

# Productivity and misallocation

## SUMMARY

*Productivity has recently slowed down in many economies around the world. A crucial challenge in understanding what lies behind this ‘productivity puzzle’ is the still short time span for which data can be analysed. An exception is Italy, where productivity growth started to stagnate 25 years ago. The Italian case can therefore offer useful insights to understand the global productivity slowdown. We find that resource misallocation has played a sizeable role in slowing down Italian productivity growth. If misallocation had remained at its 1995 level, in 2013 Italy’s aggregate productivity would have been 18% higher than its actual level. Misallocation has mainly risen within sectors rather than between them, increasing more in sectors where the world technological frontier has expanded faster. Relative specialization in those sectors explains the patterns of misallocation across geographical areas and firm size classes. The broader message is that an important part of the explanation of the productivity puzzle may lie in the rising difficulty of reallocating resources across firms within sectors where technology is changing faster rather than between sectors with different speeds of technological change.*

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*—Sara Calligaris, Massimo Del Gatto, Fadi Hassan, Gianmarco I.P. Ottaviano and Fabiano Schivardi*



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# The productivity puzzle and misallocation: an Italian perspective

Sara Calligaris, Massimo Del Gatto, Fadi Hassan,  
Gianmarco I.P. Ottaviano and Fabiano Schivardi

OECD and EIEF; 'G.d'Annunzio' University and CRENoS; CEP, Bank of Italy and Trinity College Dublin; London School of Economics, University Bocconi Milan CEP and CEPR; EIEF, LUISS and CEPR

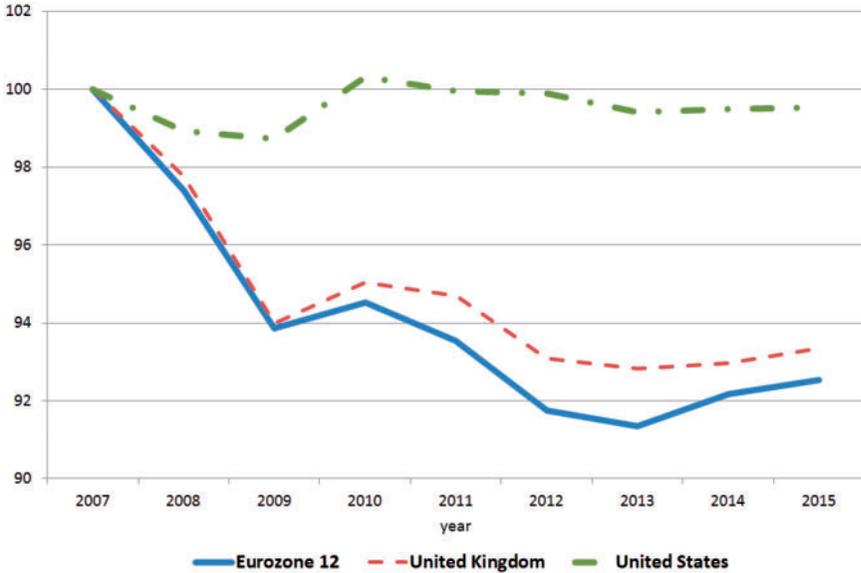
## 1. INTRODUCTION

In recent years, many advanced economies have experienced a serious productivity slowdown. As [Figure 1](#) shows, in the United States, the Eurozone, and the United Kingdom, total factor productivity (TFP) is still below the pre-global financial crisis level. Moreover, in 2016 in the US labour productivity growth fell into negative territory for

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**Figure 1. Evolution of TFP since the global financial crisis (2007 = 100)**

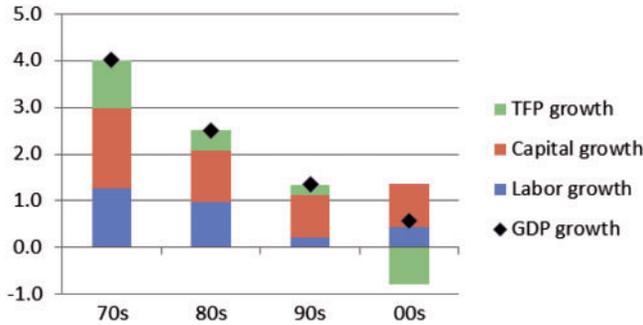
Source: Conference Board.

the first time in the last three decades (Conference Board, 2016). Productivity has reached the headlines of global media, which have started focusing on ‘The productivity puzzle that baffles the world’s economies’.<sup>1</sup> These trends are particularly worrisome because productivity lies at the heart of long-term growth.

A crucial challenge in understanding what lies behind this productivity puzzle is the still short time span for which data can be analysed. As Fernald (2014) and Cetto *et al.* (2016) point out, in some countries like the United States, the productivity slowdown dates back a few years before the crisis. However, in Italy, this is a much longer standing issue. Figure 2 shows a growth accounting decomposition for Italy over the past four decades and the results are quite emblematic. TFP growth shrank throughout the decades, becoming negative in the 2000s. Italy turned from being among the fastest growing EU economies into the ‘sleeping beauty of Europe’, a country rich in talent and history but suffering from a long-lasting stagnation (Hassan and Ottaviano, 2013). TFP dynamics in the manufacturing sector, where measurement issues are less binding than in services, captures well the timing of the Italian decline. Figure 3 shows a dramatic slowdown in TFP growth since the mid-90s for Italy compared with France and Germany, where TFP continued to grow up to the global financial crisis.<sup>2</sup>

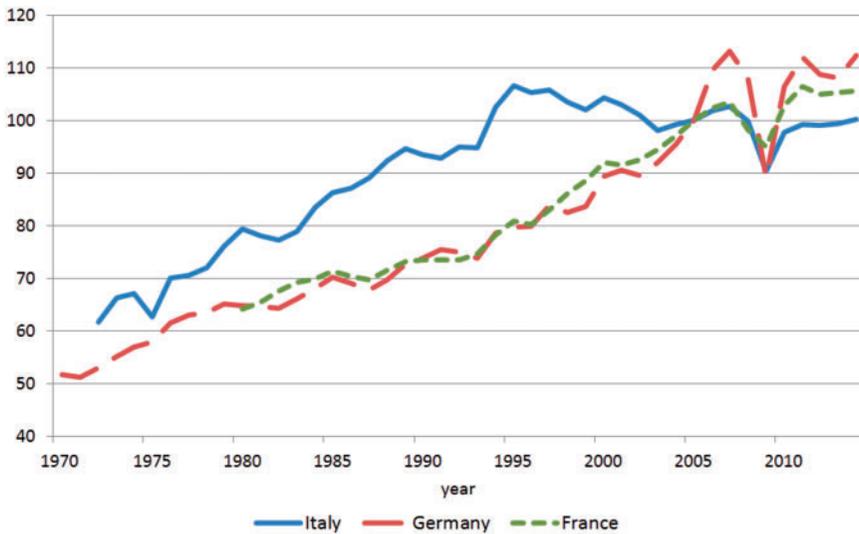
<sup>1</sup> *The Financial Times*, 29 May 2016.

<sup>2</sup> In the paper we focus on firms in the manufacturing sector, because firm-level TFP measurement is less controversial than in services due to better accounting of the capital stock. We have run the same analysis also for firms in the service sector and the results are very similar.



**Figure 2. Contribution to value-added growth, Italy**

Source: EU-Klems.



**Figure 3. TFP in manufacturing for Italy, Germany, and France (2005 = 100)**

Source: Hassan and Ottaviano (2013).

The relatively long time-series dimension that characterizes the Italian productivity slowdown makes Italy a relevant case-study for analysing the key features of the productivity decline (and draw policy recommendations) that can be of general interest to other countries. We analyse the firm-level dimension of aggregate productivity and focus on the concept of resource ‘misallocation’ and its impact on productivity. The ‘productivity’ we refer to is TFP, which measures how effectively given amounts of productive factors (capital and labour) are used. Clearly the economy’s aggregate TFP depends on its firms’ TFP. This happens along two dimensions. On the one hand, for given amounts of factors used by each firm, aggregate TFP grows when individual firm TFP grows, for example thanks to the adoption of better technologies and management practices. If market imperfections prevent firms from seizing these opportunities, the economy’s

productive apparatus is exposed to obsolescence and senescence with adverse effects on aggregate TFP.

On the other hand, for given individual firm-level TFP, aggregate TFP depends on how factors are allocated across firms. As long as market frictions ‘distort’ the allocation of product demand and factor supply away from high TFP firms towards low TFP firms, they lead to lower aggregate TFP than in an ideal situation of frictionless markets. Building on the distinction, introduced by Foster *et al.* (2008) between physical TFP (TFPQ or simply TFP, i.e., measured as the ability to generate physical output from given inputs) and revenue TFP (TFPR, i.e., measured as the ability to generate revenue from given inputs), Hsieh and Klenow (2009) – henceforth HK – construct a model of monopolistic competition in which, although firms can differ in their physical TFP, in the absence of frictions TFPR is the same for all firms. The idea behind this result is simple: with no frictions, the marginal revenue product (MPR) of inputs should be equalized across firms as factors move from low to high MPR firms. As MPR equalization implies TFPR equalization, HK call deviations from a situation in which TFPR is equalized ‘misallocation’, and propose a simple way to measure its effect on aggregate TFP. This is also the definition of ‘misallocation’ we adopt. It implies that the dispersion of TFPR across firms can be used to measure the extent of misallocation. It also implies that firms with a TFPR higher than the sectoral average are inefficiently small, while those with a TFPR below the sectoral average are inefficiently large. These are the two key implications of the misallocation literature that we use in this paper.

With these definitions in mind, we study the universe of Italian incorporated companies over the period 1993–2013 and find strong evidence of increased misallocation since 1995. If misallocation had remained at its 1995 level, in 2013 aggregate TFP would have been 18% higher than its current level. This would have translated into 1% higher GDP growth per-year, which would have helped to close the growth gap with France and Germany.

We then present a decomposition of misallocation into *within-* and *between-group* components, with firms grouped according to the sector, the geographical area, and the size class. This analysis shows that the main source of misallocation comes from the within component: misallocation has mainly risen within sectors rather than between them, within geographical areas rather than between them, within different size classes rather than between them.

To shed light on this result, we consider the relationship at the sectoral level between the estimated within-sector component of misallocation and the sectoral speed of technological change. Following Griffith *et al.* (2004), we proxy the speed of technological change with the increase in sectoral R&D intensity (R&D expenditure over value added [VA]) in advanced countries over the period 1987–2007. The positive and significant correlation that we find entails that misallocation seems to have increased more in sectors where the world technological frontier has expanded faster. Once we account for the sectoral composition of Italian macro-regions and firm size classes, the implied ‘frontier shocks’ are the strongest for Northern regions and big firms, thus matching the

relatively higher increase in misallocation estimated for those classes of firms, which are traditionally the driving forces of the Italian economy.

Finally, we analyze a number of firm characteristics (i.e., ‘markers’) potentially associated with firms being inefficiently sized. In particular, we consider corporate ownership and management, finance, workforce composition, internationalization, and innovation. We find that the firms that employ a larger share of graduates or invest more in intangible assets are inefficiently small and thus under-resourced. These are likely to be the firms keeping up with the technological frontier. On the contrary, the firms that have a large share of workers under the Italian wage supplementation scheme, that are family managed, or financially constrained, are inefficiently large and thus over-resourced. These firms are less likely to be keeping up with technological progress. We interpret this as evidence that rising within-industry misallocation is consistent with a heterogeneous ability of firms to respond to sectoral ‘frontier shocks’ in the presence of sluggish reallocation of resources.

The broader message we draw from the above results is that an important part of the explanation of the recent productivity puzzle may lie in a generally rising difficulty of reallocating resources between firms in sectors where technology is changing faster rather than between sectors with different speeds of technological change. This implies that moving factors of production from traditional, for example, ‘textile’, into IT sectors would increase aggregate productivity less than ensuring that the most efficient firms within the textile sector are the ones that absorb more resources.

A concern with our quantification exercise relates to the caveats associated to measure of misallocation of HK. For instance, *Asker et al. (2014)* argue that, in the presence of adjustment costs in investment (time-to-build), transitory idiosyncratic TFP shocks across firms naturally generate dispersion in productivity without this implying inefficiency. From a different angle, *De Loecker and Goldberg (2014)* and *Haltiwanger (2016)* argue that if firms had the same TFP but different initial market power due to demand characteristics, convergence of market power to the top would reduce TFPR dispersion but could be hardly considered an improvement in efficiency. Finally, *Bils et al. (2017)* stress the role of mismeasurement in the calculation of misallocation and propose a methodology to assess its impact. We show that our results are robust to these issues and that the caveats characterizing the HK concept of misallocation are unlikely to drive our results.

Our work relates to a number of studies that have used the framework of HK to measure the extent of misallocation in various countries, such as *Bellone and Mallen-Pisano (2013)*, *Bollard et al. (2013)*, *Ziebarth (2013)*, *Chen and Irarrazabal (2014)*, *Crespo and Segura-Cayela (2014)*, *Dias et al. (2014)*, *Garcõa-Santana et al. (2016)*, *Gamberoni et al. (2016)*, and *Gopinath et al. (2017)*. Our paper is closer in spirit to *Garcõa-Santana et al. (2016)*, who analyse the patterns of misallocation for Spain, and to *Gamberoni et al. (2016)*, who look at the evolution of misallocation across European countries.

Our paper is also related to studies that have analysed more specifically the issue of the Italian productivity slowdown since the 1990s, such as *Faini and Sapir (2005)*, *Barba-Navaretti et al. (2010)*, *Bugamelli et al. (2010, 2012)*, *Lusinyan and Muir (2013)*,

Michelacci and Schivardi (2013), De Nardis (2014), Lippi and Schivardi (2014), Bandiera *et al.* (2015), Calligaris (2015), Daveri and Parisi (2015), Linarello and Petrella (2016), Calligaris *et al.* (2016), Pellegrino and Zingales (2017), and Schivardi and Schmitz (2012). Our contribution is to focus more specifically on the role of resource misallocation and its impact on productivity.

The rest of the paper is organized as follows. Section 2 introduces the methodological approach. Section 3 presents the main features of the database. Section 4 reports our aggregate findings on productivity and misallocation. Section 5 analyzes the role of the increase in R&D intensity. Section 6 looks at idiosyncratic firm shocks and the cyclical behaviour of misallocation. Section 7 estimates the impact of misallocation on aggregate TFP. Section 8 discusses the robustness of our findings to the limitations of the Hsieh–Klenow framework. Section 9 discusses the markers of misallocated firms. Section 10 concludes.

## 2. MEASURING MISALLOCATION

We follow HK in defining ‘misallocation’ as an inefficient allocation of productive factors (labour and capital) across firms with different TFPR (see Appendix 1 for details).<sup>3</sup> Inefficiency is defined with respect to the ideal allocation of factors that would result in a world of frictionless product and factor markets where consumers are free to spend their income on the firms quoting the lowest prices and owners of productive factors are free to supply the firms offering the highest remunerations. In this ideal allocation, the value of the marginal product (MRP) of each factor is equalized across firms so that the factor’s remuneration is the same for all firms. This is an equilibrium as consumers have no incentive to change their spending decision, firms have no incentive to change their production decisions, and factor owners have no incentive to change the provision of their services. It is also a stable equilibrium as any exogenous shock creating gaps in a factor’s MRP across firms would trigger a reallocation of that factor from low to high MRP firms until its remuneration is again equalized across all firms.

Shocks that can create such gaps are idiosyncratic shocks that increase the TFP of some firms relative to others. As firms with higher MRPs after the shocks are able to offer higher factor remunerations at the pre-shocks equilibrium allocation, they have the opportunity to expand their operations by attracting additional factor services away from less productive firms until convergence in factors’ MRPs restores the equalization of factor remuneration across firms in the new post-shocks equilibrium. In this respect, observed gaps in factors’ MRPs across firms reveal ‘distorted’ factor allocation across them as factors are inefficiently used. This inefficient allocation of resources is what HK

3 The only quantitative results from HK we will use are those on the computation of TFPR and factors’ MRPs. As these follow standard textbook definitions, we provide here only a qualitative discussion of the logic of the HK approach, referring interested readers to Appendix 1 for additional details.

call ‘misallocation’ and its extent can be measured by the width of the observed gaps (‘wedges’) in factors’ MRPs between firms. It implies that, though offering higher remunerations, more productive firms are not able to attract the factors they would need to grow and thus remain inefficiently small. Vice versa, though offering lower remunerations, less productive firms are inefficiently large.

The dispersions of MPRs map into the dispersion of ‘revenue TFP’ (TFPR). Under the HK assumptions more dispersion of TFPR is, in turn, associated with more inefficient allocation and lower welfare (‘misallocation’).<sup>4</sup> If we use  $TFPR_{si}$  to denote the TFPR of firm  $i$  in sector  $s$  and  $\overline{TFPR}_s$  to denote the sectoral average, then  $TFPR_{si}/\overline{TFPR}_s > 1$  implies that the firm is inefficiently small and should be allocated more inputs in order to be able to increase its output and decrease its price until  $TFPR_{si}/\overline{TFPR}_s = 1$ . Conversely,  $TFPR_{si}/\overline{TFPR}_s < 1$  implies that the firm is inefficiently large and should be allocated less inputs in order to be able to decrease its output and increase its price until  $TFPR_{si}/\overline{TFPR}_s = 1$ . The dispersion of  $TFPR_{si}$  around  $\overline{TFPR}_s$  has a direct impact on sectoral TFP as the latter can be expressed in terms of the ideal level of sectoral TFP that would be achieved under the efficient allocation of resources minus the observed variance of firm TFPR in the actual allocation.<sup>5</sup>

The extent of the misallocation in the economy can be measured in terms of aggregate TFPR dispersion as a weighted average of the sectoral misallocations, with the weights expressed in terms of sectoral value added (VA) shares with respect to the total economy

$$\text{Var}(\text{TFPR}) = \sum_{s=1}^S \frac{VA_s}{VA} \underbrace{\sum_{i=1}^{N_s} \frac{VA_{si}}{VA_s} (TFPR_{si} - \overline{TFPR}_s)^2}_{\text{Var}(\text{TFPR}_s)}, \tag{1}$$

where  $N_s$  is the number of firms in sector  $s$  and  $S$  is the number of sectors. This is the expression we use to measure aggregate misallocation for the economy.<sup>6</sup>

We are also interested in understanding the extent to which aggregate dispersion is driven by variations between and within geographical areas or firm size classes. Using  $g$  to denote an area/size group,  $TFPR_{gsi}$  will refer to the TFPR of firm  $i$  in sector  $s$  and area/size group  $g$  and  $N_{gs}$  to the number of firms in that sector and group. Aggregate

4 As discussed in the introduction, this is not necessarily the case when markups vary across firms (Asker *et al.*, 2014), or firms incur adjustment costs in reacting to idiosyncratic shocks (De Loecker and Goldberg, 2014; Haltiwanger, 2016).  
 5 For our purposes it is conceptually crucial to measure TFPR based on cost shares as in HK rather than from the residual of a firm-level production function estimation as in the productivity literature in IO (Foster *et al.*, 2017).  
 6 The same measure is used by HK (2009), although they do not weight across units (i.e., the shares  $VA_{si}/VA_s$ ). Thus, compared with HK, our measure assigns more importance to misallocation in larger firms.

TFPR dispersion in the economy can then be decomposed into within-group and between-group components as

$$\begin{aligned} \text{Var}(\text{TFPR}) = & \underbrace{\sum_{g=1}^G \frac{\text{VA}_g}{\text{VA}} \sum_{s=1}^S \frac{\text{VA}_{gs}}{\text{VA}_g} \sum_{i=1}^{N_{gs}} \frac{\text{VA}_{gsi}}{\text{VA}_{gs}} (\text{TFPR}_{gsi} - \overline{\text{TFPR}}_{gs})^2}_{\text{Var}(\text{TFPR})_g} \\ & \underbrace{\hspace{10em}}_{\text{Var}(\text{TFPR})_g} \\ & \underbrace{\hspace{15em}}_{\text{WITHIN-GROUP}} \\ & + \underbrace{\sum_{g=1}^G \frac{\text{VA}_g}{\text{VA}} \sum_{s=1}^S \frac{\text{VA}_{gs}}{\text{VA}_g} (\overline{\text{TFPR}}_{gs} - \overline{\text{TFPR}})^2}_{\text{BETWEEN-GROUP}}, \end{aligned} \quad (2)$$

where  $G$  is the number of area/size groups. In Equation (2), the overall TFPR variance is decomposed in two parts: a weighted average of the within-group-squared deviations from the group mean, and a weighted average of the squared deviations of the group means from the overall mean. Specifically, the within-group component represents a weighted average of the group-specific variances, in turn expressed in terms of weighted averages of the variance within the sector-specific TFPR distributions in the group.

When the economy is considered a single area/size group (so that the number of groups is equal to one), the within-group component in 2 boils down to 1, that is to a simple within-sector component, consisting of a weighted average of the within-sector variances.

### 3. DATA DESCRIPTION

We use two main databases. The first – CERVED – covers the universe of incorporated companies, with information from firms' balance sheets that we use in Section 4 and to study the evolution of aggregate misallocation. The second – INVIND – is a panel of representative Italian manufacturing firms with at least 50 employees, with more detailed information on firms' characteristics that we use in Section 9 to analyse the firm-level markers of misallocation. We group manufacturing firms into three-digit sectors using the ATECO 2002 classification, which allows us to distinguish detailed categories such as 'machines for producing mechanic energy', 'machines for agriculture', 'tooling machines', 'machines for general use', etc.<sup>7</sup>

7 The total number of third-digit sectors is 91. We also use a classification at two-digit and four-digit and results hold. We exclude 'coke and petroleum products' and 'other manufacturing n.e.c.' from manufacturing. These sectors have peculiar behaviours, whose study lies outside the scope of this paper.

CERVED accounts for 70% of manufacturing VA from national accounts and the trend rate follows very closely the national one. In order to compute firm-level measures of TFPR as in HK, we need measures of output as well as of labour and capital inputs. We measure the labour input using the cost of labour and the capital stock using the book value of fixed capital net of depreciation, while we take firms' VA as a measure of the total revenue of the model as this does not consider intermediate inputs. All variables are deflated through sector-specific deflators (with base year 2007). We clean the database from outliers by dropping all observations with negative values for real VA, cost of labour, or capital stock. We are left with a pooled sample of 1,740,000 firm-year observations for manufacturing over the period 1993–2013. The average number of observations per firm is 12. To compute firm-level TFPR we also need capital and labour shares at industry level. We compute the labour share by taking the industry mean of labour expenditure on VA measured at the firm level. We then set the capital share as one minus the computed labour share.

INVIND is the Bank of Italy's annual 'Survey of Industrial and Service Firms'. The survey contains detailed information on firm revenues, ownership, production factors, year of creation, and number of employees since 1984. In order to analyse the firm-level features of misallocation, the INVIND data are matched with those from 'Centrale dei Bilanci', a representative sample with more detailed information on firms' characteristics. INVIND contains balance sheet data on around 30,000 Italian firms and is matched with 'Centrale dei Bilanci' using the tax identification number of firms. We drop observations pre-1987, in order to have a proper sample coverage, as well as those not matched. We are left with a pooled sample of 19,924 firm-year observations over the 25-year period 1987–2011, with an average of 11 observations per firm. We divide the INVIND panel in low-tech and high-tech sectors using the OECD classification of manufacturing industries according to their global technological intensity, based on R&D expenditures respect to VA and production.<sup>8</sup>

Table 1 presents sectoral descriptive statistics from CERVED at two-digits for average real VA, capital stock, and cost of labour over the period of observation, both in absolute terms and in percentages with respect to the total.<sup>9</sup> The sectors 'machinery', 'metals', and 'textile and leather' are the sectors with the largest numbers of firms and represent 62% of the total number of manufacturing firms. Real VA ranges from a

8 High-tech industries include firms that produce office, accounting, and computing machines; radio, TV, and communication equipment; aircraft and spacecraft; medical, precision, and optical instruments; electrical machinery and apparatus n.e.c.; motor vehicles, trailers, and semi trailers; chemicals excluding pharmaceuticals; rail-road equipment and transport equipment n.e.c.; and machinery and equipment n.e.c. Low-tech industries account for firms that work in building and repairing of ships and boats; rubber and plastic products; other non-metallic mineral products; basic metals and fabricated metal products; wood, pulp, and paper; paper products; printing and publishing; food products; beverage and tobacco; textiles; and leather and footwear.

9 We present the descriptive statistics for two-digit sectors for ease of exposition, but the quantitative analysis is at three-digit level.

mean of around 0.8 m euro in ‘wood’ to around 4.4 m euro in ‘vehicles’. Variation in the average capital stock is sizable, ranging from around 1 m euro in ‘textile and leather’ to around 4.9 m euro in ‘vehicles’. The cost of labour varies notably too, ranging between 0.5 m euro in ‘wood’ and 3.2 m euro in ‘vehicles’.

In order to better understand the evolution of misallocation, we divide the dataset into geographic and firm size cells. In particular, we group firms within each industry into four macro-areas: Northwest, Northeast, Centre, South-Islands.<sup>10</sup> We also divide the firms in the dataset into four groups according to their size: ‘micro’, ‘small’, ‘medium’, and ‘big’.<sup>11</sup> We report the summary statistics of the main variables divided by geographic area and size, both in absolute terms and percentages, in Table 2. Around two-thirds of manufacturing firms are located in the Northern areas of the country. In these areas, manufacturing firms’ VA, capital stock, and cost of labour are higher than the average. Looking at firm size, more than 88% of manufacturing firms are ‘micro’ or ‘small’, while only 2.2% are ‘big’. However, ‘micro’ and ‘small’ firms account for only around 30% of total VA and input costs, whereas big firms account for around 45%.

In Table 3, we present the summary statistics of firms clustered by sector-area and by sector-size. For most of the industries the majority of firms are located in the North. Moreover, practically all sectors are composed mainly by ‘micro’ and ‘small’ firms, with the majority of bigger manufacturing firms concentrated in ‘chemicals’, ‘food and tobacco’, and ‘vehicles industries’. Table 4 shows the relevance of firm size by geographic area. In the Northwest more than half of the VA in manufacturing comes from ‘big’ firms. Finally, Table 5 looks at the distribution of VA by firm size across geographical areas. About 56% of VA produced by big firms in the manufacturing sector comes from the Northwest, this confirms a strong overlap between the Northwest region and big firms.

#### 4. THE PATTERNS OF AGGREGATE MISALLOCATION

We first investigate the misallocation pattern in the manufacturing sector by computing the TFPR variance as described in Equation (1). The output of this exercise (in logs) is depicted in Figure 4, where we also report the average TFPR based on the same weighting scheme used for the variance. The figure shows that a large decline in average TFPR occurred in the mid-90s, followed by a temporary recovery from 2005 to 2007

10 We use the ISTAT (National Institute of Statistics) classification of macro-areas. ‘Northwest’ includes the regions Liguria, Lombardy, Piedmont, and Aosta Valley; ‘Northeast’ includes Emilia-Romagna, Friuli-Venezia Giulia, Trentino-South Tyrol, and Veneto; ‘Centre’ includes Lazio, Marche, Tuscany, and Umbria; ‘South and Islands’ include Abruzzi, Basilicata, Calabria, Campania, Molise, Apulia, Sicily, and Sardinia.

11 We use the European Commission classification of firms according to their turnover. ‘Micro’ are firms with a turnover <2 m euros, ‘small’ <10 m euros, ‘medium’ <50 m euros, ‘big’ >50 m euros. See [http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition/index\\_en.htm](http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition/index_en.htm).

**Table 1. Summary statistics**

	Value added	Capital	Cost of labour	Obs.
Textile and leather	1,265 10.92%	969 8.86%	802 10.91%	249,000 16%
Paper	1,342 5.93%	1,410 6.6%	834 5.81%	127,000 8.2%
Chemicals	2,990 14.36%	3,138 15.96%	1,769 13.38%	138,000 8.9%
Minerals	1,790 5.97%	2,451 8.65%	1,075 5.65%	96,000 6.2%
Metals	1,426 15.81%	1,436 16.86%	909 15.88%	319,000 20.5%
Machinery	2,092 28.3%	1,276 18.29%	1,398 29.79%	390,000 25.1%
Vehicles	4,405 7.93%	4,884 9.31%	3,177 9.01%	51,800 3.3%
Food+tobacco	1,994 9.48%	2,693 13.56%	1,102 8.25%	137,000 8.8%
Wood	807 1.31%	1,109 1.91%	520 1.33%	46,800 3%

*Notes:* CERVED database. Main variables expressed both in absolute values and in percentages of the total. Absolute values are expressed in thousand of 2007 euros.

**Table 2. Summary statistics by geographic area and size**

	Value added	Capital	Cost of labour	Obs.
Panel A: By geographic area				
Northwest	2,438 50.1%	2,175 47.35%	1,559 50.49%	592,000 38.1%
Northeast	1,921 27.71%	1,689 25.81%	1,196 27.19%	416,000 26.8%
Centre	1,403 14.3%	1,222 13.2%	894 14.36%	294,000 18.9%
South and Islands	896 7.86%	1,462 13.6%	574 7.93%	253,000 16.3%
Panel B: By firm size				
Micro	267 8.37%	263 8.73%	193 9.51%	902,000 58%
Small	1,224 20.01%	1,117 19.34%	816 21.01%	471,000 30.3%
Medium	4,950 25.48%	4,613 25.15%	3,105 25.17%	148,000 9.5%
Big	39,400 46.14%	37,700 46.78%	24,000 44.31%	33,700 2.2%

*Notes:* CERVED database. Main variables expressed both in absolute values and in percentages of the total. Absolute values are expressed in thousand of 2007 euros. Firms divided into four geographic areas and four firm sizes.

**Table 3. Percentages of firms in each sector, by geographic area and size**

	Northwest (%)	Northeast (%)	Centre (%)	South and Islands (%)	Micro (%)	Small (%)	Medium (%)	Big (%)	Tot. (%)
Textile and leather	4.6	3.4	5.1	2.9	9.2	5.0	1.5	0.2	16.0
Paper	28.6	21.0	32.2	18.2	57.4	31.5	9.7	1.4	100
Chemicals	3.4	1.8	2.0	1.1	5.7	1.9	0.5	0.1	8.2
Minerals	41.1	21.5	24.6	12.8	69.7	22.9	6.2	1.3	100
Metals	4.3	2.1	1.3	1.2	4.2	3.1	1.2	0.4	8.9
Machinery	48.4	23.9	14.8	12.9	47.6	34.6	13.8	4.1	100
Vehicles	1.3	1.7	1.4	1.7	3.5	2.0	0.5	0.1	6.2
Food and tobacco	21.7	27.7	22.9	27.8	57.5	32.0	8.7	1.8	100
Wood	9.0	5.7	2.9	3.0	12.8	5.9	1.5	0.3	20.5
Tot.	43.6	27.7	14.0	14.7	62.4	28.9	7.1	1.5	100
	11.4	8.0	3.3	2.3	14.1	7.9	2.5	0.5	25.1
	45.6	31.9	13.3	9.2	56.4	31.5	9.9	2.2	100
	1.3	0.8	0.6	0.7	1.8	1.0	0.4	0.1	3.3
	38.2	22.8	18.4	20.5	54.6	28.9	12.3	4.2	100
	2.1	2.3	1.6	2.8	4.6	2.7	1.2	0.3	8.8
	24.2	26.4	17.8	31.6	52.0	30.5	13.6	3.9	100
	0.7	1.0	0.6	0.7	2.0	0.8	0.2	0.0	3.0
	24.2	33.3	20.4	22.2	65.6	28.2	5.7	0.5	100
	38.1	26.7	18.9	16.3	58.0	30.3	9.5	2.2	100

Notes: CERVED database. Percentages of firms in each group. Firms divided into four geographic areas and four firm sizes. For each sector, the first line reports the group percentage with respect to the whole manufacturing, while the second one the percentage with respect to the specific sector.

**Table 4. Value-added shares of firms in each geographic area, by size**

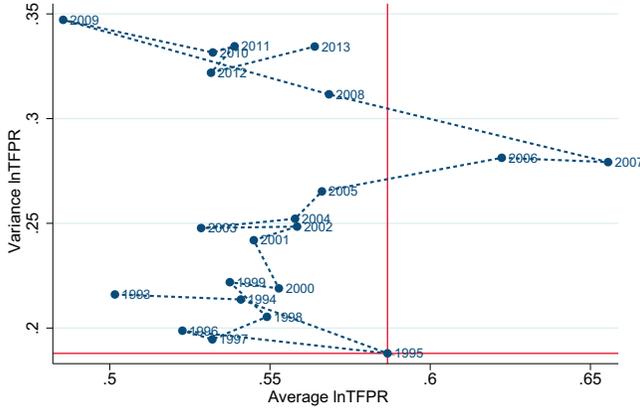
	Micro (%)	Small (%)	Medium (%)	Big (%)	Tot. (%)
Northwest	6.4	17.5	24.1	52.0	100.0
Northeast	7.9	21.7	29.2	41.2	100.0
Centre	11.5	21.7	22.8	44.0	100.0
South and Islands	18.3	25.9	25.2	30.5	100.0

Notes: CERVED database. Value-added shares of firms in each group. Firms divided into four geographic areas and four firm sizes. For each geographic area, reported the group percentage with respect to the specific size class.

**Table 5. Value-added shares of firms in size class, by geographic area**

	Northwest (%)	Northeast (%)	Centre (%)	South and Islands (%)	Tot. (%)
Micro	37.6	26.0	19.4	17.0	100.0
Small	43.6	30.5	15.6	10.3	100.0
Medium	47.2	32.1	12.8	7.8	100.0
Big	56.1	25.0	13.7	5.2	100.0

Notes: CERVED database. Value-added shares of firms in each group. Firms divided into four geographic areas and four firm sizes. For each size class, reported the group percentage with respect to each geographic area.



**Figure 4. Evolution of TFPR average and variance (1993–2013)**

Source: CERVED.

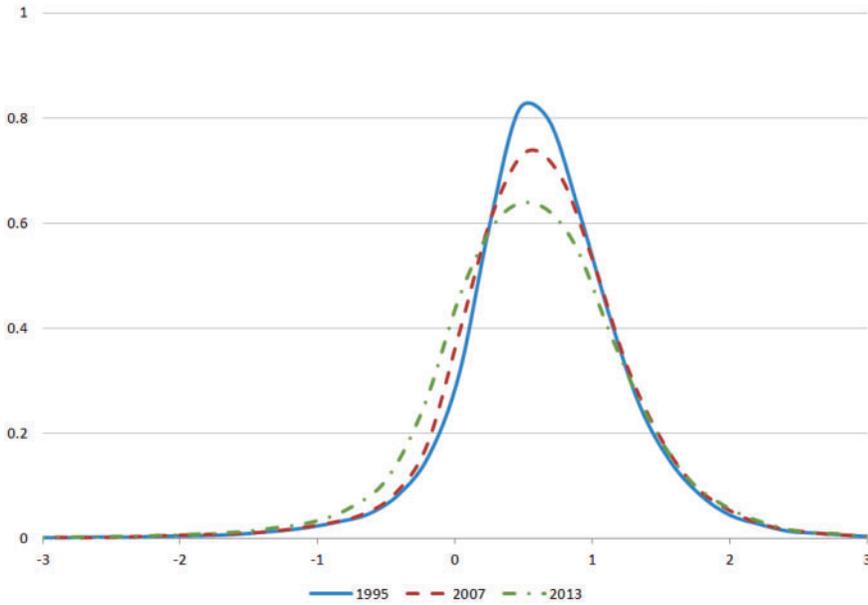
and a new fall associated with the economic crisis with a drop of about  $-10.5\%$ . Moreover, aggregate misallocation (as measured by the variance of TFPR) steadily and steeply increased between 1995 and 2009 and slightly decreased after its peak in 2009. However, aggregate misallocation increased by almost 69% between 1995 and 2013 with most of the increase taking place in the first decade.<sup>12</sup>

Figure 5 shows quite clearly that the evolution of TFPR highlighted above (i.e., decreasing average and increasing variance) mainly occurred through a rising share of low TFPR firms. When the comparison is made, instead, between 2007 and 2013 (see Figure 5), the difference in the share of low TFPR firms is much less pronounced. In fact, recalling what we have seen in Figure 4, 2007 represents a critical year for average TFPR but not for its variance as this grows until 2009. Figure 6 shows the evolution of aggregate misallocation, captured by the variance of TFPR over the full sample of firms per-year. We can see that misallocation raised sharply from 1995 to 2009, when it started a process of slow reversion. This suggests that the aggregate decrease in TFPR occurred in the last years compounds a long-run increase in misallocation with a crisis-related fall in average firm productivity. Interestingly, misallocation stopped increasing after the global financial crisis. This is probably due to some cleansing effect of the crisis, as firms in the lowest percentiles of the productivity distribution are much more likely to exit the market after the crisis than in previous years.<sup>13</sup>

In principle, the increasing misallocation pattern documented in the aggregate might hide substantial differences across sectors, areas, and firm size categories. However,

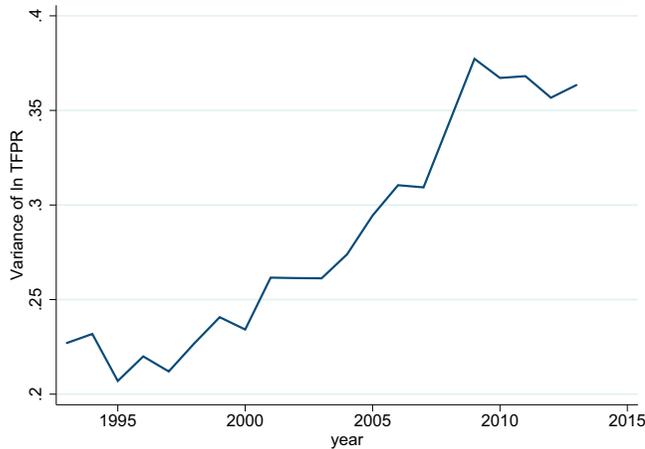
12 In order to have some insight about the trend of misallocation before 1993, we also use the INVIND database which starts in 1987–2011, but accounts for a more limited sample of firms above 50 employees. This longer database confirms that the rise of misallocation is a phenomenon that started in the mid-90s and it was not a previously undergoing trend. In INVIND, misallocation has a similar trend with respect to CERVED, although the raise starts a couple of years later in 1997 and is quantitatively stronger.

13 Details available upon request.



**Figure 5. Distribution of TFPR, 1995, 2007, and 2013**

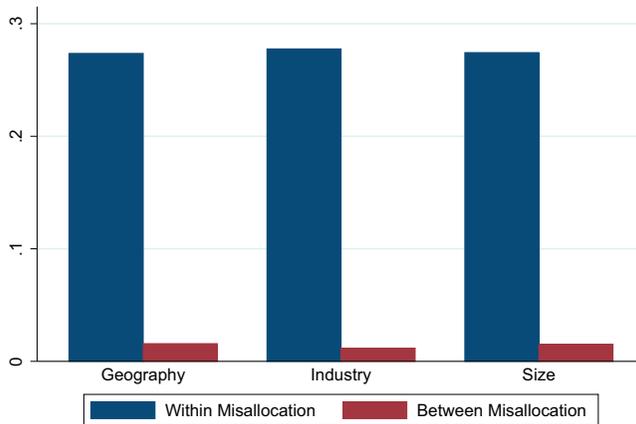
*Source:* CERVED.



**Figure 6. Evolution of aggregate misallocation, 1993–2013**

*Source:* CERVED.

before going into the details of each dimension, we implement the decomposition in Equation (2) in order to understand to what extent aggregate misallocation can be traced back to differences in terms of TFPR dispersion across the categories. In Figure 7, we report the computed within and between components of aggregate TFPR variance for the three dimensions, along the whole period under consideration (1993–2013). The message is clear-cut as the between component is always small compared



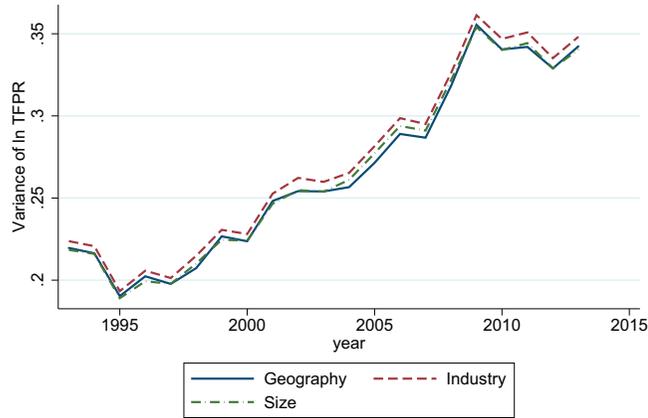
**Figure 7. Misallocation, within versus between categories**

*Source:* CERVED. The figure reports a decomposition exercise of the dispersion of ln TFPR within and between each of the three categories (geographic area, industry, and size class). The values are computed over the whole 1993–2013 period.

with the within component with only slight differences emerging across the three dimensions (Figures 8 and 9). Moreover, since the between components start growing only after 2000, the increase in aggregate variance occurred between 1995 and 2000 is almost entirely driven by the within components. We wonder whether this pattern is driven by firms' entry and exit, so in Figure 10 we report the evolution of within misallocation for firms that are always in our data set (balanced panel) and for the full sample that accounts also for entry and exit. Even if the level of misallocation is lower for the balanced panel, the trend of misallocation is qualitatively very similar in both samples. However, from a quantitative point of view, after 1995 misallocation increases more significantly for the balanced panel than for the full sample; this implies that, if anything, the process of entry and exit is dampening the raise of misallocation, which is consistent with the findings of Linarello and Petrella (2016).

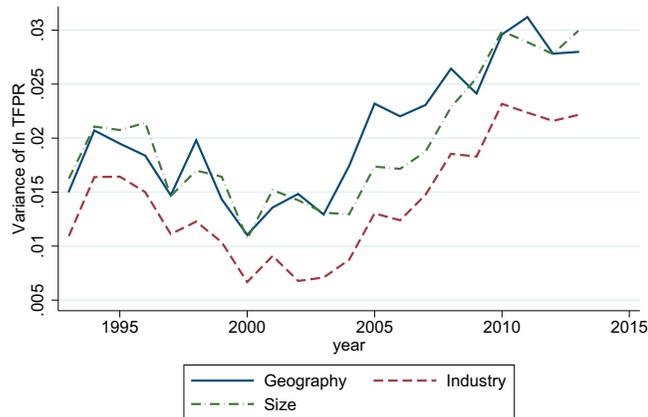
As shown by HK, TFPR is proportional to the geometric average of the marginal product of capital (MRPK) and labour (MRPL). Hence, the dispersion of TFPR and our measure of misallocation are going to be proportional to MRPK and MRPL. Figure 11 reports the patterns of MRPK and MRPL dispersion. Capital is the factor of production that experiences the sharpest increase in its marginal product's dispersion since the mid-1990s, although the pattern has flattened out since the global financial crisis. To some extent the dispersion of MRPL increased too, but it does not show a striking trend.<sup>14</sup> This seems to suggest that the capital market is a very important source of misallocation in Italy.

14 If we look at the change of the distribution of MRPK and MRPL between 1995 and 2013, we see that MRPK experienced a fattening of both tails and it kept a very similar mean; whereas the distribution of MRPL experienced a clear leftward shift with a significant decrease of the mean. Results are available upon request.



**Figure 8. Evolution of within-misallocation by category**

*Source:* CERVED. The figure reports the evolution of the within component of the variance of ln TFPR, by category.

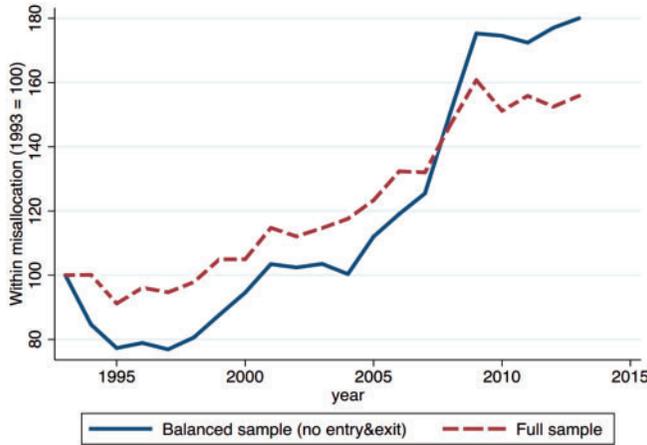


**Figure 9. Evolution of between-misallocation by category**

*Source:* CERVED. The figure reports the evolution of the between component of the variance of ln TFPR, by category.

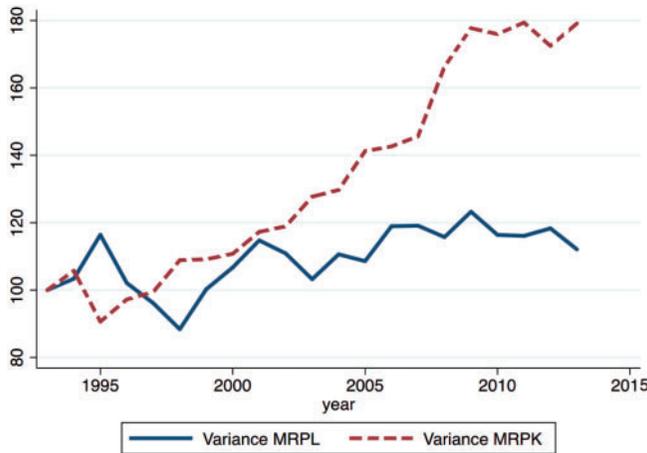
## 5. INSIGHTS FROM REGIONAL AND SIZE PATTERNS

To better understand the geographical distribution of misallocation, we report in [Figure 12](#) the evolution of misallocation within macro-regions (i.e., the term  $\text{Var}(\text{TFPR})_g$  in [Equation \(2\)](#)). We note that misallocation in the Northwest and the Centre grew at a considerably higher rate, compared with the other areas; misallocation in the South was higher than in the rest of Italy at the beginning of the period but, being quite stable over time, ends up being lower than in the North at the end



**Figure 10. Evolution of misallocation, balanced versus full-sample (1993 = 100)**

Source: CERVED.



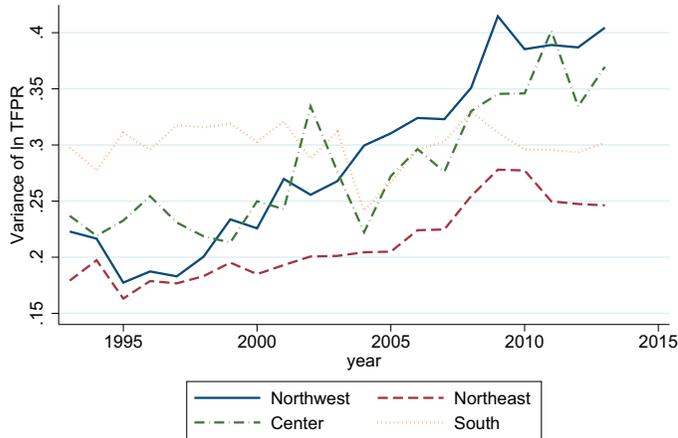
**Figure 11. Evolution of misallocation, marginal product of capital and labour (1993 = 100)**

Source: CERVED.

of the period.<sup>15</sup> The same analysis can be carried out in terms of firm size categories (Figure 13). This exercise shows that, while misallocation grew in all size classes, a steeper increase is reported for the big firms class, which faced the lowest degree of misallocation 1995 and turns to be the group with the highest level of misallocation towards the end of the period.

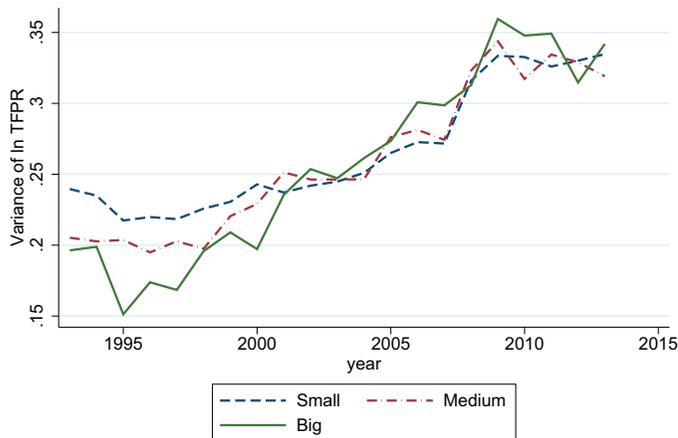
15

To save on space, we do not show the graphs of group-specific distributions, but they support this finding.



**Figure 12. Misallocation by geographic area**

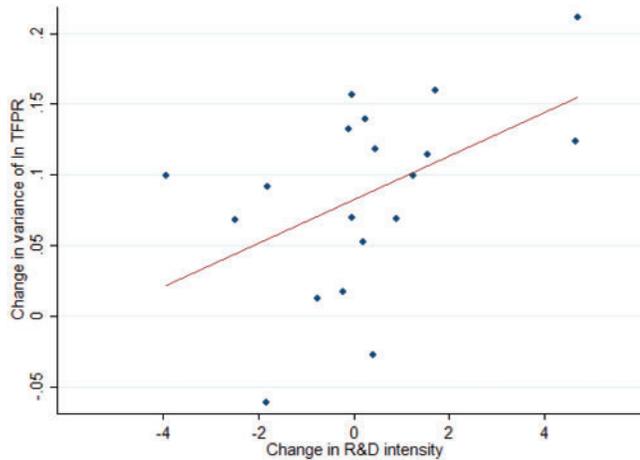
Source: CERVED.



**Figure 13. Misallocation by firm size**

Source: CERVED.

These results are surprising because firms in the Northwest region and bigger firms are traditionally more advanced and closer to the technological frontier. This suggests a possible explanation of raise of misallocation: for given level of frictions, the shocks hitting firms have become more dispersed; this might be the result of a fast changing technological frontier (due for instance to the IT revolution, see [Schivardi and Schmitz, 2012](#)). To explore this possibility we build on [Griffith \*et al.\* \(2004\)](#). As a proxy of shocks to the technology frontier by sector, we take the change of R&D intensity between the period 1993–2007 and 1987–1992. We measure R&D intensity as the share of R&D expenditure to VA at the two-digit sectoral level in advanced countries other



**Figure 14. Change in R&D intensity and misallocation at the sectoral level**

*Source:* CERVED and OECD. The figure reports the correlation between the change of misallocation and R&D intensity at the two-digit sectoral level. The change in misallocation is computed between 2013 and 1993. The change in research intensity is measured by taking the difference between the period 1993–2007 and 1987–1992. R&D intensity is measured as the share of R&D expenditure on VA.

than Italy.<sup>16</sup> Figure 14 plots the correlation between the change of misallocation over our sample period and the change of R&D intensity described above. The correlation is positive and significant, such that an increase of one standard deviation of R&D intensity growth is associated with a 0.14 standard deviation increase of misallocation growth (statistically significant at the 1% level). Moreover, we compute the implied ‘frontier shocks’ at the regional level, by taking the weighted average of the sectoral changes in R&D intensity. It turns out that the ‘frontier shock’ is higher in the Northwest (4.6%) and the Centre (5.1%) and lower in the Northeast (3.1%) and the South (2.2%). This follows the region and size patterns of misallocation highlighted above.<sup>17</sup>

An implication of this result is that firms in the upper part of the TFPR distribution should be those that contribute more to the overall increase in misallocation. We find that the standard deviation of log TFPR is about 0.4 for firms in the top quartile of the TFPR distribution and it is increasing over time. Whereas for firms in the second and third quartile misallocation is slightly increasing after the crisis, but its level is low (0.1). Finally for firms in the bottom quartile, the dispersion is higher (0.6), but it is stable up

16 The countries we consider are Canada, Denmark, Finland, France, Germany, Japan, Netherlands, Norway, Sweden, United Kingdom, and United States. Results hold also if we take R&D intensity in the United States only. Data are from the ANBERD database of the OECD.

17 Interestingly, these results are unlikely to be linked to the raise of international competition. Firstly, as Griffith *et al.* (2004) show, import penetration has no significant effect on innovation. Secondly, we have looked at the effect of sectoral exposure to the raise of China after its access to the WTO, using an indicator similar to Autor *et al.* (2013). We find no relation between sectoral exposure to China and increase in misallocation.

to the crisis and then decreases. Therefore, the dispersion across the firms that are in the top quartile of the distribution is the one that contributes the most to the rise of aggregate misallocation.

## 6. IDIOSYNCRATIC SHOCKS AND THE CYCLICAL BEHAVIOUR OF MISALLOCATION

The rise of the dispersion of TFPR across firms that we highlight could be driven by an increase in the dispersion of idiosyncratic shocks that firms face. To investigate this issue we measure the idiosyncratic shocks to firms' TFPR following [Gopinath \*et al.\* \(2017\)](#). We assume that firms' productivity is the product of an aggregate effect, a permanent firm level effect, and an idiosyncratic transitory effect, which depends on past TFPR and an idiosyncratic shock. More specifically we consider:

$$\ln \text{TFPR}_{ist} = \gamma_i + \delta_{st} + \beta \ln \text{TFPR}_{ist-1} + u_{ist}, \quad (3)$$

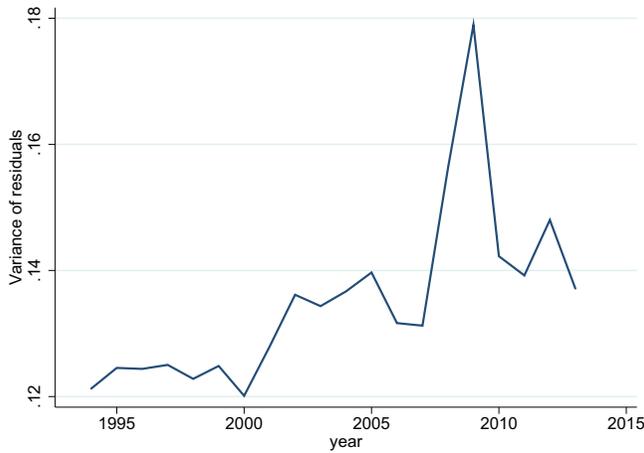
where  $\gamma_i$  captures the firm permanent component,  $\delta_{st}$  is an industry-year-fixed effect that denotes the aggregate component of firm productivity, and  $u_{ist}$  is the residual that captures the idiosyncratic shock that firms face.

In [Figure 15](#), we show the dispersion of the residuals estimated from [Equation \(3\)](#). We find that there is no increase in the dispersion of idiosyncratic shocks between 1995 and 2000. This means that, at least initially, the raise in misallocation that we observe since 1995 is unlikely to be driven by a higher dispersion of firm-level shocks. Nonetheless, we see an increase in the dispersion of shocks in the period 2000–2002 and then in 2008–2009. The former is associated to a sharp slowdown in GDP growth (from 3.7% to 0.2%), the latter with the recession due to the global financial crisis.

Interestingly, there is no significant rise in the dispersion of idiosyncratic shocks after the European debt crisis of 2011, although the level of the dispersion remains higher than the pre-2008 period. Moreover, as we observed in [Figure 6](#), the level of misallocation decreases slightly after the European debt crisis. This could be due to some cleansing effect that this crisis had. [Figure 16](#) shows the exit rate of firms by TFPR decile: before the European crisis (i.e., before 2007), after the global financial crisis (i.e., after 2009), and after the European sovereign debt crisis (i.e., after 2012). The results show that, for firms in the lowest deciles, the exit rate increases significantly after the European crisis, but not after the global financial crisis. This provides suggestive evidence of some cleansing effect following the European crisis.

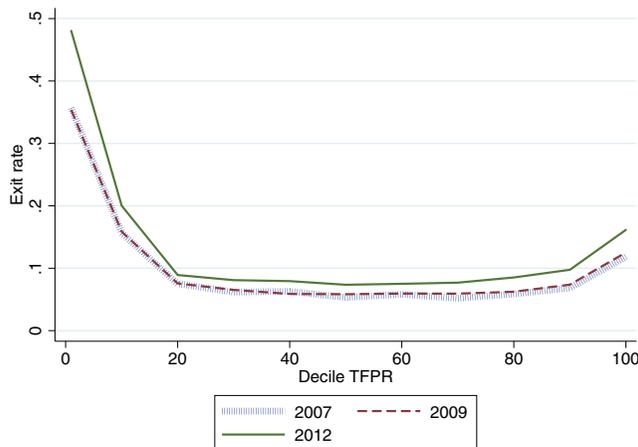
## 7. THE IMPACT OF MISALLOCATION ON AGGREGATE PRODUCTIVITY

The overarching message of the evidence presented in the previous sections is that overall the stagnation of Italian productivity since the 1990s has been accompanied by a steady increase in misallocation. We now quantify the impact that the increase in



**Figure 15. Dispersion of idiosyncratic productivity shocks**

Source: CERVED. The figure reports the evolution of the dispersion of idiosyncratic productivity shocks, constructed as the residuals of a regression of TFPR on firm-fixed effects, sector-year-fixed effects, and lagged TFPR. See the main text for the details.

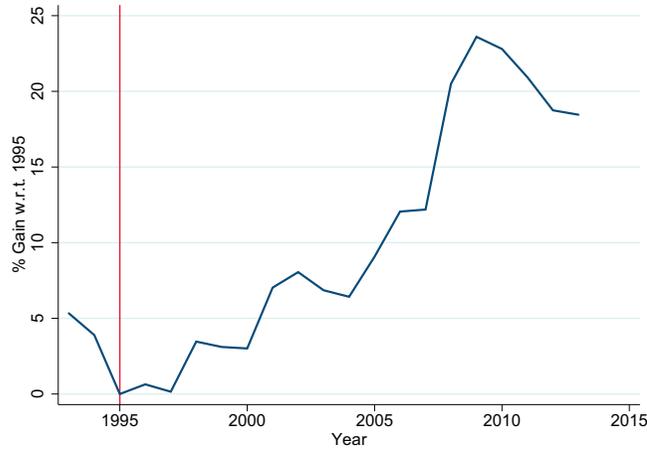


**Figure 16. Exit rate by productivity decile**

Source: CERVED. The figure shows the share of firms that exit the market for each decile of firms’ productivity in specific years.

misallocation had on aggregate TFP during our period of observation. In particular, we want to understand how much aggregate TFP in 2013 would have changed if misallocation had remained constant at the 1995 level.

Following HK, we proceed as follows. First, in each year  $t$  from 1995 to 2013 we evaluate the increase in aggregate output that could be achieved by completely eliminating misallocation (i.e., by reallocating productive factors so as to equalize their remunerations across all firms). In any given year, within the HK framework that increase is dictated by the ratio between the observed aggregate output level  $Y$  and the efficient



**Figure 17. Productivity gains from equalizing TFPR dispersion to its 1995 value, manufacturing**

Source: CERVED.

aggregate output level  $\gamma^*$  in the absence of gaps in factor remunerations. We can, therefore, evaluate the percentage increase in aggregate productivity that could have been achieved in any year  $t$  by completely eliminating misallocation as:

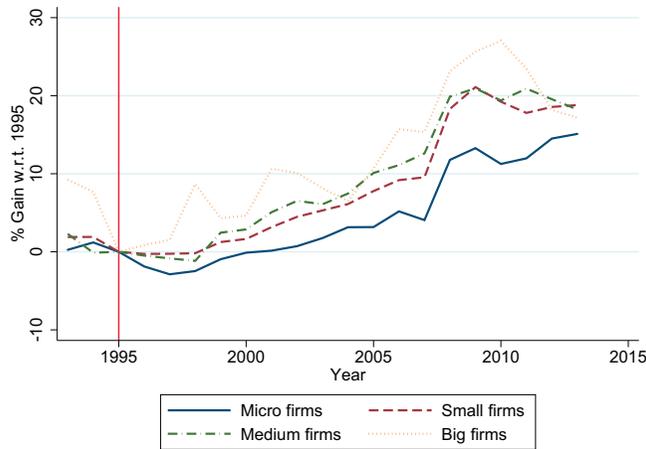
$$\text{Gain}_t = \left( \frac{\gamma_t^*}{\gamma_t} \right) - 1. \quad (4)$$

Second, to understand how much aggregate productivity in year  $t$  would have changed if misallocation had remained constant at the 1995 level, we can look at the percentage relative change in the efficient-to-observed output ratios in the 2 years:

$$\text{Gain}_{t/95} = \left( \frac{\gamma_t^*/\gamma_t}{\gamma_{95}^*/\gamma_{95}} \right) - 1. \quad (5)$$

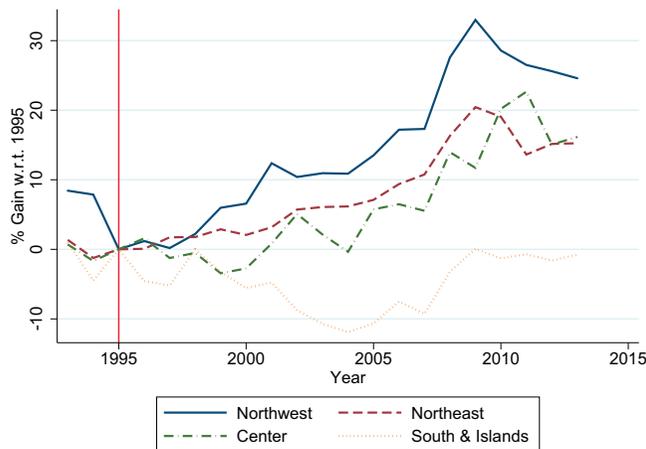
When applied to our data, Equation (5) implies that, if misallocation had remained at its 1995 level, in 2013 aggregate productivity would have been 18% higher than its actual level (Figure 17). Moreover, the effect of misallocation on productivity peaked in the aftermath of the global financial crisis leading to a 23% foregone productivity gain, but weakened slightly after the euro-debt crisis. So, even after netting out the spike in the productivity penalty of misallocation associated with the crisis, the adverse effects of misallocation on Italian productivity remain sizeable.<sup>18</sup>

18 The quantitative results of this exercise are sensitive to the values chosen for the elasticity of substitution  $\sigma$  between products sold by firms. In the baseline we set  $\sigma$  equal to 3 as in HK. This is a conservative value also in light of Broda and Weinstein (2006) who find that for SITC-3 digits the average



**Figure 18. Productivity gains from equalizing TFPR dispersion to its 1995 value, by firm size**

Source: CERVED.



**Figure 19. Productivity gains from equalizing TFPR dispersion to its 1995 value, by geographic area**

Source: CERVED.

From a size class (Figure 18) and geographical (Figure 19) perspective, the observed patterns are mainly driven by misallocation across big firms and by firms in the Northwest. In fact, in the cases of big firms and the Northwest, productivity would have been 18% and 25% higher if misallocation in 2013 had stayed at its 1995 level.

value of the elasticity of substitution after 1990 is about 4. Higher values of the elasticity deliver stronger gains: 12% with  $\sigma = 2$  and 19% with  $\sigma = 4$ .

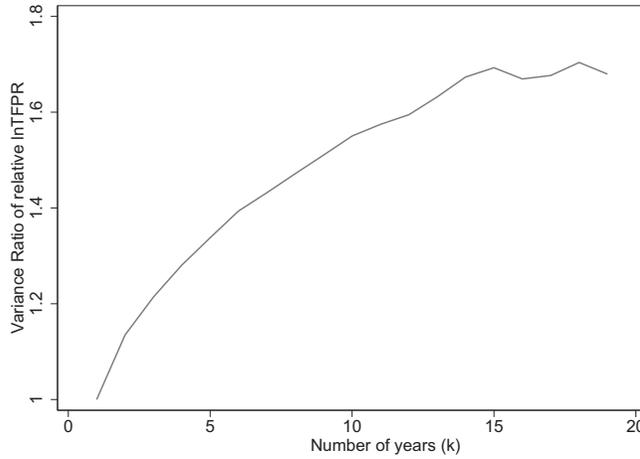
## 8. CAVEATS OF THE HSIEH–KLENOW FRAMEWORK: A ROBUSTNESS ANALYSIS

Even if the measure of misallocation of HK is extensively used in the literature, there are important caveats to keep in mind. For instance, the very idea of interpreting the entire observed dispersion of TFPR across firms as evidence of inefficiency is contentious. [Asker et al. \(2014\)](#) argue that, in the presence of adjustment costs in investment (‘time-to-build’), transitory idiosyncratic TFP shocks across firms naturally generate dispersion of the MPR of capital (MRPK). In this case, as long as adjustment costs are determined by technological factors, the dispersion of MRPK is an efficient outcome and thus the observed gaps (‘wedges’) in MRPK should not be taken as evidence of any misallocation. In this respect, HK neglect the distinction between technology-driven adjustment costs, such as the natural time needed to build a new plant, and wasteful frictions, such as the bureaucratic procedures of authorization that may delay the construction and activation of a new plant. In order to explore whether time to build can be a driver of our findings, we explore the stationarity of our firm-level misallocation measure  $\ln(\text{TFPR}_{i,t}/\text{TFPR}_{i,t-k})$ . The idea is that this ratio should converge towards one over time if the adjustment process after a TFP shock is the main driver of TFPR dispersion. Firstly, we consider the variance ratio statistics ([Cochrane, 1988](#); [Engel, 2000](#)), defined as  $\text{Var}(X_{t+k} - X_t)/\text{Var}(X_{t+1} - X_t)$ , where  $X$  denotes the average of the relative log-TFPR (i.e.,  $\ln \frac{\text{TFPR}_{i,t}}{\text{TFPR}_{i,t-k}}$ ). For stationary series, the variance ratio approaches a limit. The output of this exercise is reported in [Figure 20](#). The pattern suggests that the variation in firm-level misallocation tends to stabilize in a time horizon of around 15 years, which is a too long period for being consistent with an adjustment cost story. We also run a series of unit root tests to investigate the mean reversion property of this ratio. [Table 6](#) reports the Im–Pesaran–Shin ([Im et al., 2003](#)) and the Fisher-type ([Choi, 2001](#)) tests for the presence of unit root. The null hypothesis is rejected in all cases, entailing the series to be stationary and firms’ relative TFPR not being mean reverting.<sup>19</sup>

From a different angle, [De Loecker and Goldberg \(2014\)](#) and [Haltiwanger \(2016\)](#) argue that a reduction in the observed wedges does not necessarily imply more market efficiency. For example, if firms had the same TFP but different initial market power due to demand characteristics, convergence of market power to the top would reduce TFPR dispersion but could be hardly considered an improvement in efficiency. [Melitz and Ottaviano \(2008\)](#) show that in the case of linear demand, markup is increasing with size (the elasticity of demand is decreasing with size). Therefore, if heterogenous markups drive dispersion, we should observe that TFPR increases with size. However, in [Figure 21](#), where we report the average TFPR by size percentile, we find that there is no clear relation between TFPR and size.<sup>20</sup> Moreover, as [Gopinath et al. \(2017\)](#) stress, if

19 Analogous conclusions can be reached by carrying out the tests on the log-TFPR series.

20 In [Figure 21](#), we drop the top and the bottom percentile as a robustness to outliers. The variation of average  $\ln$  TFPR across percentiles is low and it oscillates between 0.52 and 0.56.



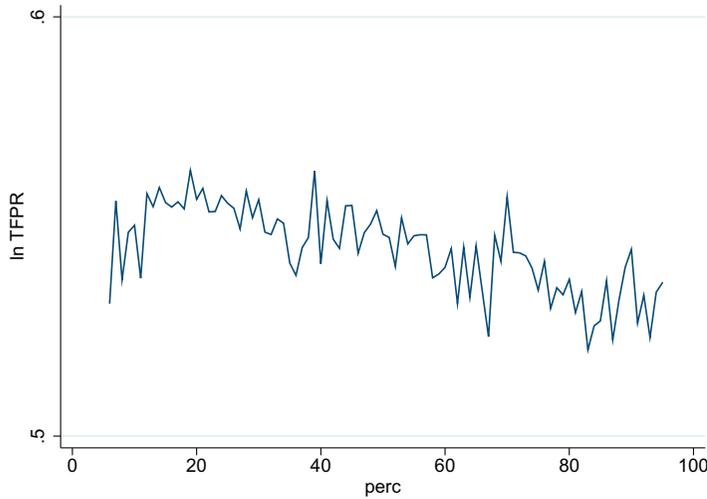
**Figure 20. Variance ratio statistics (stationarity of relative TFPR)**

Source: CERVED. Variance ratio of relative ln TFPR defined as  $\text{Var}(X_{t+k} - X_t) / \text{Var}(X_{t+1} - X_t)$ , with  $X$  denoting the average value of  $\ln \frac{\text{TFPR}_{i,t}}{\text{TFPR}_{i,t-k}}$ .

**Table 6. Unit root tests on relative TFPR**

Test	Statistic	p-value
Im–Pesaran–Shin	Statistic	p-Value
W-t-bar (a)	-17.2958	0.0000
W-t-bar (b)*	-63.9714	0.0000
Fisher-type, Augmented DickeyFuller (c)		
Inverse chi-squared (degrees of freedom 3,476)	5,901.691	0.0000
Inverse normal	-8.8742	0.0000
Inverse logit t(degrees of freedom 8,669)	-13.9079	0.0000
Modified inv. chi-squared	29.0925	0.0000
Fisher-type, Augmented DickeyFuller (c)*		
Inverse chi-squared(degrees of freedom 3,476)	6,539.15	0.0000
Inverse normal	-12.8297	0.0000
Inverse logit t(degrees of freedom 8,599)	-19.645	0.0000
Modified inv. chi-squared	36.7378	0.0000
Fisher-type, PhillipsPerron (d)		
Inverse chi-squared(degrees of freedom 3,476)	7,465.222	0.0000
Inverse normal	-21.5148	0.0000
Inverse logit t(degrees of freedom 8,639)	-29.4953	0.0000
Modified inv. chi-squared	47.8446	0.0000
Fisher-type, PhillipsPerron (d)*		
Inverse chi-squared(degrees of freedom 3,476)	8,073.704	0.0000
Inverse normal	-26.0377	0.0000
Inverse logit t(degrees of freedom 8,614)	-35.8587	0.0000
Modified inv. chi-squared	55.1425	0.0000

Notes: The null hypothesis states that the estimated coefficient  $\phi_{is}$  in the following autoregressive model is equal to zero for all firms:  $\Delta \ln \frac{\text{TFPR}_{i,t}}{\text{TFPR}_{i,t-1}} = \phi_{is} \ln \frac{\text{TFPR}_{i,t-1}}{\text{TFPR}_{i,t-2}} + \mathbf{D}'_{is,t} \gamma_{is} + \epsilon_{is,t}$ .  $\mathbf{D}_{is,t}$  represents a firm-fixed effect in the standard cases and includes a linear time trend in the cases indicated with asterisk;  $\epsilon_{is,t}$  is independently distributed normal for all  $i$  and  $t$  and is allowed to have heterogeneous variances across firms. The alternative hypothesis is that  $\hat{\phi}_{is} \neq 0$  for a fraction of firms. We assume errors to be serially correlated. We let the routine chose the lag in the Im–Pesaran–Shin test, while we set the lag to one in the Fisher-type test. \*, trend included. Serially correlated errors: (a) 1.03 lags – chosen by AIC; (b) 1.72 lags – chosen by AIC; (c) 1 lag Augmented Dickey–Fuller; and (d) 1 lag Newey–West.



**Figure 21. ln TFPR by the percentile of firm size**

Source: CERVED.

markups drive dispersion, the effect should be symmetric for capital and labour and we should observe proportional increases in the dispersion of both MRPK and MRPL. As shown in Figure 11, this is not the case: dispersion increases more for capital.<sup>21</sup>

Finally, another source of concern is related to measurement error in firms' revenues and inputs. As *Bils et al. (2017)* point out, this is likely to distort the misallocation analysis. In fact, a firm's TFPR is higher when revenues are overstated and/or inputs are understated: if, for example, the extent of revenue overstatement (input understatement) systematically grows (shrinks) with firms' true revenues (inputs), the dispersion of measured TFPR is unequivocally biased upward. *Bils et al. (2017)* suggest to tackle this issue by exploiting the intuition that, while without measurement error revenue growth solely depends on TFPR and input growth (i.e.,  $P_{si}Y_{si} = \text{TFPR}_{si}K_{si}^{\alpha_s}L_{si}^{1-\alpha_s}$ ), the presence of measurement error introduces spurious correlation between firms' TFPR and input growth. Their suggested methodology consists of regressing revenue growth on input growth, revenue productivity, and their interaction. While the interaction term is expected to be zero if the level of revenue productivity reflects true differences in marginal products, inverse negative correlation is expected when revenue productivity is a spurious indicator of true marginal products. This approach allows us to evaluate the fraction of observed TFPR dispersion reflecting the actual presence of distortions by estimating the following equation (under the assumption that the measurement error is

21 In ongoing work, Calligaris (2017) extends the analysis of this paper to allow for heterogeneous markups, finding that, if anything, measured misallocation actually increases.

additive with respect to the true revenues and inputs and orthogonal to the true marginal product):

$$\Delta VA_{si} = \Phi \ln \tilde{TFPR}_{si} + \Psi \Delta \zeta_{si} + \Psi(1 - \lambda) \ln \tilde{TFPR}_{si} \Delta \zeta_{si} + D_s + \epsilon_{si,t},$$

where  $\Delta$  denotes the annual growth rate from  $t - 1$  to  $t$ ;  $\zeta_{si}$  is the composite input  $K_{si}^{\alpha_s} (wL_{si})^{1 - \alpha_s}$ ;  $\ln \tilde{TFPR}_{si} = (\ln TFPR_{si,t} + \ln TFPR_{si,t-1})/2$ , with  $\ln TFPR_{si,t} = \ln TFPR_{si,t} - \sum_{i=1}^{N_s} \frac{VA_{si,t}}{VA_{s,t}} \ln TFPR_{si,t}$ ;  $D_s$  is a sector dummy. The parameter  $\lambda$  indicates the fraction of observed misallocation (i.e., differences in TFPR) reflecting actual input misallocation. Our estimated value for this fraction is 0.54, suggesting that more than 50% of our measured misallocation is not driven by measurement error and can thus be regarded as true misallocation.<sup>22</sup> More interesting for us, this fraction is relatively constant over time (if anything slightly increasing) over our sample period, suggesting that, although the level of misallocation has to be taken with caution, our discussion about the trend in misallocation is mostly unaffected by measurement error issues.

**9. PRODUCTIVITY, MISALLOCATION, AND FIRM CHARACTERISTICS**

In order to shed additional light on the relation between exposure to frontier shocks and misallocation within industries, we now investigate which firm characteristics (‘markers’) are associated with firms being inefficiently sized. We use data from INVIND, which is described in Section 3. In particular, we consider corporate ownership and management, finance, workforce composition, internationalization, and innovation, relying on the following reduced form at the firm level:

$$\ln \frac{TFPR_{sit}}{TFPR_{st}} = \beta_0 + \beta_1 X_{sit} + \delta_t + \gamma_s + \epsilon_{sit}, \tag{6}$$

where  $i, s,$  and  $t$  refer to firm, sector, and year, respectively;  $X_{sit}$  is the marker (or vector of markers) we want to analyse<sup>23</sup>;  $\delta_t$  is a year dummy that captures common shocks to all firms in a given year;  $\gamma_s$  is a sector-fixed effects controlling for time-invariant sector characteristics that can influence the effect of the marker on misallocation;  $\epsilon_{sit}$  is the error term. This regression relates a firm’s relative TFPR with the chosen marker (or vector of markers). Thus, if our estimates point to  $\beta_1 > (<) 0$ , we can conclude that firms with larger  $X_{sit}$  are characterized by higher (lower) relative TFPR. It is worth noting how this econometric specifications allow us to identify correlations, but not causation.

In Equation (6), the main variable of interest is marker  $X$ . Its coefficient  $\beta_1$  could be zero in two different scenarios. First, it would be zero if the aggregate allocation of resources was efficient (i.e., if  $TFPR_{is}/\overline{TFPR}_s = 1$  holds true for all firms). As we have

22 Bilal *et al.* (2017) find that this ratio is 0.23 for the United States.  
 23 For robustness, we also enter the markers with a squared term in order to allow for non-linearity.

seen, this is not the case in our data. Second, even if the allocation of resources were not efficient,  $\beta_1$  would be zero if  $X$  did not directly affect relative TFPR. As in the end only the second scenario is relevant, we can conclude that a non-zero estimate for  $\beta_1$  reveals that the marker increases misallocation.<sup>24</sup> In particular, larger (smaller) values of the marker are correlated to more misallocation for positive (negative) estimated  $\beta_1$ . In other words, if the estimated  $\beta_1$  is positive, firms with relatively large  $X$  are inefficiently small and should absorb more resources; vice versa, if the estimated  $\beta_1$  is negative, firms with relatively large  $X$  are inefficiently large and should downsize or exit the market.

Our benchmark specification is based on standard pooled OLS regression, always including sector and year dummies. In fact, with respect to our aim of investigating the markers of misallocation, the most appropriate specification does not include firm-fixed effects. Indeed, we are mainly interested in how cross-firm differences in relative TFPR are related to given firm characteristics; we are less concerned with the effects of the within-firm variation in those characteristics across time.<sup>25</sup>

For each marker, we run Regression (6). Moreover, following HK, we quantify the firm-level output and capital distortions ('wedges') and we use them as alternative dependent variables in Equation (6).<sup>26</sup> In order to interpret the regressions, it is important to keep in mind that capital and labour distortions are each other's mirror image, as a high labour distortion would show up as a low capital distortion. A positive and significant coefficient of the capital wedge on marker  $X$  reveals that  $X$  is associated to higher capital distortion relative to labour (without implying that labour distortion is zero), so that capital compensation is too low relative to labour compensation, given the output elasticities of these two factors. A negative and significant coefficient means instead that firms characterized by marker  $X$  tend to suffer from high labour distortion relative to capital, so that labour compensations are too low relative to capital. Similarly, the output wedge is large when the labour share is small given the industry elasticity of output with respect to labour.

24 In Calligaris *et al.* (2016), we show that a marker could still be linked to misallocation even if  $\beta_1$  were zero, if it is related to the dispersion of the residuals of Equation (6). We have checked whether this is the case and found no evidence, which implies that  $\beta_1 \neq 0$  is the necessary and sufficient condition for a marker to induce misallocation. We omit these results for parsimony but they are available from the authors on request.

25 We have also run a number of different specifications, including additional controls, lagged regressors, and firm effects. Moreover, we have run these regressions by geographic area, firm size, and low- versus high-tech sectors using the OECD classification of manufacturing industries according to their global technological intensity (based on R&D expenditures with respect to VA). While the corresponding results are available upon request, for parsimony we provide here a synthetic description of the most robust and policy relevant findings based on the benchmark case with our aggregate sample.

26 HK show that, for firm  $i$  in sector  $s$ , the capital and output distortions ('wedges') can be computed as  $\tau_{K_{si}} = \alpha_s w L_{si} / [(1 - \alpha_s) RK_{si}] - 1$  and  $\tau_{Y_{si}} = 1 - \sigma w L_{si} / [(1 - \sigma)(1 - \alpha_s) P_{si} Y_{si}]$ , respectively.  $w$  is the wage,  $R$  is the rental rate of capital,  $P_{si}$  is the price of output, and  $\alpha_s$  is the capital share of firm expenditures.

Therefore, we run Regression (6) using as dependent variable not only *relative TFPR*, but also the *output wedge* and the *capital wedge*. The independent variables ('markers') we use refer to a series of usual suspects that include various proxies for ownership, finance, labour force, innovation, foreign exposure, and cronyism.<sup>27</sup>

### 9.1. Corporate ownership/control and governance

We construct an indicator of ownership type, distinguishing between firms controlled by an individual or a family, a conglomerate, a financial institution, the public sector, or a foreign entity. As Michelacci and Schivardi (2013) already found that family firms tend to choose activities with a lower risk/return profile compared with firms controlled by other entities, we expect family firms to have lower relative TFPR and thus to be inefficiently over-resourced with respect to other firms. This is exactly what we find by regressing the relative TFPR on dummies for each ownership type, using family controlled firms as the reference group (Table 7).

Specifically, we find that firms controlled by either a financial institution, a group, or a foreign company have between 3% and 8% higher relative TFPR than family controlled firms (Columns 1 and 2). Differently, we do not find any statistical difference of relative TFPR between public and family controlled firms. This implies that for instance foreign controlled firms are too small and should be allocated more resources than family owned firms. Columns 3 and 4 of Table 7 confirm this finding by showing that these types of firms suffer from higher output distortion with respect to family owned firms. Moreover, Columns 5 and 6 highlight that these firms specifically suffer from an additional distortion in terms of capital-labour ratio. In particular, the negative coefficient implies that they suffer more strongly of labour distortions and they should increase the labour compensation with respect to capital, that is, absorb a higher share of workers.

Reading these findings through the lenses of the HK framework, they imply that aggregate productivity would likely increase if family firms and government controlled firms were acquired by private groups or foreign entities. On the other hand, keeping corporate ownership unchanged, aggregate productivity would increase if misallocation were reduced within all corporate ownership categories with the largest productivity gains coming from firms controlled by groups and foreign entities.<sup>28</sup>

27 In order to check if our results are driven by the financial crisis, we run all regressions also up to 2008 only. Results are very similar qualitatively, quantitatively, and in terms of statistical significance. The only difference is for the regression on delocalization, whose coefficient turns to be statistically significant, but very similar in magnitude.

28 Although the database is not representative in terms of young firms, we looked at the relationship between age and relative TFPR. We did not find any significant relationship when only linear terms are considered. Things seem to change substantially when we allow for a squared term. In that case, our regression results suggest that the relation between relative TFPR and age is *U-shaped*. Unfortunately, the nature of our database prevents us from performing a robust analysis of other aspects of governance.

**Table 7. Firm-level ‘markers’ of misallocation: Ownership**

	(1) Relative TFPR	(2) Relative TFPR	(3) Output wedge	(4) Output wedge	(5) Capital wedge	(6) Capital wedge
Family	-0.0526*** (0.0125)	–	-0.0346*** (0.00532)	–	0.209*** (0.0262)	–
Conglomerate		0.0582*** (0.0147)		0.0417*** (0.00593)		-0.219*** (0.0291)
Financial institution		0.0308* (0.0183)		0.0159* (0.00812)		-0.133*** (0.0368)
Government		-0.0237 (0.0326)		-0.0169 (0.0160)		-0.250*** (0.0547)
Foreign		0.0803*** (0.0176)		0.0498*** (0.00681)		-0.238*** (0.0369)
Constant	0.107 (0.221)	0.0647 (0.219)	5.415*** (0.0464)	5.388*** (0.0456)	5.094*** (0.465)	5.299*** (0.469)
Observations	17,420	17,420	17,420	17,420	17,420	17,420
R-squared	0.029	0.032	0.098	0.102	0.293	0.294

*Notes:* The table reports OLS regressions of relative TFPR, output, and capital wedges on ownership dummies. Specifically, Family is a dummy equal to 1 if the firm is controlled by an individual or a family, Conglomerate is equal to 1 if controlled by a non-financial corporation, Financial Institution by a financial institution, Government by a public institution, and Foreign by foreign entity. The sample includes manufacturing firms with at least 50 employees over the years 1987–2011. All regressions include year and two-digit sector-fixed effects. Standard errors are clustered at the sectoral level. \*\*\*, \*\*, and \* indicate significant at the 1%, 5%, and 10%, respectively.

## 9.2. Finance

We investigate in [Table 8](#) the importance of credit constraints, equity emissions, and relational banking. We also explore in [Table 9](#) the impact of the introduction of the euro on firms’ financial characteristics.

**9.2.1. Credit constraints.** We define credit constrained firms as those that declared that they would have liked a higher level of debt ([Table 8](#), Panel A). We also use an alternative measure of credit constraint based on the willingness of having more credit even at higher interest rates, which delivers the same results.<sup>29</sup> Both measures enter the regression with a lag in order to mitigate endogeneity. In this way, we capture how being credit constrained at time  $t - 1$  is correlated to TFPR and misallocation at time  $t$ .

In particular, we find that firms that are credit constrained at time  $t - 1$  tend to have lower relative TFPR at time  $t$ .<sup>30</sup> This implies that credit constrained firms are absorbing too many resources and should downsize (or exit the market), so in this sense the ‘right’ firms seem to be financially constrained. Moreover, Column 2 shows that credit constrained firms are characterized by a negative and significant output distortion; this is

29 Results available upon request.

30 This effect is particularly pervasive in low-tech industries.

**Table 8. Firm-level ‘markers’ of misallocation: Finance**

	(1) Relative TFPR	(2) Output wedge	(3) Capital wedge
Panel A			
Credit constraint	-0.0657** (0.0298)	-0.0322** (0.0157)	-0.00445 (0.0485)
Observations	1,188	1,188	1,188
R-squared	0.155	0.132	0.375
Panel B			
Increased equity	-0.0629*** (0.0151)	-0.0305*** (0.00801)	0.000297 (0.0276)
Observations	9,527	9,527	9,527
R-squared	0.035	0.076	0.255
Panel C			
Relational banking	-0.0823** (0.0336)	-0.0202 (0.0257)	-0.0273 (0.0600)
Observations	774	774	774
R-squared	0.080	0.148	0.335

*Notes:* The table reports OLS regressions of relative TFPR, output, and capital wedges on indicators of financial conditions. Each panel report a separate set of regressions. Credit constraint is the lagged value of a dummy equal to 1 if the firm declared that, at the current borrowing conditions in terms of interest rate and collateral, the firm would prefer a higher level of debt from banks or other financial institutions. Increased equity is a dummy equal to 1 if the firm increased equity in the current year. Relational banking is a dummy equal to 1 if the firm declares that the principal reason for dealing with its main bank is ‘personal relationship and assistance’. The sample includes manufacturing firms with at least 50 employees over the years 1989–2011 in Panel A, 1998–2011 in Panel B, and 2002 in Panel C. Regressions in Panel A and B include year and two-digit sector-fixed effects; regression in Panel C includes two-digit sector-fixed effects. Standard errors are clustered at the sectoral level. \*\*\*, \*\*, and \* indicate significant at the 1%, 5%, and 10%, respectively.

**Table 9. Firm-level ‘markers’ of misallocation: Euro effect**

	(1) Relative TFPR	(2) Output wedge	(3) Capital wedge
Leverage	-0.381*** (0.0663)	-0.0303 (0.0353)	-0.979*** (0.133)
Post99	-0.0206 (0.0240)	0.105*** (0.0157)	-0.260*** (0.0430)
Leverage * Post99	-0.197** (0.0966)	-0.0708 (0.0460)	0.176 (0.175)
Constant	0.0574*** (0.0201)	5.468*** (0.0149)	5.613*** (0.0352)
Observations	15,633	15,633	15,633
R-squared	0.037	0.119	0.314

*Notes:* The table reports OLS regressions of relative TFPR, output, and capital wedges on Leverage, defined as debt over total assets, Post, which is a dummy equal to 1 for years after 1999, and their interaction. The sample includes manufacturing firms with at least 50 employees over the years 1987–2007. All regressions include two-digit sector-fixed effects. Standard errors are clustered at the sectoral level. \*\*\*, \*\*, and \* indicate significant at the 1%, 5%, and 10%, respectively.

equivalent to saying that these firms are actually receiving an implicit subsidy, so it would be more efficient if they exited the market. Finally, in credit-constrained firms the capital–labour ratio is not significantly distorted.

**9.2.2. Equity.** In Panel B, we look at the relation of firms' relative TFPR and the timing of their equity emissions. In particular, we look at the correlation between relative TFPR at time  $t$  and equity emissions at time  $t - 1$ ,  $t$ , and  $t + 1$ . We report results for time  $t$  only, but there is virtually no difference with the other timings. We find that firms that have lower relative TFPR in a given year tend to issue more equity (either in the same year, the year after or the one before). This may suggest that equity issuance may be a relevant source of funding when firms are hit by a negative productivity shock. This calls for further investigation about the allocative efficiency of different sources of external funding, such as equity, bonds, and bank credit.

**9.2.3. Relational banking.** We consider a firm as being involved in 'relational banking' if it declares that the principal reason for dealing with its main bank is 'personal relationship and assistance'. In Panel C we observe that relational banking is associated with lower relative TFPR, so that the firms that engage in relational banking are larger than what they should optimally be. This suggests that relational banking might be a key motivation for low productive firms to choose a specific bank, perhaps because it grants more support in time of need. Hence, relational banking may be a drag on aggregate productivity because it diverts resources from more productive firms with weak banking connections to less productive firms with strong banking connections.

**9.2.4. Euro effect.** An important issue about the effect of the euro on productivity and misallocation relates to the interest rate convergence that characterized peripheral countries thanks to the common currency. The traditional argument, as in Gopinath *et al.* (2015) and Benigno and Fornaro (2014), is that the availability of cheaper funds led to a misallocation of capital towards low productive firms that rather than exiting the market increased their leverage. We do not provide a formal test of this hypothesis, but we look for observationally consistent facts. If this were the case, we should observe a significant increase in leverage for firms with lower relative TFPR after the introduction of the euro.<sup>31</sup> We check if, after the introduction of the euro, the correlation between TFPR and leverage has changed.

In Table 9, Column 1, we see that high leverage indeed characterizes lower TFPR firms. This relation becomes significantly stronger after national exchange rate parities were fixed to the euro in 1999. This is consistent with the assumption that the interest

31 Leverage is defined as debt over total assets. By looking at this variable we check if firms' debt increased disproportionately with respect to total assets during the period of cheap credit that followed the introduction of the euro.

rate convergence that followed the introduction of the euro led to a misallocation of credit to less productive firms that are disproportionately large given their productivity. Of course, this evidence is only suggestive and cannot be taken as causal. First, both TFP and leverage are co-determined, so we are simply measuring the change in a correlation. Second, the result does not hold when we look at labour and capital wedges separately (Columns 2 and 3): not surprisingly, more leveraged firms are characterized by a misallocation of the capital–labour ratio as the share of capital is too large. However, this effect did not increase significantly after the euro.

### 9.3. Workforce composition

The functioning of the labour market is one of the structural features of the Italian economy that has been more extensively reformed since the 1990s.<sup>32</sup> Misallocation is less likely to emerge when less productive firms are free to reduce (and more productive firms are free to increase) the amount of labour. In this perspective, by introducing more flexibility in the labour market, the reforms that the Italian economy underwent in the 1990s should have induced a better allocation of labour. In this section, we analyse the relation between firms' workforce and misallocation from different perspectives. In particular we consider: the Italian Wage Supplementation Scheme, which is the main instrument of labour hoarding that firms use, the shares of temporary and foreign workers that firms hire, the skill intensity among blue- and white-collar workers. Results are reported in Table 10.

**9.3.1. Wage supplementation scheme (cassa integrazione guadagni).** Firstly, we look at how intensively firms resorted to the Wage Supplementation Scheme ('Cassa Integrazione Guadagni' – CIG). This scheme allows distressed firms to hoard labour, so that workers suspend temporarily their job or reduce the hours of work and receive an income supplement from the government. The worker receives the benefit as long as he remains employed by the firm. We define the variable Wage Supplementation Scheme as hours paid by the supplementation scheme over total hours paid. The key characteristic of CIG is that it protects not only the worker, but also the specific job match between worker and firm. Thus, it can have either a positive or negative effect on misallocation, because it facilitates labour hoarding guaranteeing to firms and workers a useful buffer in downturns, but at the same time it might end up protecting a job match that would

32 Two major reforms of the labour market took place: the Treu Law and the Biagi Law. The former was introduced in 1997 (law 196/97) with the aim of making the Italian labour market more flexible. The main novelty of the Treu Law consisted in the introduction of temporary contracts and in the creation of Temporary Work Agencies (jobcentres were privatized and decentralized). The Treu Package also modified the discipline of fixed-term contracts, modified the regulation related to employment in the research sector and rose from 22 to 24 the age limit for apprenticeship contracts. The Biagi Law, introduced in 2003 (law 30/03), created new contractual forms and renovated some existing ones, mainly affecting the subordinated workers.

**Table 10. Firm-level ‘markers’ of misallocation: Workforce composition**

	(1) Relative TFPR	(2) Output wedge	(3) Capital wedge
Panel A			
Wage supplementation	−0.425*** (0.0979)	−0.165*** (0.0432)	−0.515*** (0.0740)
Observations	19,078	19,078	19,078
R-squared	0.041	0.106	0.283
Panel B			
Temporary employment, share	0.116** (0.0565)	−0.0398 (0.0280)	0.597*** (0.120)
Observations	11,825	11,825	11,825
R-squared	0.028	0.072	0.246
Panel C			
Graduate share, white collars	0.359*** (0.0765)	0.105*** (0.0308)	−0.241* (0.133)
Observations	1,412	1,412	1,412
R-squared	0.080	0.152	0.279
Panel D			
Graduate share, blue collar	−0.234 (0.421)	−0.159 (0.412)	−1.092* (0.571)
Observations	1,366	1,366	1,366
R-squared	0.059	0.143	0.278

*Notes:* The table reports OLS regressions of relative TFPR, output, and capital wedges on indicators of financial conditions. Each panel reports a separate set of regressions. Wage supplementation is hours paid by the Government wage supplementation scheme over total hours worked. Temporary employment, share is the number of temporary employees over total number of employees. Graduate share, white collars is the number of graduate white collar over the total number of white collar workers, and similarly for blue collar workers. The sample includes manufacturing firms with at least 50 employees over the years 1987–2011 in Panel A, 1999–2011 in Panel B, and 2000 and 2010 in Panel C and in Panel D. Regressions in Panels A and B include year and two-digit sector-fixed effects; regressions in Panels C and D include two-digit sector-fixed effects. Standard errors are clustered at the sectoral level. \*\*\*, \*\*, and \* indicate significant at the 1%, 5%, and 10%, respectively.

be more efficient to break. Our methodology allows us to understand in which direction productivity and misallocation are affected by this specific policy tool.

Panel A of Table 10 shows that the firms that use the CIG more intensively are largely over-resourced and their size should be smaller than what it currently is. There is also a positive and significant correlation with output distortion implying that these firms are receiving an implicit subsidy, which is indeed the case. Finally, our results show that, as it might be expected, firms using the CIG suffer from a larger labour distortion relative to capital.

These findings support the idea that less productive firms are more likely to take advantage of the CIG and that, through the associated (temporary) reduction in labour costs, the CIG works against the reduction of the amount of labour used by low productive firms, thereby fostering misallocation especially on the labour side.<sup>33</sup>

33 To go more into the details of these relationships, we run contemporaneous and one-year lagged fixed effects regressions, always finding that the decision to start using CIG is associated with lower relative TFPR.

**9.3.2. Temporary workers.** Panel B analyses the relation between temporary workers and misallocation. We define ‘Temporary employment share’ as the ratio of the number of temporary employees to the total number of employees at the end of the year. We find that firms that use a higher share of temporary workers have higher relative TFPR, so they are inefficiently under-resourced and their size should be larger than what it actually is.<sup>34</sup> At the same time, these firms suffer from a significantly stronger distortion on capital inputs relative to labour (while we do not find a significant association with output distortions). A possible explanation could be that more productive firms find stronger distortions in the capital market and, given the complementarity between capital and labour, they tend to respond favouring a higher share of temporary and more flexible workers.

**9.3.3. Skill intensity.** We consider two measures of skill-intensity: the share of white collars holding a degree (Panel C) and the share of blue collars holding a degree (Panel D). We are able to observe these two variables only in 2010 and 2011, thereby we run a cross-section regression for the 2 years together.<sup>35</sup>

Firms with a higher share of high-skilled workers among white collars have higher TFPR on average, hence they should be allocated more inputs to increase their size.<sup>36</sup> These firms suffer also from a large output distortion and from a relatively larger distortion for labour relative to capital, where the labour distortion could be related to both skilled and unskilled labour. However, if we look at the share of skilled workers among blue collars, we do not find any significant association with misallocation or output distortion, but only a marginally significant association with stronger distortions in labour input relative to capital.

## 9.4. Internationalization

We study the correlation of misallocation with two main dimensions of firms’ internationalization: delocalization and foreign direct investment (FDI). In Table 11, we report in both cases no evidence of resource misallocation for firms engaging in these types of international activities with respect to those that do not (we use dummy variables). Notice that this result does not imply the absence of misallocation within those groups. However, this is an aspect that, given the low number of observations, we are not able to analyse.

34 These findings support the idea that higher TFPR firms are more likely to take the opportunity of resorting to temporary work. This result is in sharp contrast with Daveri and Parisi (2015), who find a negative correlation between a firm’s share of workers in a temporary contract and its productivity. However, the different productivity measure and the different time period (2001–2003 in their case) may explain the difference.

35 We also run the regressions for the 2 years separately and the results are similar.

36 This result is particularly strong for big firms and for low-tech firms.

**Table 11. Firm-level ‘markers’ of misallocation: Internationalization**

	(1) Relative TFPR	(2) Output wedge	(3) Capital wedge
Panel A			
Delocalization	-0.00715 (0.0386)	-0.000137 (0.0114)	-0.0313 (0.0709)
Observations	655	655	655
R-squared	0.109	0.203	0.295
Panel B			
FDI	0.00640 (0.0585)	-0.0137 (0.0196)	0.0772 (0.115)
Observations	201	201	201
R-squared	0.304	0.399	0.463

*Notes:* The table reports OLS regressions of relative TFPR, output, and capital wedges on indicators of Internationalization. Each panel reports a separate set of regressions. Delocalization is a dummy equal to 1 if the firm delocalized part of its production activity. FDI is a dummy equal to 1 if the firm has engaged in FDI. The sample includes manufacturing firms with at least 50 employees. Panel A is a cross-section for the year 2011 and Panel B is a cross-section for 2003. All regressions include two-digit sector-fixed effects. Standard errors are clustered at the sectoral level. \*\*\*, \*\*, and \* indicate significant at the 1%, 5%, and 10%, respectively.

Another stylized fact about productivity and internationalization is the well-known higher productivity of the exporting firms, when compared with non-exporters. Given the nature of our sample, in which more than 80% of the firms export, we have to somehow take this evidence for granted. We have nonetheless considered the intensity of the export activity, measured in terms of the export share of revenues, finding some evidence of a positive relationship with relative TFPR.<sup>37</sup>

## 9.5. Innovation

Innovation is a fairly reasonable marker of both productivity and misallocation. The relationship can in principle go both ways. On the one hand, innovation can be thought to foster productivity; on the other hand, more productive firms (e.g., Melitz, 2003) and/or firms with higher revenues (e.g., Bustos, 2011) can display a higher propensity to innovate. If the innovation choice is made in a dynamic context with adjustment costs for capital, a positive relationship with misallocation can be expected (Asker *et al.*, 2014). To investigate the role of innovation, we consider the share of intangible assets (associated, essentially, with R&D, marketing and branding) on firms' total assets. While our database does not allow us to address innovation using alternative and more focused measures, relying on intangibles is consistent with Battisti *et al.* (2015), who show

37 The variability in the data does not allow for a proper analysis of this issue. Given the low variability in the data, the relationship emerges only when controls are introduced for the export share in  $t-1$  and  $t+1$ , or when the nonlinearity in the relationship is taken into account. Results are available upon request.

**Table 12. Firm-level ‘markers’ of misallocation: Innovation**

	(1) Relative TFPR	(2) Output wedge	(3) Capital wedge
Intangible assets share	0.144*** (0.0381)	-0.00188 (0.0160)	0.377*** (0.0688)
Constant	-0.0796 (0.176)	5.377*** (0.110)	4.849*** (0.398)
Observations	11,689	11,689	11,689
R-squared	0.030	0.071	0.247

*Notes:* The table reports OLS regressions of relative TFPR, output, and capital wedges on the share of intangible assets over total assets. The sample includes manufacturing firms with at least 50 employees over the years 1999–2011. All regressions include year and two-digit sector-fixed effects. Standard errors are clustered at the sectoral level. \*\*\*, \*\*, and \* indicate significant at the 1%, 5%, and 10%, respectively.

intangible assets to be positively associated with both TFP and technology adoption at the firm-level.

Table 12 shows that a higher share of intangible assets is associated with higher relative TFPR.<sup>38</sup> This implies that firms that invest more in innovation tend to be under-resourced and should have larger size. Moreover, these firms tend to suffer from a larger distortion in the allocation of capital relative to labour. This is consistent with the view that credit provision to firms that innovate may play a key role in reducing misallocation.

### 9.6. Combining markers: a short horse race

We complete our investigation of the firm markers associated with misallocation by running the regressions on different subsets of independent variables entered simultaneously. This should give some guidance on the relative importance of these variables. More specifically, we look at the share of graduates among white collars, innovation, family ownership, reliance on the wage supplementation scheme (CIG), and the share of temporary employment. We focus on variables that are available over subsequent years and are consistently part of our panel and not just of some year-specific cross-section. Although there might be concern of collinearity between the variables, cross-correlations are never above 0.27 (in absolute value).

Table 13 summarizes the main results. As some of the variables are dummies (i.e., ‘family ownership’), whereas the others are continuous variables, comparing the magnitude of the coefficients is difficult. Hence, we focus more on their relative statistical significance. The results show that the share of graduates among white collars and the use of the wage supplementation scheme (CIG) are the statistically most significant markers of misallocation, although of opposite sign (firms with a high share of graduates are too

38 We also enter the regressor with a lag and the results are very similar.

**Table 13. Firm-level ‘markers’ of misallocation: a short horse race**

	(1) Relative TFPR	(2) Relative TFPR	(3) Output wedge	(4) Output wedge	(5) Capital wedge	(6) Capital wedge
Graduate share, white collars	0.350*** (0.0746)	0.313*** (0.0736)	0.0854** (0.0336)	0.0747** (0.0353)	-0.229* (0.128)	-0.269** (0.129)
Intangible assets share	0.0855 (0.0753)	0.139* (0.0720)	-0.0265 (0.0351)	-0.00886 (0.0348)	0.571*** (0.143)	0.609*** (0.141)
Family	-0.0527** (0.0247)	-0.0619** (0.0243)	-0.0154 (0.0128)	-0.0182 (0.0127)	0.179*** (0.0491)	0.169*** (0.0488)
Wage supplementation		-0.782*** (0.141)		-0.279*** (0.0784)		-0.393 (0.244)
Temporary employment, share		0.169 (0.130)		0.0179 (0.0436)		0.423* (0.233)
Constant	-0.00547 (0.377)	0.0228 (0.306)	5.537*** (0.0390)	5.554*** (0.0215)	5.331*** (0.742)	5.286*** (0.712)
Observations	1,290	1,289	1,290	1,289	1,290	1,289
R-squared	0.101	0.131	0.158	0.170	0.315	0.319

*Notes:* The table reports OLS regressions of relative TFPR, output, and capital wedges on a selected set of variables from the previous tables. Graduate share, white collars is the number of graduate white collar over total number of white collar workers; Intangible assets, share is the share of intangible assets over total assets; Family is a dummy equal to 1 if the firm is controlled by an individual or a family; Wage supplementation is hours paid by the Government wage supplementation scheme over total hours worked; Temporary employment, share is the number of temporary employees over total number of employees. The sample includes manufacturing firms with at least 50 employees over the years 2000 and 2010. All regressions include year and two-digit sector-fixed effects. Standard errors are clustered at the sectoral level. \*\*\*, \*\*, and \* indicate significant at the 1%, 5%, and 10%, respectively.

small and those using the CIG are too large). Family ownership and, to some extent, innovation are also two significant markers with opposite signs. However, the share of temporary workers loses significance with respect to the results presented in Table 10. In terms of output distortion, the most significant markers are again the share of graduates among white collars, which has a positive and significant coefficient (implying an implicit tax), and the use of CIG, which has a negative and significant coefficient (implying an implicit subsidy). Finally, in terms of the capital–labour ratio, innovative and family-owned firms are the ones with the strongest distortion in terms of capital, whereas firms with a higher share of white-collar graduates confirm to suffer from a significant distortion in terms of labour.

These findings, in particular the strong significance of the share of graduates among white collars and the CIG, can be interpreted as two sides of the same coin. The share of high-skill employees among white collars drives firm technological and organizational innovation, which in turn increases firm productivity relative to competitors. In an efficient process of creative destruction labour should seamlessly flow from firms with falling relative productivity to firms with rising relative productivity thereby enhancing aggregate productivity. This process of efficient reallocation is impaired if firms with falling relative productivity can use the wage supplementation scheme to keep them afloat when faced not only with contingent problems (as in the original spirit of the CIG) but also with structural problems (as in the consolidated practice of the CIG).

More generally, our findings on the importance of the different markers suggest that firms more likely to keep up with the technological frontier are inefficiently small and thus under-resourced. These are the firms that employ a larger share of graduates and invest more in intangible assets. On the contrary, firms less likely to keep up are inefficiently large and thus over-resourced. These are the firms that have a large share of workers under a wage supplementation scheme, that are family managed, and that are financially constrained. We interpret this pattern as evidence that rising within-industry misallocation is consistent with an increase in the volatility of idiosyncratic shocks to firms due to their heterogeneous ability to respond to sectoral ‘frontier shocks’ in the presence of sluggish reallocation of resources.

## 10. CONCLUSIONS AND POLICY IMPLICATIONS

We have provided a detailed analysis of the patterns of misallocation in Italy since the early 1990s. In particular, we have shown that the extent of misallocation has substantially increased since 1995, and that this increase can account for a large fraction of the Italian productivity slowdown since then. We have shown that the increase in misallocation has mainly risen within than between sectors, increasing more within those in which the world technological frontier has expanded faster.

We have highlighted that rising misallocation has hit firm categories that traditionally are the spearhead of the Italian economy, in particular firms in the Northwest and big firms. We have argued that relative specialization in sectors where the world technological frontier has expanded faster helps explaining the patterns of misallocation across geographical areas and firm size classes. The broader lesson is that part of the explanation of the recent productivity puzzle in other advanced economies may lie in a generalized growing difficulty of reallocating resources between firms in sectors where technology has been changing faster rather than between sectors with different speeds of technological change.

We have shed additional light on the relation between exposure to ‘frontier shocks’ and misallocation within industries by investigating which firm characteristics are associated with firms being inefficiently sized. We found evidence that inefficiently small under-resourced firms are those that, by employing a larger share of graduates and investing more in intangible assets, are more likely to be keeping up with the technological frontier. Vice versa, inefficiently over-resourced firms are those that, being featuring larger shares of workers under wage supplementation, more family managers and stricter financial constraints, are more likely to be falling behind the technological frontier. We have interpreted this pattern as evidence consistent with rising within-industry misallocation being associated with increasing volatility of idiosyncratic shocks to firms due to their heterogeneous ability to respond to sectoral ‘frontier shocks’ in the presence of sluggish reallocation of resources.

Beyond Italian specificities, several of these implications may apply more broadly to other advanced economies facing their own ‘productivity puzzles’.

## Discussion

Alberto Martín<sup>39</sup>

European Central Bank, CREI, and Barcelona GSE

There is a growing concern over the perceived slowdown of TFP growth in many advanced economies, particularly in southern Europe. In Italy, for instance, TFP growth has been essentially zero (or slightly negative) between 1995 and 2014 (Hassan and Ottanasio, 2013). In Spain, despite high rates of GDP growth, TFP fell at an annual rate of 0.7% between 1995 and 2007 (García-Santana *et al.*, 2016). Understanding the evolution of TFP in these economies is clearly of first-order importance.

In this paper, Calligaris, Del Gatto, Hassan, Ottaviano, and Schivardi (henceforth, CDHOS) focus on one particular aspect of Italian TFP (or, more precisely, revenue TFP): its dispersion across firms, industries, and geographical regions. The idea, following Hsieh and Klenow (2009), is that a greater dispersion of revenue TFP is a symptom of underlying market frictions. In an ideal world, resources would flow from less to more productive firms to eliminate any such dispersion. If we do not observe this, the logic goes, it is because there must be misallocation, that is, frictions preventing the efficient allocation of resources.

Starting from this logic, CDHOS study the universe of Italian incorporated companies to provide a very thorough description of TFP and revenue TFP (henceforth, TFPR) in Italy between 1995 and 2013. They complement this evidence with firm-level data to establish how firm characteristics are correlated with their being inefficiently sized. Their paper is full of interesting and, in some cases, surprising facts.

First, CDHOS confirm that misallocation in Italy has increased substantially: had the dispersion of RTFP remained at its 1995 level, they estimate that Italian GDP would have been 18% higher in 2013. Second, somewhat surprisingly, CDHOS show that this increase in misallocation is largely due to greater misallocation among firms within a given group, that is, firms of similar size, in a given sector, or in the same geographical region. In other words, misallocation does not appear to have increased because specific groups of firms (e.g., small firms, located in the South, or in traditional sectors) have been 'left behind'. Third, this increase in misallocation appears to be correlated to R&D intensity at the sector level: specifically, there is a positive correlation between a sector's increase in measured misallocation and the increase in its R&D intensity. Finally, using

39 This paper should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the author and do not necessarily reflect those of the ECB. I thank Manuel García-Santana for helpful discussions in preparing these comments.

firm-level data, CDHOS find that firms that employ a larger share of graduates or invest more in intangible assets appear to be inefficiently small.

These are important facts, which should be seriously considered by anyone interested in the recent evolution of productivity in Italy and, more broadly, in Southern Europe. Indeed, CDHO's findings are largely consistent with those of previous studies that have focused on other European economies. In particular, they align remarkably well with the results of [Garcia Santana \*et al.\* \(2016\)](#) for the case of Spain. Also in Spain misallocation increased dramatically, and also in Spain this increase appears to have been pervasive across activities and sectors.

The paper is very polished and the authors have done a thorough job of addressing previous suggestions. I have therefore little to say on the specific results, which seem overall convincing. Instead, I will make three general comments.

My first comment is entirely complimentary. Although the methodology of [Hsieh and Klenow, \(2009\)](#) has been extremely influential in shaping the profession's thinking about productivity and resource allocation, it is not without caveats. In particular, it is not clear that the entire measured dispersion of TFPR across firms can be attributed to inefficiency. Alternative factors such as adjustment costs, idiosyncratic risk, or measurement error may contribute to such dispersion as well.<sup>40</sup> It has also been noted that reductions in the dispersion of TFPR need not reflect an improvement in inefficiency, as they could be driven by the convergence of 'undesirable' characteristics at the firm level (e.g., convergence of market power to high levels). CDHOS now devote a full section to explaining these caveats while also exploring their relevance in the Italian data. They also devote a new section to exploring whether the increased dispersion in TFPR is associated to a greater dispersion in idiosyncratic risk.

In my view, both of these sections are great additions to the paper. As a consumer of this literature, I often find that papers engaging in this type of exercise are quick to jump to conclusions (taking the reader along!) without exercising due caution. CDHOS now provide the reader with both, a condensed conceptual discussion of the methodology's shortcomings and a collection of simple empirical exercises to assess their validity in the Italian context.

My second comment refers to the interpretation of some of the firm-level results. CDHOS study the correlation between 'relative TFPR' (i.e., a firm's TFPR relative to the average in the sector) and a host of firm-level variables related to ownership structure, access to finance, and workforce composition. The results are extremely interesting but, at times, their causal interpretation is pushed too far.

On the finance front, for instance, relative TFPR appears to be negatively correlated with the (lagged) tightness of credit constraints. CDHOS interpret this as evidence that credit-constrained firms are absorbing too many resources and should downsize. But

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40 [Bils \*et al.\* \(2017\)](#), for instance, find that measurement error may account for a significant fraction of the level and/or evolution of measured misallocation in the United States and India.

other interpretations are also natural. Maybe credit-constrained firms are precisely those that face negative productivity shocks, which they need credit to absorb: in fact, this is exactly how the authors interpret the negative correlation between low TFPR and equity emissions. An alternative interpretation is that these firms have low productivity precisely because of their limited access to credit. On the workforce composition, relative TFPR appears to be negatively correlated with the use of government-subsidized programs to temporarily suspend workers ('wage supplementation schemes') and with the use of temporary workers. CDHOS interpret this as evidence that firms that resort to these programmes and type of workers are inefficiently large and should downsize. But, once again, an alternative interpretation is that firms use these programmes and type of workers precisely to absorb negative productivity shocks.

To conclude, let me make one final comment regarding CDHOS's general interpretation of their findings. By jointly considering the evolution of TFPR dispersion and its correlation with R&D at the sector level, CDHOS conclude that misallocation has increased in Italy because it has become harder to reallocate resources across firms in sectors where technology is changing fast, rather than between sectors with different speeds of technological change. This is a very interesting interpretation, but I wonder if the authors could have followed it up with more analysis. For instance, they could have focused on the sectors with fast technological change to try to understand the drivers of increasing TFPR dispersion. One possibility is that this increase is driven by the co-existence of firms with high- and low-TFPR growth. This would suggest that there are highly innovative firms in Italy, even if the reallocation of resources towards these firms is limited. A far bleaker alternative is that the increase in dispersion is driven by the co-existence of firms with stagnant and with mildly declining TFPR. This would suggest that Italy's lackluster productivity growth is not just related to its inability to reallocate resources towards highly productive firms, but rather its inability to create and nurture these firms altogether.

Overall, CDHOS have written a great paper, which provides a very thorough picture of productivity and misallocation in Italy. It contains many new and interesting facts to guide future research, which should be taken into account by all those seeking to understand Italy's and – more generally – Southern Europe's productivity malaise.

## Panel discussion

Beata Javorcik suggested using TFP as the dependent variable (rather than TFP relative to the average TFP) and have sector-year-fixed effects in the right-hand side of the regression, while Tommaso Monacelli argued that dispersion in firm-level productivity is countercyclical and asked the authors why this is not observable in their data. Regarding the finding that firms that innovate are inefficiently small, Andrea Ichino conjectured that innovative firms are typically smaller to begin with.

Replying to comments and questions, F.H. first agreed that it is important to have a separate section in the paper outlining the limitations of their approach and how these are addressed. Regarding the policy conclusions, he acknowledged that their arguments might need to be softened as these are mostly based on correlations, but mentioned that the results are in line with existing literature. He also said it is possible to put more structure into the TFP process to account for the idiosyncratic component of productivity shocks. Finally, F.H. clarified that they do not observe an increase in misallocation after the global financial crisis due to a cleansing effect during this period, with firms in the lowest percentiles of the productivity distribution more likely to exit the market.

**APPENDIX 1: DEFINING MISALLOCATION (HSIEH AND KLENOW, 2009)**

In this appendix, we review the main framework of HK, highlighting the main concepts and measurers of misallocation. From standard profit maximization, we know that firms choose the amount of capital  $K$  and labour  $L$  by equalizing the MPR of each input to its marginal cost. While this process yields MPR of capital (MRPK) and MPR of labour (MRPL) equalization across firms when all firms face the same input cost, the presence of market distortions can drive ‘wedges’ between MRPK and MRPL across firms. In this case, we say that capital and labour are ‘misallocated’ across firms.

To see this, let us start with a standard Cobb–Douglas technology with sector-specific production coefficients

$$Y_{si} = A_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}, \tag{7}$$

and follow HK in denoting distortions that increase the marginal products of capital and labour by the same proportion (‘output distortions’) by  $\tau_{si}^Y$ , and distortions that raise the marginal product of capital relative to labour (‘capital distortions’) by  $\tau_{si}^K$ . From the FOC of firm  $i$ , active in sector  $s$ , we have that

$$\text{MRPK}_{si} = P_{si} \frac{\partial \tilde{Y}_{si}}{\partial K_{si}} = \alpha_s P_{si} \frac{Y_{si}}{K_{si}} = \tilde{W}^K \tag{8}$$

and

$$\text{MRPL}_{si} = P_{si} \frac{\partial \tilde{Y}_{si}}{\partial L_{si}} = (1 - \alpha_s) P_{si} \frac{Y_{si}}{L_{si}} = W^L, \tag{9}$$

with  $\tilde{Y}_{si} = (1 - \tau_{si}^Y) Y_{si}$  and  $\tilde{W}^K = (1 - \tau_{si}^K) R$ , where  $R$  and  $W^L$  refer to rental and wage rates of capital and labour, respectively.

If  $\tau_{si}^Y = \tau_{si}^K = 0 \quad \forall i \in s$ , firms face the same inputs costs and the MRP of the two inputs is equalized across them. In this case, capital and labour are efficiently allocated. When this happens, the within-sector distributions of MRPK and MRPL exhibit zero dispersion around the mean, as the average MRPK in sector  $s$  ( $\overline{\text{MRPK}}_s$ ) equals  $\text{MRPK}_{si} \quad \forall i \in s$  (and analogously for MRPL). No misallocation emerges in this case.

Note that the MRP equalization condition holds independently of the way in which firms set  $P_{si}$  that is, independently of market structure, the only condition being the absence of distortions in capital and labour markets.

### A.1. A measure of misallocation

Since the higher the dispersion the larger are the distortions, it would be relatively easy to investigate the presence, and the magnitude, of resource misallocation by looking at the within-industry dispersion of MRPK and MRPL. However, if one is interested in the aggregate effects of those distortions, more structure is needed.

To this aim, a useful strategy is suggested by HK, whose approach allow us to study the effect of misallocation on aggregate TFP. The intuition is quite simple and rests on the proportionality between firm TFP and MRP of inputs. In particular, using Equation (7), it is possible to write firm  $i$ 's TFP as

$$\text{TFP}_{si} = A_{si} = \frac{Y_{si}}{K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}}. \quad (10)$$

As statistical information on either physical output  $Y_{si}$  or firm price  $P_{si}$  is hardly available (see e.g., Foster *et al.*, 2008), TFP is usually calculated/estimated on the basis of firms' revenues. In particular, by Equation (10) we have

$$\text{TFPR}_{si} = P_{si} A_{si} = \frac{P_{si} Y_{si}}{K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}}. \quad (11)$$

While using  $\text{TFPR}_{si}$  instead of  $\text{TFP}_{si}$  usually represents a shortcoming, this is not the case for the HK framework. The reason is that, under specific assumptions on market structure,  $\text{TFPR}_{si}$  can be shown to be unaffected by firm-specific characteristics other than the distortions  $\tau_{si}^L$  and  $\tau_{si}^K$ . In particular, if each sector  $s$  is monopolistically competitive, firms set prices according to the markup rule

$$P_{si} = \frac{\sigma}{\sigma - 1} \beta_s (W^K)^{\alpha_s} (W^L)^{1-\alpha_s} \frac{(1 + \tau_{si}^K)^{\alpha_s}}{(1 - \tau_{si}^L)} \frac{1}{A_{si}}, \quad (12)$$

where  $\frac{\sigma}{\sigma - 1}$  is the markup and  $\beta_s = \alpha_s^{-\alpha_s} (1 - \alpha_s)^{\alpha_s - 1}$  is the bundle of parameters associated with the Cobb–Douglas production function (7). Note that, apart from  $A_{si}$ , the only firm-specific terms in Equation (12) are the distortions. When substituted into Equation (11), the pricing rule in Equation (12) yields

$$\text{TFPR}_{si} = \frac{\sigma}{\sigma - 1} \beta_s (W^K)^{\alpha_s} (W^L)^{1-\alpha_s} \frac{(1 + \tau_{si}^K)^{\alpha_s}}{(1 - \tau_{si}^L)}. \quad (13)$$

According to Equation (13), also the cross-firm variability of  $\text{TFPR}_{si}$  is not influenced by firm-specific characteristics other than  $\tau_{si}^K$  and  $\tau_{si}^L$  (as the term  $A_{si}$  cancels

out). Moreover, HK show that it is proportional to the weighted geometric average of  $\text{MRPK}_{si}$  and  $\text{MRPL}_{si}$ , with weights given by the Cobb–Douglas parameters:

$$\text{TFPR}_{si} \propto (\text{MRPK}_{si})^{\alpha_s} (\text{MRPL}_{si})^{1-\alpha_s} \propto \frac{(1 + \tau_{si}^K)^{\alpha_s}}{(1 - \tau_{si}^L)^{1-\alpha_s}}. \tag{14}$$

As a result, *the extent of misallocation can be studied by looking at the dispersion of the TFPR<sub>si</sub> distribution*, instead of considering the distributions of  $\text{MRPK}_{si}$  and  $\text{MRPL}_{si}$ .

**A.2. Misallocation, aggregate TFP, and aggregate gains from eliminating misallocation**

The usefulness of this approach stems from the fact that it is relatively easy to sum up across firms and obtain a measure of the aggregate TFP loss due to misallocation. To see this, assume that the economy produces a single homogeneous final good  $\mathcal{Y}$  by combining the output  $\mathcal{Y}_s$  of the  $S$  manufacturing industries in a Cobb–Douglas fashion:

$$\mathcal{Y} = \prod_{s=1}^S \mathcal{Y}_s^{\theta_s} = \prod_{s=1}^S (A_s K_s^{\alpha_s} L_s^{1-\alpha_s})^{\theta_s}, \quad \text{with} \quad \sum_{s=1}^S \theta_s = 1, \tag{15}$$

where  $K_s = \sum_i K_{si}$  and  $L_s = \sum_i L_{si}$  are the total stocks of capital and labour used in sector  $s$ , the industry output  $\mathcal{Y}_s$  is a CES aggregate of  $M_s$  horizontally differentiated products  $\mathcal{Y}_s = \left( \sum_{i=1}^{M_s} \mathcal{Y}_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$ , and the sectoral TFP is defined as

$$A_s = \left[ \sum_{i=1}^{M_s} \left( A_{si} \frac{\overline{\text{TFPR}}_s}{\text{TFPR}_{si}} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}}, \tag{16}$$

with  $\overline{\text{TFPR}}_s$  referring to the weighted geometric average of average MRPK and average MRPL in the sector (i.e.,  $\overline{\text{TFPR}}_s \propto (\overline{\text{MRPK}}_s)^{\alpha_s} (\overline{\text{MRPL}}_s)^{1-\alpha_s}$ ).

According to Equation (16), without misallocation, aggregate TFP is a CES aggregation of individual TFP. Otherwise, a TFP loss will emerge in the aggregate.

The relationship between  $\text{TFP}_s$  and the dispersion of  $\text{TFPR}_{si}$  can be made more explicit by assuming that the distributions of TFP and TFPR are jointly lognormally distributed. In this case, HK show that

$$\ln \text{TFP}_s = \frac{1}{\sigma - 1} \ln \left( \sum_i A_{si}^{\sigma-1} \right) - \frac{\sigma}{2} \text{var}(\ln \text{TFPR}_{si}). \tag{17}$$

Finally, the ratio  $\mathcal{Y}/\mathcal{Y}^*$  can be expressed as a weighted geometric average of the sectoral ratios of observed to efficient TFP levels  $A_s/A_s^*$  across sectors, with each sector's weight given by its share  $\theta_s$  of aggregate output (VA)<sup>41</sup>:

$$\frac{\mathcal{Y}}{\mathcal{Y}^*} = \prod_{s=1}^S \left( \frac{A_s}{A_s^*} \right)^{\theta_s} = \prod_{s=1}^S \left[ \sum_{i=1}^{N_s} \left( \frac{A_{si}}{A_s^*} \frac{\overline{\text{TFPR}}_s}{\text{TFPR}_{si}} \right)^{\sigma-1} \right]^{\frac{\theta_s}{\sigma-1}}, \quad (18)$$

where  $N_s$  is the number of firms in sector  $s$  and  $\sigma$  is the elasticity of demand (which we set equal to 3 as in HK). Notice that Equation (18) implies that the output ratio  $\mathcal{Y}/\mathcal{Y}^*$  equals the ratio of observed to efficient aggregate TFP levels  $\text{TFP}/\text{TFP}^* = \prod_{s=1}^S (A_s)^{\theta_s} / \prod_{s=1}^S (A_s^*)^{\theta_s}$ .

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41 Following HK, we assume that the sectoral share  $\theta_s$  is constant over time, which is the case if one assumes that aggregate output is a Cobb–Douglas composite of sectoral outputs.

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