989-1991 (before the analyzed period of 1993-2013) and we are capturing in this study only the lasting effects, which could potentially emphasize long-run specialization, complementarity with human capital, etc. The data prior to 1993 do not exist and hence this hypothesis cannot be explicitly tested. However, only few plants were privatized over this period and firms were not exiting until the end of 1992 (i.e. they were provided state support to prevent closure until that date). Moreover, observing the persistent correlation across nearly three decades suggests that recovering from misallocation may indeed be a lengthy rather than abrupt process. At least some misallocation found in 1988 have been persistent over time, putting a strain on economic growth.

Table 5 Links between misallocation and subsequent growth: sensitivity to misallocation measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	05-13	05-13	05-13	99-05	99-05	99-05	93-98	93-98	93-98
OP gap (sector)	0.0848***	0.0829***	0.103***	0.147**	0.141**	0.173**	0.0943**	0.0854**	0.0810*
	(0.0301)	(0.0302)	(0.0310)	(0.0686)	(0.0686)	(0.0738)	(0.0421)	(0.0434)	(0.0436)
OP gap (region)	0.0239	0.0259	0.0288	0.0533	0.0565	0.0468	-0.00114	-0.00200	-0.0174
	(0.0518)	(0.0518)	(0.0477)	(0.0449)	(0.0453)	(0.0466)	(0.0346)	(0.0344)	(0.0350)
overcapitalization	-0.00206			-0.0113			-0.0134		
(DEU - raw)	(0.0108)			(0.0145)			(0.0132)		
undercapitalization	-0.0126**			-0.0195***			-0.0292***		
(DEU - raw)	(0.00563)			(0.00580)			(0.00708)		
deviation		0.00486			0.00339			0.0117	
(DEU - raw)		(0.00484)			(0.00678)			(0.00770)	
deviation squared		-0.00309*			-0.00586**			-0.00538*	
(DEU - raw)		(0.00183)			(0.00260)			(0.00292)	
average K/L			0.000851			0.000935*			0.000282
			(0.000664)			(0.000545)			(0.000441)
Output share	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Productivity (sector)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Productivity (region)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0220	0.0218	0.00964	0.0285	0.0246	-0.00702	0.0648**	0.0544**	0.00463
	(0.0525)	(0.0513)	(0.0488)	(0.0529)	(0.0522)	(0.0503)	(0.0266)	(0.0256)	(0.0210)
Observations	266	266	266	241	241	241	340	340	340
R-squared	0.073	0.076	0.068	0.109	0.111	0.097	0.074	0.069	0.026

Notes: Reference country: Germany Columns correspond to different time periods and measures of misallocation. The OP GAP measures shows the covariance term of the Olley-Pakes (1997) decomposition computed for sectors and regions. The overcapitalization (undercapitalization) measure (columns 1, 4 and 7) shows average deviation from benchmark capital-labor ratio for firms that are above (below) the target capital-labor ratio, when no threshold for departure from benchmark is imposed. Columns 3, 5 and 7 include a deviation from benchmark capital-labor ratio as one continuous variable (either negative or positive) and the same variable squared to check for non-linearities. Columns 3, 6 and 9 include the raw measure of sector-region capital-labor ratio.. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The interpretation that all the boost from misallocation was observed prior to 1993 is also at odds with the conclusions from other studies, which emphasize that misallocation typically increases in the periods of large shocks. This finding was confirmed in several studies for Latin American countries over several recessions (e.g. Oberfield, 2013; Sandleris and Wright, 2014). A recent study of misallocation during the Great Depression of the 1930s in the US confirms these conclusions (Ziebarth, 2015).

Our findings are novel, but certainly not the first to look at the consequences of central planning. For example, Song et al (2011) show that inputs are being misallocated between state-owned firms and private firms in China, with state-owned plants receiving disproportional share in inputs (see also Brandt et al, 2013). Hence, it appears that the central planning misallocations influence the potential output in China. Using evidence from one former centrally planned economy – Romania – Bartelsman et al (2013) show that in the first decade of transition the misallocation declines, as limitations to resource reallocation were gradually removed. By contrast, analyzing the elimination of firm entry barriers in India (the so called "raj" system), Bollard et al (2013) show that easier entry into manufacturing raised productivity in larger firms, but changes in misallocation played no role in this process.

Our results are robust but subject to several criticisms. First, although we address the criticism of Restuccia and Rogerson (2017) and use measures of misallocation relative to an external benchmark – our results base on dispersion of standardized K/L ratios rather than a pure ratio of K/L ratios. This is a consequence of data limitations (no plausible deflators exist for 1980s inputs from central planning). Yet, an analysis utilizing an entire distribution of firms from a benchmark economy (a la Hsieh and Klenow, 2009) could provide more power to our results. Firm level data for 1980s are rare even in advanced market economies, but with access to such data one could verify further the robustness of our finding. Partly to address this limitation, we utilize a variety of benchmarks, i.e. used input ratios for economies known for efficiency (Germany, UK) as well as plausibly less efficient economies (France, Italy). While results are robust to the choice of benchmark economy per se, they also reveal that the magnitude of relative misallocation measures may vary significantly.

Second, one could prefer value added based measures to revenue based measures. When analyzing allocative efficiency in the Olley and Pakes approach, we utilize labor productivity computed as sales revenues over head count. This measure suffers from both not accounting for the capital input and the potentially misguided prices for intermediary and final goods under central planning. This issue cannot be addressed, because centrally planned economies of Central and Eastern Europe did not utilize value added, nor system of national accounts.[11]

7 Conclusions

In this paper we analyze the link between substantial resource misallocation and subsequent economic growth. To this aim, we utilize previously undiscovered plant level data on resource utilization from centrally planned economy, Poland. Our data is a full registry of all plants with at least 50 workers, and reports fixed assets as well as sector and location. We match this data to another unique source providing information on economic growth in output

[11] They relied on material production system.

across sectors and regions for this economy over the three decades of economic transition to a market economy. Over this period, Poland has raised GDP per capita by a factor of four.

Our assessment of misallocations shows that it indeed was a problem in the pre-transition Polish economy. In particular, we have shown that the measures of allocative efficiency in most of the Polish sectors were negative, suggesting that indeed the economy of Poland was dominated by large and inefficient firms. Moreover, a high fraction of firms suffered from insufficient capital. The capital-labor ratios in some sectors have been less than half than that of benchmark industrialized countries. These differences were particularly large for modern industrial sectors such as production of machinery and equipment, electronics as well as motor vehicles. We have also shown that while there are apparent differences in the development of regions of Poland, the differences of misallocation mainly stem from sectoral and plant level.

We do find robust correlation between pre-transition misallocation and subsequent economic growth across regions and sectors. This effect is visible in all of the three analyzed periods, i.e. even twenty years after the beginning of the transition process. We find that both allocative efficiency and capital-labor ratios adequacy are important for economic growth. Higher positive correlation between firm size and firm productivity in a given sector-region cell is followed by higher rates of output growth in that sector-region. We also find that while undercapitalization correlates with lower economic growth. Our results are robust to different specification choices and different measures of misallocation.

Central planning imposed many limitations on efficient allocation of resources across firms that are uncommon in the market economies. However, the economies of Central and Eastern Europe provide a fruitful area for research, because majority of the formal limitations to efficient resource allocation were lifted almost instantaneously and in a sense exogenously, i.e. due to reasons unrelated directly to performance of a given firm. While we do not claim that exogeneity makes our correlations between misallocation and subsequent growth causal, they still are instructive. As of 2013, Polish economy has roughly 20,000 firms employing 50 workers or more, as opposed to slightly under 2,000 in 1988. The inflow of foreign capital, trade liberalization and integration into the European Single Market, accompanied with technological change and generational exchange – should make the effects of resource misallocation from the period of central planning completely uncorrelated with the economic growth. The robust correlations we show point to the paramount relevance of resource allocation for economic growth, even over the long run.

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8 Appendices

Data

Table A1 Number of firms by sector and region

Voivodeship/ Industry	Basic Metals	Chemicals	Electricity, Gas & Water Supply	Food, Beverages, & Tobacco	Machinery Equipment	Manu-facturing nec	Mining & Quarrying	Other Non-Metallic	Refined Petroleum	Rubber Plastic	Textiles & Leather	Transport Equipment	Wood, Pulp & Paper	Total
GRQRUØNLH	8	5	4	13	38	1	16	22	0	0	5	2	2	116
kujawsko-	3	7	4	14	25	4	0	13	0	0	7	2	4	83
lubelskie	4	2	3	24	10	3	3	14	0	2	12	5	2	84
lubuskie	2	1	2	7	7	2	1	5	0	0	14	2	5	48
ódzNLH	10	7	11	47	105	9	3	27	2	3	12	7	13	256
PDORSRØNLH	13	1	9	14	15	0	12	19	0	1	5	4	4	97
mazowieckie	6	2	2	6	10	2	2	8	0	0	4	0	1	43
opolskie	2	4	3	26	11	7	10	18	0	3	9	3	6	102
podkarpackie	3	0	3	23	9	4	3	6	0	2	9	1	6	69
podlaskie	3	2	7	12	23	4	0	13	1	0	4	8	7	84
pomorskie	1	0	1	17	11	4	0	11	0	1	8	3	8	65
ØNLH	7	2	6	26	38	3	9	13	0	3	8	5	5	125
ZWRNJØNLH	3	2	4	15	15	3	3	10	0	0	5	6	11	77
ØBLVNR **-**	6	6	7	16	21	5	4	21	0	1	35	0	5	127
wielkopolskie	15	4	15	22	37	8	33	40	4	1	6	4	3	192
zachodniopomorski	4	2	1	15	8	1	10	17	0	0	3	1	3	65
Total	90	47	82	297	383	60	109	257	7	17	146	53	85	

Source: 1988 registry of the plants employing 50 workers or more (full time equivalent)

Table A2. Number of firms by sector and cohort

Cohort of establishment/ Industry	1940s	1950s	1960s	1970s	1980s	Total
Basic Metals	0	31	20	35	4	90
Chemicals	1	16	13	15	2	47
Electricity, Gas & Water Supply	1	16	24	24	5	70
Food, Beverages, & Tobacco	0	69	78	127	23	297
Machinery Equipment	4	100	105	143	31	383
Manufacturing nec	0	10	17	27	6	60
Mining & Quarrying	0	34	49	16	9	108
Other Non-Metallic	0	50	57	148	2	257
Refined Petroleum	0	1	2	2	1	6
Rubber Plastic	0	4	4	8	1	17
Textiles & Leather	0	53	32	60	1	146
Transport Equipment	4	23	9	14	3	53
Wood, Pulp & Paper	0	26	25	26	8	85
Total	10	433	435	645	96	

Source: 1988 registry of the plants employing 50 workers or more (full time equivalent)

Table A3. Regional misallocation measures

Region	no of firms	OP GAP	%over-capitalized	%under-capitalized	over-capitalization raw	under-capitalization raw	over-capitalization std	under-capitalization std
dolnośląskie	117	17.1	10.8	35.3	45.5	71.0	301.7	186.3
kujawsko-pomorskie	83	-23.8	8.2	39.7	27.3	76.9	214.2	191.8
lubelskie	84	-14.9	6.6	28.9	15.3	78.6	157.5	231.6
lubuskie	48	-16.2	2.4	45.2	27.9	95.2	921.3	211.7
łódzkie	127	-22.4	9.3	40.7	20.2	96.4	163.3	209.3
małopolskie	97	3.1	9.9	22.2	36.4	54.7	253.6	208.6
mazowieckie	258	24.6	5.6	41.9	15.9	87.0	186.3	208.5
opolskie	44	-19.9	12.1	30.3	33.7	64.9	233.2	209.9
podkarpackie	102	-34.2	13.3	28.9	30.6	67.8	202.3	198.3
podlaskie	69	-32.3	5.1	32.2	19.1	69.8	279.4	171.7
pomorskie	84	10.4	8.2	45.2	25.7	94.1	251.7	202.3
śląskie	193	-15.5	6.8	29.6	21.1	68.3	197.0	197.7
świętokrzyskie	65	-5.7	11.7	21.7	34.3	54.9	201.5	175.3
warmińsko-mazurskie	65	-17.4	0.0	42.4	9.0	82.9	0.0	181.4
wielkopolskie	127	-4.1	5.6	35.5	14.6	78.5	186.6	203.9
zachodniopomorskie	78	-10.4	5.8	34.8	19.2	83.9	174.8	216.8

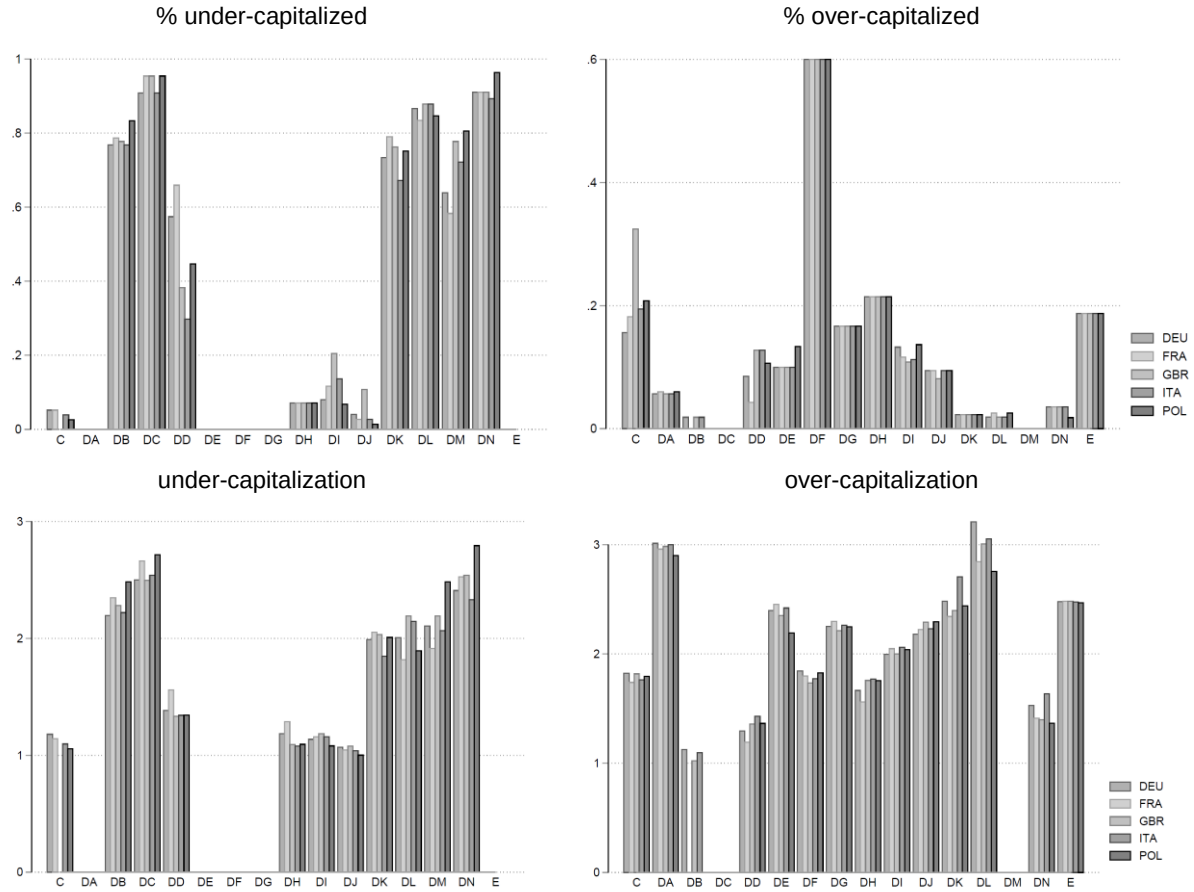
Notes. Data come from plant level 1988 registry. Data for Germany is the benchmark. Figure A1 reports the %over-capitalized and %under-capitalized for alternative benchmark countries. The OP gap column shows the covariance term of the Olley-Pakes (1997) decomposition computed for a given industry. The OP gap shows the covariance between the share of a firm in employment and its labor productivity relative to the weighted average of productivity and this amounts to a percentage difference between the labor-weighted average labor productivity and simple average of labor productivity. %over-capitalized (%under-capitalized) columns show percentage of firms in a given aggregate with the capital-labor ratio above (below) the target capital labor ratio plus (minus) one standard deviation. The over-capitalization (under-capitalization) columns shows average deviation from target capital-labor ratio for firms that are identified as over-capitalized (under-capitalized). Note that %under-capitalized and % over-capitalized do not have to add up to unity, as some plants may report K/L ratio within one standard deviation of the benchmark within the sector.

Table A4 Cohort misallocation measures

Cohort	number of firms	OP GAP	%over-capitalized	%under-capitalized	over-capitalization	under-capitalization
1940s	10	-3.7	0.0	66.7	0.4	39.6
1950s	437	-14.4	6.7	37.6	19.2	68.8
1960s	436	11.6	6.2	38.9	18.7	86.8
1970s	648	-3.9	7.3	31.7	24.6	78.4
1980s	96	-53.0	19.8	33.7	58.0	82.0

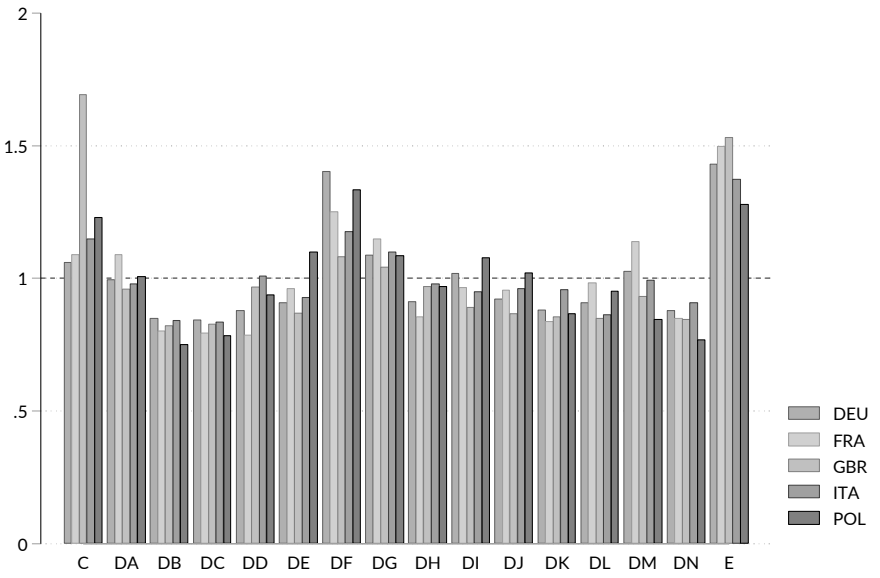
Notes. Data come from plant level 1988 registry. Data for Germany is the benchmark. Figure A1 reports the %over-capitalized and %under-capitalized for alternative benchmark countries. The OP gap column shows the covariance term of the Olley-Pakes (1997) decomposition computed for a given industry. The OP gap shows the covariance between the share of a firm in employment and its labor productivity relative to the weighted average of productivity and this amounts to a percentage difference between the labor-weighted average labor productivity and simple average of labor productivity. %over-capitalized (%under-capitalized) columns show percentage of firms in a given aggregate with the capital-labor ratio above (below) the target capital labor ratio plus (minus) one standard deviation. The over-capitalization raw (under-capitalization raw) shows the average deviation from target form firms above (below) the target K/L. The over-capitalization std (under-capitalization std) columns shows average deviation from target capital-labor ratio for firms that are identified as over-capitalized (under-capitalized). Note that %under-capitalized and % over-capitalized do not have to add up to unity, as some plants may report K/L ratio within one standard deviation of the benchmark within the region.

Figure A1. Sensitivity of the misallocation measures to the choice of the benchmark country



Notes. Data source: 1988 registry of the plants employing 50 workers or more (full time equivalent). %over-capitalized (%under-capitalized) graphs show percentage of firms in a given sector with the capital-labor ratio above (below) the target capital labor ratio plus (minus) one standard deviation. The over-capitalization (under-capitalization) columns shows average deviation from target capital-labor ratio for firms that are identified as over-capitalized (under-capitalized). Note that %under-capitalized and % over-capitalized do not have to add up to unity, as some plants may report K/L ratio within one standard deviation of the benchmark within the sector. NACE Sector codes: C - Mining and quarrying, CB- Mining and quarrying nec, DA- Food, beverages and tobacco, DB – Textiles, DC – Leather, DD - Wood and wood products, DE - Pulp, paper, publishing, DF- Refined petroleum, DG – Chemicals, DH - Rubber and plastic, DI - Non-metallic minerals, DJ - Metals and metal products, DK - Machinery and equipment, DL - Electrical and optical equipment, DM - Transport equipment, DN - Manufacturing nec, E - Electricity, gas and water supply

Figure A2. Deviation in K/L ratio (standardized to 1 on average)



Notes. Data source: 1988 registry of the plants employing 50 workers or more (full time equivalent). Data for benchmarking taken from World Input-Output Database, the earliest available year is 1995. Measures standardized (i.e the ratio of K/L ratios between registry data and benchmark equals 1 on average). NACE Sector codes: C - Mining and quarrying, CB- Mining and quarrying nec, DA- Food, beverages and tobacco, DB – Textiles, DC – Leather, DD - Wood and wood products, DE - Pulp, paper, publishing, DF- Refined petroleum, DG – Chemicals, DH - Rubber and plastic, DI - Non-metallic minerals, DJ - Metals and metal products, DK - Machinery and equipment, DL - Electrical and optical equipment, DM - Transport equipment, DN -Manufacturing nec, E - Electricity, gas and water supply

Robustness analysis

Table 6 Sensitivity to misallocation measure

Period/variable	Description	OPGAP (sector)	OPGAP (region)	%under-capitalized	under-capitalization
05-13	coefficient	0.0821***	0.0356	-0.0288**	-0.0142***
	s.e.	(0.0294)	(0.0507)	(0.0130)	(0.00521)
	R-squared	0.052	0.018	0.037	0.032
99-05	coefficient	0.138**	0.0556	-0.0467***	-0.0217***
	s.e.	(0.0657)	(0.0469)	(0.0153)	(0.00604)
	R-squared	0.077	0.022	0.049	0.054
93-98	coefficient	0.0582	-0.0114	-0.0530***	-0.0215***
	s.e.	(0.0394)	(0.0347)	(0.0149)	(0.00599)
	R-squared	0.021	0.015	0.054	0.048

Notes: Table shows a coefficient from the growth regression when only one misallocation measure is included. *%under-capitalized* variable shows percentage of firms in a region-sector pair with the capital-labor ratio above below the benchmark capital-labor ratio minus one standard deviation. The under-capitalization measure shows average deviation from target capital-labor ratio for firms that are below the target capital-labor ratio minus one standard deviation. Reference country: Germany. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1