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Allocative efficiency of UK firms during the Great Recession

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Abstract

This paper argues that the fall and persistently low level of UK Total Factor Productivity (TFP) following the Great Recession was caused by the turnover (entry and exit) of firms, rather than by resource misallocation between firms within industries. I conduct a misallocation exercise employing the Hsieh and Klenow (2009) and the Olley and Pakes (1996) methods using the FAME micro-level dataset that contains more than 9 million firms within the UK over the 2006 - 2014 period. The main findings are that, first, service sector TFP drops far more than manufacturing TFP and therefore drives the fall and long-lasting depression in aggregate productivity. Second, within-industry misallocation cannot account for the drop in TFP. Third, the entry and exit of firms both contribute to the decline in aggregate TFP while the entry of firms has a larger negative effect on TFP than the exit of firms. And fourth, the pattern of within-industry misallocation and firm dynamics is the same for the manufacturing and the service sector.

Keywords: Great Recession in the UK, Factor Misallocation, FAME dataset
JEL Code: D24, E13, E32, L11

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Non-technical summary

Research shows that financial crises are accompanied by severe and long-lasting drops in TFP. The most recent Global Financial Crisis does not seem to be any different from this pattern. On the contrary, Gerth and Otsu (2017) find significant correlations between financial variables and long-lasting drops in aggregate productivity measures for a myriad of European countries. This finding matches a branch of structural models that saw their advent in the aftermath of the financial crisis that began by the end of 2007. Even though each of these models chooses different measures to indicate financial distress in the economy, the mechanism how a financial shocks propagates is uniform. That is, through resource misallocation. This study therefore tries to empirically determine whether these models are valid to explain the behaviour of the UK economy during the last 8 years. In order to do this, the paper relies on the FAME dataset. This is a micro-level dataset that contains more than 9 million firms within the UK.

The first technique to quantitatively assess the effect of within-industry resource misallocation on aggregate TFP, the methodology developed by Hsieh and Klenow (2009) is used. The authors build a standard model of monopolistic competition extended by generic tax rates which formally shows that frictions distorting the MRP of capital and/or labour lead to the misallocation of production factors and ultimately lower aggregate TFP.The second methodology is the productivity decomposition technique by Olley and Pakes (1996). Compared to the former model whereby misallocation is determined through the dispersion of firm-level MRPs within an industry, Olley and Pakes assume misallocation once high-productivity firms posses less relative market share than low-productivity firms.

The results are surprising. That is, while the manufacturing sector recovers three periods after the beginning of the crisis, the service sector drives the severe and long-lasting drop in aggregate TFP in the UK from 2008 to 2014. Therefore, analysing only the manufacturing sector leads to spurious results. Second, resource misallocation does not account for the drop in sectoral TFP of any of these sectors and therefore fails to explain the drop in aggregate productivity. Third, the drop in aggregate TFP is due to low-productivity firms entering and high-productivity leaving the sample. Observing turnover for the manufacturing and the service sector highlights the fourth finding. That is, the pattern of firm dynamics in and out of the sample is the same for both sectors. And last, the financial sector, as part of the service sector, drives productivity levels and firm dynamics of the service sector. These findings conclude that structural models that rely on the static misallocation mechanism of firms within industries to explain low-levels of TFP fail to represent the behaviour of the UK economy during the Great Recession in the UK.

1 Introduction

Even seven years into the aftermath of the Global Financial Crisis, European TFPs have not shown any signs of recovery[1]. Against this backdrop, the recent paper tries to investigate why aggregate TFP in the UK dropped with the onset of the Global Financial Crisis. One possibility might be that, on a micro-level basis, factors of production were misallocated from productivity-rich towards productivity-poor firms, thereby worsening the efficiency potential of the entire economy. Kehrig (2015) finds that misallocation during the US business cycles has been countercyclical from 1972 to 2009. This paper, on the other hand, shows that this was not the case in the UK. Rather, the fall and persistently low level of UK TFP following the Great Recession was caused by the turnover (entry and exit) of firms.

The outbreak of the Global Financial Crisis led to a surge in articles designing structural models with financial frictions whereby the misallocation mechanism leads to severe and long-lasting drops in aggregate TFP. In order to gauge their validity, this article empirically investigates whether factors of production moved away from their most efficient use towards firms with relatively less production efficiency. This is done through two different sets of indicators; the first is the Hsieh and Klenow (2009) misallocation index and the second set is the Olley and Pakes (1996) covariance term.

This study defies the long-standing tradition that firm-level research should focus on the manufacturing sector only, but takes all the sectors of the British economy into account.[2] While the manufacturing sector recovers three periods after the beginning of the crisis, the service sector drives the severe and long-lasting drop in aggregate TFP in the UK from 2008 to 2014. Therefore, analysing only the manufacturing sector leads to spurious results. The key finding is that within-industry resource misallocation neither accounts for the drop in aggregate nor in sectoral TFP. Instead, the comparison between the unbalanced and the balanced panel shows that the drop in aggregate TFP is due to low-productivity firms entering and high-productivity leaving the economy, while the entry effect is much stronger than the exit effect. In addition, the pattern of firm dynamics in and out of the sample is the same for both sectors.

This study contributes to the literature on the recent financial crisis on at least two different dimensions. First, -according to my knowledge- this paper is the first to measure resource misallocation on a firm-level basis during the financial crisis on the UK economy to assess its importance in the recession starting at the end of 2007. And

[1] Gerth and Otsu (2015, 2017) show that post-WWII recessions that follow financial meltdown are not only long-lasting but are also accompanied by severe and persistent drops in aggregate TFP.

[2] Studies that only focus on the manufacturing sector, or on particular industries within an economy, are among others Davis and Haltiwanger (1990), Olley and Pakes (1996), Bellone and Mallen-Pisano (2013), Crespo and Segura-Cayuela (2014), and Kehrig (2015).

second, this analysis is not restricted towards a subset of sectors in the economy, but considers each and every single one in the examination of the UK economic experience during the Great Recession.

The work by Riley et al. (2015) is closely related to this study. However, the papers differ in scope. First, whereas the former uses the *Annual Respondents Database (ARD)*, which is a survey for firms smaller than 250 employees, the latter uses the *FAME* database, see section 3. Second, the former authors omit several sectors from the sample, among them the financial sector. As will be seen in the following sections, the financial sector carries crucial information regarding firm dynamics and their connection to aggregate TFP, and hence must not be omitted. Third, Riley et al. focus on the behaviour of labour productivity whereas this study's focus lies on multifactor productivity. This is preferred in times of economic unrest since labour productivity is a biased indicator when resource-substitution effects exist, (Nishimura et al., 2005).[3] Last, while their dataset contains establishment-level data, the current dataset covers firm-level data. Nakajima et al. (2000) and Nishimura et al. (2005) argue that, compared to firms, establishments do not account for indirect non-productive activities and therefore are a biased measure in determining firm survival.

The paper proceeds as follows. Section 2 reviews the literature on why misallocation might be the reason that led to a drop in TFP during times of financial unrest. Section 3 presents the data and shows its aggregate behaviour. Section 4 introduces the methodologies used. Section 5 presents the results for the unbalanced and section 6 for the balanced panel. Section 7 analyses the dynamics of firms within the sample. Section 8 decomposes the economy and analyses misallocation and firm dynamics on a sector-level basis. The last section concludes.

2 Financial crises and factor misallocation

The onset of the Global Financial Crisis by the end of 2007 caused a surge in economic models that try to explain why the world economy went into a deep and long-lasting recession. Quadrini (2011) classifies them into 3 categories. 1) non-financial shock models without financial frictions, 2) non-financial shock models with financial frictions,[4] and 3) financial shock models with financial frictions.[5] In type one and two the economy is hit by real whereas in type three by financial shocks.

[3]Also see Geroski and Gregg (1997) regarding increased capital and labour reallocation during recessions, and Field and Franklin (2014) and Harris and Moffat (2016) for the importance of TFP as driver of labour productivity.

[4]Seminal articles in this category are Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), Bernanke et al. (1999), and Kiyotaki and Moore (1997).

[5]See Shourideh and Zetlin-Jones (2012), Buera and Moll (2012), Khan and Thomas (2013), Buera and Shin (2013), Cui (2014), and Buera et al. (2015).

The studies by Almeida et al. (2009) and Duchin et al. (2010) allude towards the latter in that they find financial shocks kick-starting the Great Recession. Almeida et al. (2009) model heterogeneity in the variation of long-term debt maturity and find that the real effects in the Great Recession were caused by increasing financial contraction. Duchin et al. (2010) establish the causal effect by showing that firms with low-cash reserves, high net short-term debt, that are financially constrained or that depend mainly on external finance suffered the most after the 2007/08 credit crunch.[6]

The heterogeneity of economic agents is a second characteristic financial crisis models of the third category share. This finds support in the study by Gertler and Gilchrist (1994) who find that micro-level implications are fundamental in understanding the aggregate behaviour of the economy due to a credit crunch. They state that to correctly understand cyclical behaviour to financial shocks one must consider individual firm-level responses to their respective access to capital markets.[7]

Another common feature is the adoption of collateral borrowing constraints as the financial distortion in the model economy.[8] This dictates that borrowers can only borrow a fraction of their existing wealth from potential lenders. This is due to the limited enforceability of contracts issue, which states that lenders can, in times of default of the borrower, only recover a certain fraction of the initial loan given. This fraction represents the degree of financial frictions -financial market imperfections- and begins to decrease during a sudden tightening of credit conditions, *credit crunch*, and ultimately leads to a decrease of potential available credit to borrowers.

All three characteristics together lead through resource misallocation to a fall in aggregate TFP in that factors of production flow from high-productivity to low-productivity firms. That is, assuming that firms are heterogeneous in respect to their productivity and their wealth gives an initial wealth-ability distribution. Once a financial shock, in form of a sudden tightening of the credit conditions, hits the economy, poor and high productivity firms (in that they have a higher demand for capital as their marginal product of capital is higher) become increasingly credit constrained as the collateral constraint begins to bind. This initiates the process of misallocating capital from poor-but-productive firms towards rich-but-unproductive firms. Now that more productive firms have less access to financial markets and, therefore, cannot service their capital needs, aggregate TFP endogenously declines

[6]In addition, the papers by Amaral and Quintin (2010), Greenwood et al. (2010, 2013) and Buera et al. (2011) also emphasise the connection between imperfect financial markets and TFP drop.

[7]More recent papers that developed from this work and find the same conclusion are Fort et al. (2013), Shourideh and Zetlin-Jones (2012), and Buera and Moll (2012).

[8]The seminal idea of the collateral borrowing constraint arising from incomplete contracts was developed by Kiyotaki and Moore (1997).

together with investment.[9] Output and employment decline due to two reasons; firstly, the financial shock tightens credit and therefore the economy's productive capacity, and secondly, TFP falls which leads to a loss in production efficiency.[10]

The persistence of the shock lies in that the collateral constraint cannot immediately move back to its pre-crisis level once the financial shock recovers. This is because when capital is misallocated from poor to rich firms, poor firms have to cut down their investment projects. These lower levels of investment lead to a declining wealth of the poor-but-productive firms and to ever increasing capital constraints. Therefore, the reallocation process of capital moving back towards more productive firms is protracted. This is because firms must, incrementally, save up the collateral in order to overcome the collateral constraint to reach their most efficient level of capital/wealth. This is lengthy, whereas in the meanwhile TFP, output, investment, and employment are depressed.[11] In conclusion, even though a financial shock can only be temporary, the real effects on the economy might be long-lasting since the collateral constraint works as a bottleneck in reallocating production factors back to their most efficient use.[12,13]

In the light of these models, misallocation is the link that leads to severe and long-lasting drops in TFP. Different measures are applied to test whether this is true for the UK during the Great Recession. The first technique is the methodology by Hsieh and Klenow (2009), *HK*. The authors measure the effect within-industry factor misallocation has on aggregate TFP due to exogenous distortions. They do this by adopting and adapting a standard model of monopolistic competition with heterogeneous firms, originally developed by Melitz (2003). The motivation for their

[9] This implies pro-cyclicality of debt during financial crises. See Jermann and Quadrini (2012), Ivashina and Scharfstein (2010), Koepke and Thomson (2011), Covas and Haan (2011), Quadrini (2011), and Khan and Thomas (2013) for evidence on the pro-cyclicality of debt during the most recent crisis period.

[10] Khan and Thomas (2013) argue that the fall in TFP contributes to more than half of the decline in observed economic variables.

[11] Where this argument about resource misallocation only focuses on financial frictions due to the tightening collateral constraint, Cui (2014) and Khan and Thomas (2013) additionally include real frictions in the form of partial capital irreversibilities in order to delay the convergence to the former steady state.

[12] Kiyotaki and Moore (1997) include also balance sheet effects into the model. This is done by adding the relative prices of assets. In this framework the amplification mechanism not only works through the decline in the borrowers' assets, but also through a loss in the value of those assets. This leads to a dynamic and persistent interaction between asset prices and borrowing limits.

[13] The idea that various frictions lead to factor misallocation, which in turn leads to a lower aggregate performance is not new. See Davis and Haltiwanger (1990), Hopenhayn and Rogerson (1993), Lagos (2006), Angeletos (2007), Alfaro et al. (2008), Guner et al. (2008), Restuccia and Rogerson (2008), Castro et al. (2009), Hsieh and Klenow (2009), and Hopenhayn (2011). For a comprehensive review of the literature on misallocation see Banerjee and Duflo (2005).

work comes from the paper by Restuccia and Rogerson (2008), in that the latter focus on the misallocation of resources on a firm-level basis. HK build up a heterogeneous agent model that measures firm-level efficiency differences between the US, India and China. They find that adapting India and China's resource allocation to the level in the US, TFP in the former countries can be increased by 40% to 60% and 30% to 50%, respectively.[14,15,16]

The second technique is developed by Olley and Pakes (1996), *OP*. The authors develop a production decomposition technique to quantitatively assess the affect technological change and deregulation had on the telecommunications equipment industry in the last few decades of the twentieth century. To determine misallocation to less productive firms, they derive a *covariance term* that shows whether high-productivity firms have more than or less than average market share. The intuition is that within an industry more productive firms demand more factors of production, grow faster, and hence produce more output. Less productive firms, on the other hand, work at a smaller scale, demand less production factors, and hence produce less output than their high-productivity counterparts. Once this natural relationship changes, so does resource misallocation.[17]

3 Data

3.1 FAME database

The *FAME* (Financial Analysis Made Easy) database is a firm-level consensus commercialised through the Bureau Van Dijk, an information and business intelligence company that specialises in firm-level data around the world.

The available version of the data set consists almost 10 million firms from the years 2006 to 2015. Its coverage ranges from the United Kingdom (England, Wales, Scotland, Northern Ireland), the Republic of Ireland to several crown dependencies. The analysis in this paper focuses on the United Kingdom because after cleaning the

[14]Papers that use the HK methodology are, among others, Kalemli-Ozcan and Sorensen (2016), Bellone and Mallen-Pisano (2013), Crespo and Segura-Cayuela (2014), and Garcia-Santana et al. (2016).

[15]An extension to the liability side of the HK model is done by Whited and Zhao (2015). In their paper the authors argue that instead of focusing on the misallocation of physical production factors like capital and labour, one should assess whether financial assets are well-allocated.

[16]While HK (2009) back out the real cost of capital from the data, Gilchrist et al. (2013) directly collect borrowing costs for a subset of US manufacturing corporations that have access to the corporate bond market. The authors find that despite large differences in borrowing costs across firms, resource misallocation due to financial frictions accounts for only a small part in the loss in TFP.

[17]Papers that use the OP methodology are among others Aw et al. (2001), Foster et al. (2001), Bartelsman et al. (2004, 2013), Lewrick et al. (2014), and Garcia-Santana et al. (2016).

dataset too few observations are left for the Republic of Ireland or for any of the crown dependencies.

The information provided in this dataset covers intelligence on firm's financial and productive activities obtained through their respective balance sheets and income statements.[18] It ranges from the name, address, identification numbers of firms to information about stocks, merger and acquisition details and intelligence about mortgages held by each individual firm. According to Kalemli-Ozcan et al. (2015), the economic activity reported in this micro-dataset covers 70 to 80 percent of the economic activity reported by the national consensus in *Eurostat*. It contains large and small firms from all sectors in the economy (agricultural, manufacturing, service, mining and quarrying, utility, construction, wholesale and retail, public sector), as well as, publicly-traded and privately-owned companies. All of the almost 99 2-digit industries are represented in this database, including the finance industry.[19]

In order to prevent downloading the entire dataset, a preselection is done. That is, only firms that are located in the UK are selected. Moreover, for at least one year between 2006 and 2014 the individual firm is required to have a value for each of the variables used in this study. This decreases the sample size from almost 10 million to 104,602 firms.

Variables that are downloaded are the company name, primary UK SIC code, firm's location, date of incorporation, number of employees, fixed assets[20], profit (loss) per period[21], the interest paid[22], depreciation[23], remuneration[24], directors' remuneration[25], whether having consolidated or unconsolidated accounts, and taxation per firm per period respectively.

Value Added for firm i in time t is constructed as follows:

$$\begin{aligned} VA_{it} = &\ \textit{Profit (Loss) for Period}_{it} + \textit{Interest Paid}_{it} + \textit{Taxation}_{it} \\ &+ \textit{Depreciation}_{it} + \textit{Remuneration}_{it} + \textit{Directors' Remuneration}_{it}. \end{aligned}$$

[18] See Kalemli-Ozcan et al. (2015).

[19] The hierarchical structure starts with the firm as the smallest sample unit. Several firms are contained by one of the 79 2-digit industries in the economy. All 2-digit industries belong exclusively to one of the 19 divisions (see table 3 for the divisions). The divisions can be further categorised into one of the 8 sectors. All 8 sectors together constitute the economy.

[20] Fixed assets contain tangible assets like land, buildings, plants, and vehicles; intangible assets; and investments. By incorporating intangible assets this study is in line with the Eurostat definition of fixed assets.

[21] Profit (loss) for period consists of profit (loss) after tax plus extraordinary items plus minority interest.

[22] Interest paid to bank, on hire purchase, on leasing, and other interest paid.

[23] Depreciation on owned assets, on other assets, and impairment on tangibles.

[24] Remuneration consists of wages and sales, social security costs, pension costs, and other staff costs.

[25] Directors' remuneration consists of directors' fees, pension contribution, and other emoluments.

And the total wage bill for firm i in time t is:

$$\textit{Total Wage Bill}_{it} = \textit{Remuneration}_{it} + \textit{Directors' Remuneration}_{it}.$$

To prevent nonsense results and outliers in the data set, several cleaning steps are performed. Firms which are not resident in the UK, with no SIC code or with missing information for any of the aforementioned variables, that is not due to exit, are erased. Firms with consolidated accounts are kept and with unconsolidated accounts are left out. This is done to prevent double counting. To be consistent, the same is done for firms that change their accounts from being *unconsolidated* to *consolidated* during the 2006-2014 period.[26] To deal with potential outliers in the data, the sample is trimmed at the top and bottom 1% for fixed assets, value added and TFP. To prevent the firm that is cut off to reappear, each observation that is erased in any year is taken out for the remaining years. Firms with a negative VA for any of the years are also deleted for the whole sample period. Moreover, industries consisting of only 1 firm and industries with a labour share of bigger than 1 are also dropped. The result is an unbalanced panel of more than 40,000 observations within the 2006 to 2014 period.

3.2 Summary Statistics

Table 1 shows the 2006 size distribution of firms within the sample. Firm size is classified as the number of employees within the firm. Small firms have 0-9 and 10-19 employees. Medium-sized firms have 20-49 and 50-199 employees. Big firms have more than 200 employees. We can see that big sized firms dominate the sample in terms of the number of firms and the number of total employment. Almost 95% of employees in the sample work in firms that employ more than 200 people. Furthermore, the same firms constitute for more than 50% of the total number in the sample.

Table 2 shows the 2006 summary statistics for *Value Added* and *Employees*. For both variables the *Median* is far below the *Mean*, implying that Value Added and Employees are skewed towards the right tail of the distribution. This is consistent with the findings in table 1. Moreover, both variables show a comparatively high *Standard Deviation* and *Max* value, implying that extremely big firms exist.

Whereas the above table made inferences about the distribution of firms within the economy as a whole, table 3 disaggregates the former analysis on a divisional level. The finding is that big-sized firms are not concentrated in individual divisions only, but are allocated throughout the whole economy. That is, for every division the *mean* value is bigger than the *median* value. Furthermore, the comparatively high *Standard Deviations* imply that extremely big firms exist within the individual divisions.

[26] The number of firms changing from having unconsolidated to consolidated accounts surges in 2009.

3.3 Aggregate TFP

Aggregate TFP is computed by consolidating the firm-level variables with the following aggregator; $\widehat{TFP}_t = \frac{\sum_{i=1}^{M} \widehat{Y_{i,t}}}{\sum_{i=1}^{M} \widehat{K_{i,t}}^{\alpha} \sum_{i=1}^{M} L_{i,t}^{1-\alpha}}$. Where $\widehat{Y}$ is detrended firm value added, $\widehat{K}$ is detrended firm capital stock, and L firm labour input. From firm i to the total amount of firms in the sample M.

Figure 1 and table A1 show that for the unbalanced panel aggregate TFP in the UK drops by almost 7% with the onset of the Global Financial Crisis. It slightly recovers in 2010 to drop again to more than negative 10% compared to its pre-crisis trend level.[27] The black line is aggregate TFP computed with aggregate *Eurostat* data. Even though the firm-level dataset exhibits a slightly bigger drop in TFP at the beginning of the crisis period and a slightly smaller thereafter, its pattern is similar and therefore arguably the firm-level analysis will give unbiased results.

Both main sectors of the economy, the *manufacturing* and the *service* sector, experience a TFP drop at the beginning of the Global Financial Crisis, Figure 2. The former initially falls by almost 5%, but catches up with its pre-crisis trend level thereafter. The latter drops by almost 11% in the second year of the crisis and only marginally recovers by the end of 2014 to about negative 8% compared to its pre-crisis trend level.[28]

Observing figure (2) and figure (B3) shows that within the UK economy all sectors must be considered. Analysing the aggregate drop in TFP, in figure (1), only through the manufacturing sector does not give coherent results.

[27] The annual trend growth rate was taken to be 2.23%. It is derived via computations through aggregate data obtained from *Eurostat*. See Gerth and Otsu (2017) for more detail.

[28] Figure (B3) shows the other sectors in the economy. That is, the *agricultural*, *mining and quarrying*, *utility*, *construction*, *trade*, and *public* sector. The focus here lies on the unbalanced panel, blue graph. We can see that with the exception of the public sector, all other sectors experience a drop in TFP with the start of the Global Financial Crisis by the end of 2007. Except for the agricultural sector, none of the same recover by 2014.

Table 1: 2006 Size distribution of firms - Unbalanced Panel

	Firms		Labour	
# of employees	Total #	Total Share (%)	Total #	Total Share (%)
0-9	55	1.40	335	0.01
10-19	90	2.29	1,354	0.04
20-49	376	9.56	13,028	0.37
50-199	1,428	36.33	164,673	4.70
+200	1,982	50.72	3,322,184	94.88
Sum	3931	100	3,501,574	100

Table 2: 2006 Summary Statistics I - Unbalanced Panel

	VA	Employees
Median	8,758	203
Mean	33,905.54	891
Std. Deviation	86,287	2,959
Min	600	2
Max	883,257	73,059
N	3,931	3,931

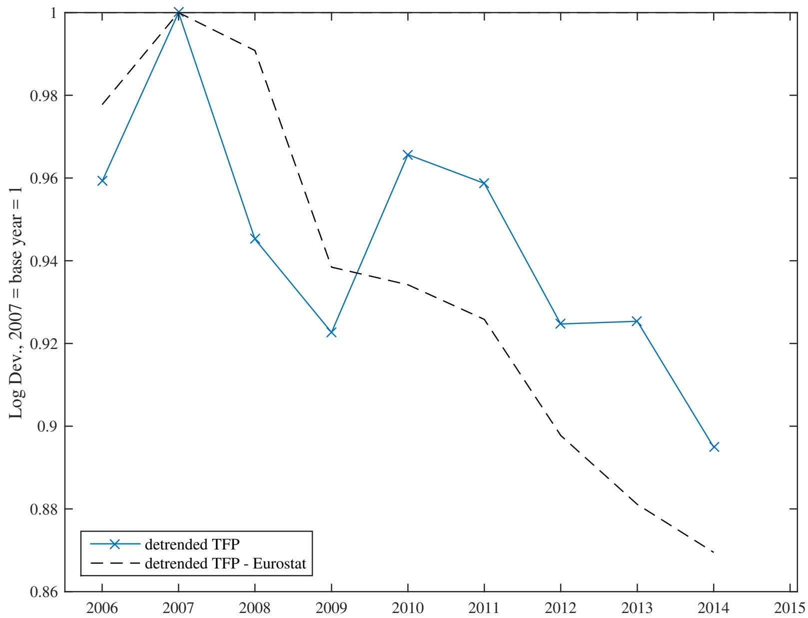
Note: Value Added (VA) is divided by one million.
The number of Employees is in absolute terms.

Table 3: 2006 Summary Statistics II - Unbalanced Panel

	Employment			Value Added			
Division	Median	Mean	Std. Deviation	Median	Mean	Std. Deviation	N
Agriculture, Forestry and Fishing	221	3,843	12,413	45	10,147	21,696	29,308
Mining and Quarrying	275	1,277	4,041	33	16,849	65,682	138,201
Manufacturing	242	758	1,948	812	8,763	26,715	66,003
Electricity, Gas, Steam and Air Conditioning Supply	204	281	236	4	13,468	194,233	365,749
Water Supply; Sewerage , Waste Mgmt. and Rem. Act.	142	516	895	26	9,512	64,529	134,960
Construction	180	554	1,244	377	9,538	26,356	56,780
Wholesale and Retail Trade; Rep. of Motor V. and Motoc.	184	933	2,865	706	7,232	27,945	81,825
Transportation and Storage	261	1,129	3,186	154	10,674	48,493	119,394
Accommodation and Food Service Activities	456	1,590	3,085	88	10,231	46,738	114,700
Information and Communication	147	507	1,395	234	7,066	26,155	66,268
Financial and Insurance Activities	114	619	1,872	331	9,024	49,364	119,635
Real Estate Activities	113	378	1,358	151	7,164	18,342	42,720
Professional, Scientific and Technical Activities	283	1,172	2,989	435	12,819	48,449	100,890
Administrative and Support Service Activities	182	982	4,360	356	8,317	30,562	79,288
Public Admin. and Defence; Comp. Soc. Sec.	1,587	4,974	6,127	8	94,319	194,468	241,699
Education	565	840	813	9	18,932	32,084	39,459
Human Health and Social Work Activities	441	1,123	3,271	46	10,521	22,513	53,777
Arts, Entertainment and Recreation	183	1,207	3,771	60	8,158	44,623	123,412
Other Service Activities	196	1,136	2,592	56	9,782	35,765	78,553

Note: Value Added (VA) is divided by one million. The number of Employees is in absolute terms.

Figure 1: Aggregate TFP for the UK between 2006 and 2014 period
- Unbalanced Panel



Note: aggregate $\widehat{TFP}_t = \frac{\sum_{i=1}^{M} \widehat{Y_{i,t}}}{\sum_{i=1}^{M} \widehat{K_{i,t}}^{\alpha} \sum_{i=1}^{M} L_{i,t}^{1-\alpha}}$. *Where M is the number of firms in the entire economy.*

4 Methodology

To answer whether the data findings of section 3 can be explained through the misallocation of resources, two different models are used.

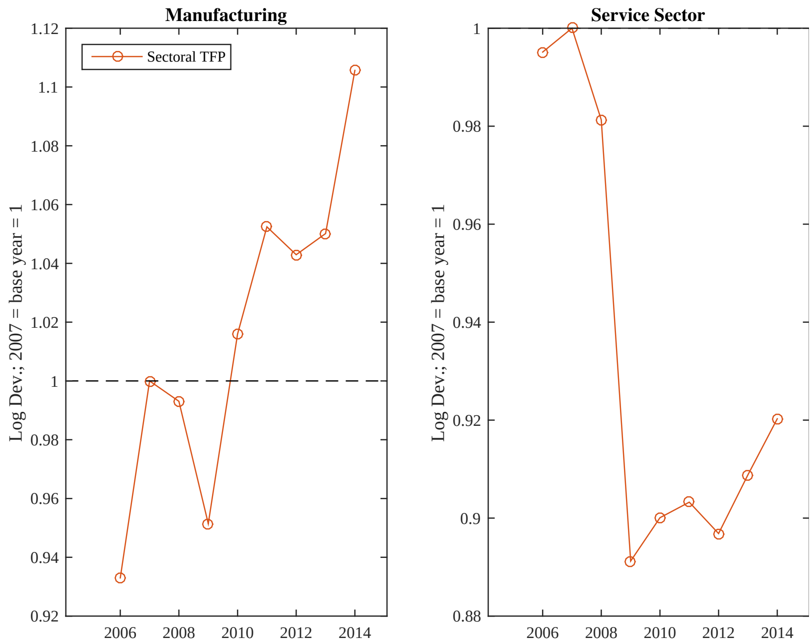
4.1 HK Methodology

To quantitatively assess the effect of within-industry resource misallocation on aggregate TFP, Hsieh and Klenow (2009) use a standard model of monopolistic competition extended by generic tax rates. It formally shows that frictions distorting the MRP of capital and/or labour lower aggregate TFP.

The model has two main assumptions. First, firms are heterogeneous in their productivity level and in the extent of factor-market and size distortions they face. Second, every firm supplies a heterogeneous good which is priced individually in the market.

Aggregate output is defined through a Cobb-Douglas production technology:

Figure 2: Sectoral TFP for the UK between 2006 and 2014 period - Unbalanced Panel



$$Y = \prod_{s=1}^{S} Y_s^{\theta_s}, \, where \sum_{s=1}^{S} \theta_s = 1. \tag{1}$$

Where aggregate output Y consists of the product of all industry-specific outputs Y_s raised to their individual industry-output share θ_s.[29] The industry-output share is computed as observed industry output divided by observed aggregated output. Industry output Y_s is computed using the following formula:

$$Y_s = \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}. \tag{2}$$

Where Y_{si} is the firm-specific output, or the heterogeneous good produced by firm i in industry s. σ is the elasticity of substitution between plant value added or the substitutability of competing manufacturers. The higher σ the more substitutable the goods become and the less the firm can control the market price. As σ goes towards ∞ the model economy leaves the monopolistic competition scenario and approaches perfect competition.

[29]The term *industry* means the aggregation of companies within the same 2-digit UK SIC code.

Each individual firm produces its unique good according to a standard Cobb-Douglas production function:

$$Y_{si} = A_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}. \tag{3}$$

Where A is TFP, K is capital, and L is labour input.[30] The industry-specific labour share $1 - \alpha_s$ is computed by dividing the total wage bill for industry s by its industry VA negative taxes paid by the sector, $\frac{TotalWageBill_s}{VA_s - taxes_s}$.

The issue of the allocation of rents between capital and labour arises when converting factor shares into production elasticities, (Hsieh and Klenow, 2009).[31] This issue is disregarded by assuming that rents are proportionally paid to labour and capital. In this case the size of the elasticity of substitution between plant VA does not effect the production elasticities.

Following Kehrig (2015), factor shares are allowed to vary between industries within the economy but not between firms within a particular industry. The author argues that firms within a common industry share a similar technological structure and therefore the use of labour and capital should proportionally be the same.[32]

To ensure comparability throughout the time horizon, industry-specific factor shares are averaged from 2006 to 2014, (Faggio et al., 2010).

Two distortions prevent individual firms from reaching their optimal production level. τ_Y, is a size distortion and prohibits the firm from reaching its optimal or profit maximising size. This distortion affects both factors of production, capital and labour, equally at the same time. τ_K, is a relative factor market distortion that only affects the marginal product of one factor of production relative to the other,

[30] Preferably the literature uses hours worked as a labour input measure. Unfortunately the *FAME* database does not provide information on hours worked within the firm. Therefore, the number of employees are used. Another method to account for labour input is to use the wage bill of the workforce. HK argue that this measure, as opposed to the number of employees, takes hours worked and the level of human capital per worker into account. However, using both measures gives similar results.

[31] Rents arise because firms sell their products at a higher value than their marginal costs. In a perfect competition model where goods are homogeneous, more firms would enter the market and take advantage of the higher price. This rent seeking behaviour would increase the supply for this particular good and henceforth lower the price to its marginal cost. Since this is a monopolistic competition model with the assumption that goods are heterogeneous, firms can absorb rents from selling their goods at a higher price. It follows that the higher σ, the more substitutable a good becomes and the lower the rents will be. If, however, σ is kept conservatively, say equal to 3, rents and potential allocation discrepancies become relatively large.

[32] Assuming that the technology, and thus factor shares, is the same for companies within a common industry is fundamental for the misallocation measures in equation 7 and 8. A point to which will be returned later in this section.

hence the capital-labour usage within the firm becomes distorted. This leads to the following profit equation:

$$\pi_{si} = (1 - \tau_{Ysi})P_{si}Y_{si} - wL_{si} - (1 + \tau_{Ksi})RK_{si}. \tag{4}$$

Where π is profits, P is the firm-specific price, w is labour income which is assumed to be constant across all firms, and R is the cost of capital which is assumed to be 10 %[33].

Foster et al. (2008) argue that when industry-deflators are used, plant-specific price differences remain which, in the end, are captured by the firms' productivity measures. Therefore, when talking about *productivity* not physical productivity, or the amount of output that can be produced with a certain amount of input, is meant but the amount of *revenues* that can be generated by using a certain amount of production factors. This is not only convenient -since it is not possible to obtain firm-level deflators- but also necessary. That is, firm survival ultimately depends on revenue instead of physical productivity, (Kehrig, 2015).[34,35]

Regarding the economic intuition of the model, in a frictionless economy each firm should borrow and lend at the same interest rate and pay the same wage rate. Firms with a marginal revenue product of capital (MRPK) above the interest rate accumulate capital and expand in size and firms with a MRPK below the interest rate sell off some of their capital and contract. This accumulation (decumulation) of capital decreases (increases) the MRPK until it is equal to the interest rate. The same argument applies to the equalisation between the marginal revenue product of labour (MRPL) and the wage rate in the labour market. Hence, resources are transferred to the firm with the higher MRPs until they are the same throughout the industry.

$$MRPL_{si} \equiv (1 - \alpha_s)\frac{\sigma - 1}{\sigma}\frac{P_{si}Y_{si}}{L_{si}} = w\frac{1}{1 - \tau_{Ysi}}, \tag{5}$$

$$MRPK_{si} \equiv \alpha_s\frac{\sigma - 1}{\sigma}\frac{P_{si}Y_{si}}{K_{si}} = R\frac{1 + \tau_{Ksi}}{1 - \tau_{Ysi}}. \tag{6}$$

[33]Following HK a real interest rate of 5% and depreciation of 5% is assumed. Since the aim is to assess how misallocation behaves through time, setting the rental rate to 10% does not influence our results.

[34]This is not the first paper that emphasises the importance of revenue productivity, or the product of physical productivity and firm-specific prices. Foster et al. (2008), Hsieh and Klenow (2009), Faggio et al. (2010), Syverson (2011), Kalemli-Ozcan and Sorensen (2016), and Kehrig (2015) already use this measure in their productivity discussions.

[35]Bartelsman et al. (2008) and Eslava et al. (2011) both find a strong and positive correlation between physical TFP and revenue TFP of about 0.75 for the US and 0.7 for Colombia, respectively.

Where $MRPL_{si}$ is the marginal revenue product of labour, and $MRPK_{si}$ the marginal revenue product of capital.

If however firms are exposed to factor market and/or output distortions, their *before-tax* marginal revenue products divert from this equilibrium. In this case, and consistent with the technical requirements for the model, only the *after-tax* marginal revenue products approach a common value. That is, since firms are individually subject to distortions that render their profit maximising behaviour, resources are misallocated. It is important to emphasise that the HK model explicitly assumes higher resource misallocation within an industry the wider the dispersion between firm-level *before-tax* marginal revenue products.

The following static misallocation indexes mechanically incorporate this idea. Meaning, they reveal a higher degree of misallocation the higher the dispersion of Marginal Revenue Products:[36]

$$1 + \tau_{Ksi} = \frac{\alpha_s}{1 - \alpha_s} \frac{wL_{si}}{RK_{si}}, \tag{7}$$

$$1 - \tau_{Ysi} = \frac{\sigma}{\sigma - 1} \frac{wL_{si}}{(1 - \alpha_s) P_{si} Y_{si}}. \tag{8}$$

Equation (7) implies that there must be a relative factor market distortion that contorts the firm's decision to maximise potential profits if the relative amount of firm-level labour and capital income differs from the industry average.[37]

The second misallocation index, (8), indicates that an output distortion can be inferred if the firm's labour income share is lower to what it should be according to the industry average.[38] Kalemli-Ozcan and Sorensen (2016) argue that this kind of distortion captures everything that reduces the optimal level of output for firm i but does not change the relative use of capital or labour. They discuss that firm-specific taxes on the firm's potential output will ultimately be captured by τ_Y.[39]

[36]Faggio et al. (2010) is an misallocation analysis that relies solely on the dispersion of productivity measures.

[37]Since the level of a marginal product is determined by the amount of usage of its factor in the production process, the argument also implies that the relationship between the MRPK and the MRPL changes.

[38]The industry labour share was computed as the total wage bill over VA negative taxes. The same must be done for the denominator in equation (8).

[39]In order to aggregate the firm-level indexes to an economy-wide measure the following aggregator is used; $X_t = \sum_{s=1}^{S} \theta_{s,t} (\frac{1}{N} \sum_{i=1}^{N} X_{i,t})$. Where X is any of the aforementioned indexes, N is the amount of firms within the industry, and S is the amount of industries in the whole economy. θ is the industry-total output share.

4.2 OP Methodology

The second methodology to quantitatively assess the effect of within-industry resource misallocation on TFP is the productivity decomposition technique by Olley and Pakes (1996). Compared to the HK methodology whereby misallocation is determined through the dispersion of firm-level MRPs within an industry, OP assume misallocation once high-productivity firms posses less relative market share than low-productivity firms.

Industry productivity, Ω, can be expressed as the share-weighted average of firm productivity:

$$\Omega_t = \sum_{i=1}^{N_t} \phi_{i,t} p_{i,t}. \tag{9}$$

where the shares $\phi_{i,t} \geq 0$ sum to 1. When the total number of firms within the industry is N, OP show that equation (9) can be decomposed as:

$$\begin{aligned} \Omega_t &= \sum_{i=1}^{N_t} (\bar{\phi}_t + \Delta\phi_{it})(\bar{p}_t + \Delta p_{i,t}) \\ &= N_t \bar{\phi}_t \bar{p}_t + \sum_{i=1}^{N_t} \Delta\phi_{i,t} \Delta p_{i,t} \\ &= \bar{p}_t + \sum_{i=1}^{N_t} \Delta\phi_{i,t} \Delta p_{i,t}. \end{aligned} \tag{10}$$

where

$$\Delta\phi_{i,t} = \phi_{i,t} - \bar{\phi}_t,$$

and

$$\Delta p_{i,t} = p_{i,t} - \bar{p}_t.$$

$\bar{p}_t$ and $\bar{\phi}_t$ illustrate the unweighted industry productivity mean and the unweighted firm-industry output share, respectively.

The focus lies on the *covariance term*, $\sum_{i=1}^{N_t} \Delta\phi_{i,t} \Delta p_{i,t}$. When positive it indicates that high-productivity firms have more than average market share, vice versa when negative.

Even though the underlying assumptions are different to the HK model, the intuition is the same; within an industry more productive firms should demand more factors of production, grow faster, and hence produce more output. Less productive firms, on the other hand, should work at a smaller scale, demand less production factors, and hence, produce less output than their high-productivity counterparts.[40]

5 Unbalanced Panel

This section focuses on the unbalanced panel. This means, the effects of entering and exiting firms on the sample composition are disregarded. To answer whether resource misallocation can explain the drop in aggregate TFP during the Great Recession in the UK, the static misallocation measures introduced in section 4 have to be analysed throughout time.

5.1 TFPR (Unbalanced Panel)

TFPR is the revenue measure of physical productivity and measures the profitability of a firm, (Foster et al., 2008). Table 4 and figure 3 show its behaviour from the years 2006 to 2014.[41,42] *Mean* is aggregate TFPR computed as the weighted average of all the industry means, *Std.Dev* is the aggregate standard deviation computed as the weighted average of all the industry standard deviations, and *90-10* is the difference between the 90th and the 10th percentile of the firm-level TFPR distribution.

Figure 3 shows that weighted aggregate TFPR drops by more than 10% with the onset of the crisis. In 2010 it starts to partially recover and levels off at around negative 6% compared to its pre-crisis level. The weighted standard deviation of revenue productivity drops steadily until 2011 by about 6.5%. It recovers halfway to be 2% below pre-crisis level.

Hsieh and Klenow (2009) find a standard deviation of 0.49 for the United States in 2005. However, they only consider the manufacturing sector and therefore restrict their analysis to only a fraction of the economy. Faggio et al. (2010) find a standard deviation for the entire UK economy that is steadily increasing from the years 1984

[40] In order to aggregate the covariance term to an economy-wide measure the following aggregator is used; $OP_t = \sum_{s=1}^{S_t} \theta_{s,t}(\sum_{i=1}^{N_t} \Delta\phi_{i,t}\Delta p_{i,t})$. Where the expression in brackets is the *covariance term* from equation (10). It is multiplied by $\theta_{s,t}$, which is the industry-output share on the whole economy and S_t is the total number of industries.

[41] Firm-level TFPR is computed as follows, $TFPR_i \equiv P_i A_i = \frac{P_i Y_i}{K_i^{\alpha_s} L_i^{1-\alpha_s}}$.

[42] For table 4, weighted aggregate TFPR and the difference between the 90th and the 10th percentile of the firm-level productivity distribution are normalised in 2007. This is done to better recognise the change from one year to the other.

to 2002. For the years between 1996 and 2002 they find a value of *0.787* and is hence close to the 2006 value found in this study, *0.6715*.

The decrease in the standard deviation indicates that the distribution of firms narrows. The difference between the 90th and the 10th percentile of the productivity distribution, *90-10*, confirms this finding. From 2007 until 2011 it decreases by more than 22%. In parallel to the above mentioned variables, it slightly recovers in the years after but stays considerably depressed until the end of 2014. Figure 4 plots the 10% least, blue line, and 10% most productive firms, black line, from 2006 until 2014. The figure shows that both tails contribute to the narrowing and the recovery of the productivity distribution, however, with the most productive firms assuming the dominant part in both phases.

Table 4: Dispersion of TFPR - Unbalanced Panel

Year	Mean	Std.Dev	90-10
2006	0.9621	0.6715	1.0162
2007	**1**	**0.6743**	**1**
2008	0.9707	0.6638	0.9003
2009	0.8943	0.6187	0.7985
2010	0.9071	0.6185	0.8091
2011	0.9203	0.6096	0.7512
2012	0.9323	0.6325	0.7766
2013	0.9127	0.6423	0.8490
2014	0.9411	0.6566	0.8983

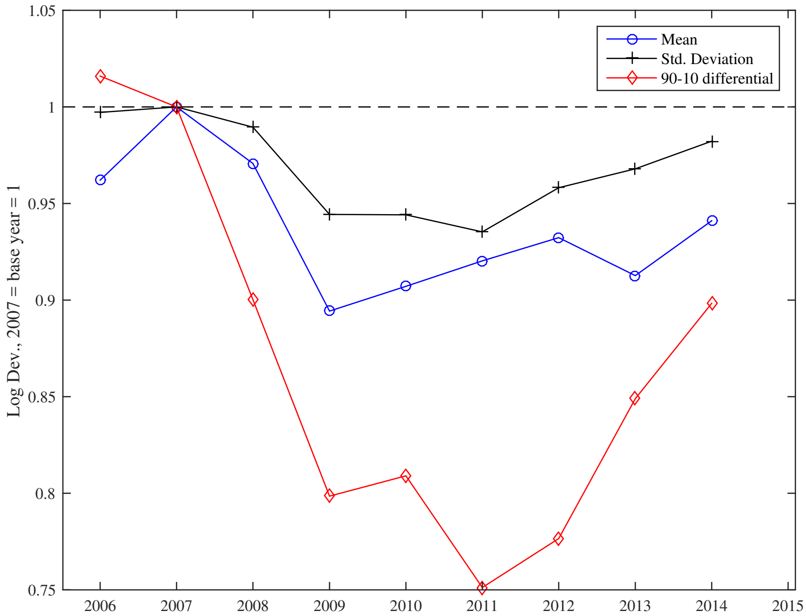
This subsection shows that while weighted aggregate TFPR drops with the onset of the Great Recession, the productivity distribution of firms begins to narrow and fails to fully recover thereafter. Alas, this does not say much about the possibility of resource misallocation between firms within the sample. The following subsections try to shed light on this issue.

5.2 MRPs (Unbalanced Panel)

Table 5 and figure 5 highlight the distribution of the MRPs. The figure shows that the MRP of capital, blue line, narrowly oscillates around its pre-crisis level in the four years following the outbreak of the crisis. In 2012 it increases until the end of 2014 to almost 4% above its pre-crisis level. By contrast, the MRP of labour, black line, declines by more than 7% from 2007 to the end of 2011. From 2012 to 2014 it starts to rise again without reaching its pre-crisis level.

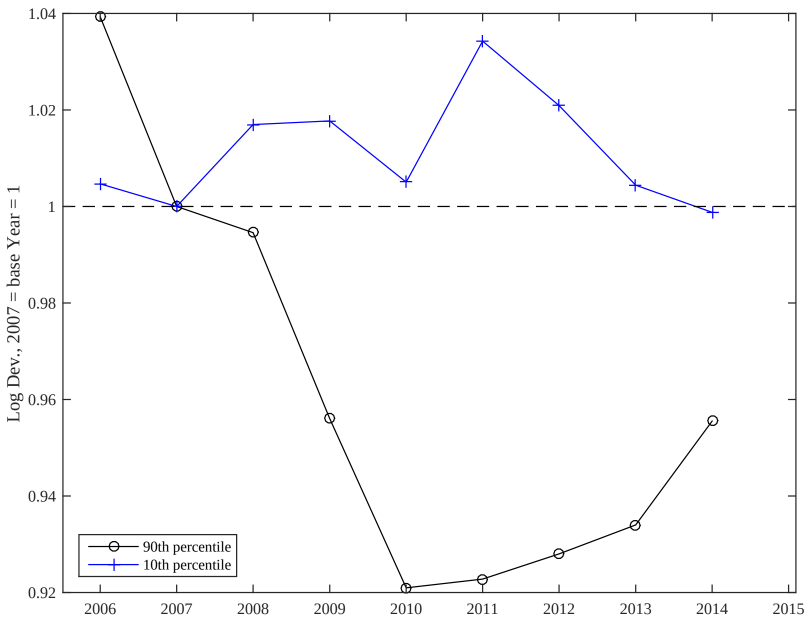
The findings are twofold. The former indicates that capital was not substantially misallocated with the onset of the crisis, but remained even until four years after

Figure 3: Dispersion of TFPR - Unbalanced Panel



Note: Industries are weighted by their industry total output shares.

Figure 4: 90th and 10th percentile of the TFP distribution - Unbalanced Panel



from where it deteriorated. The latter suggests the crisis saw labour to be allocated to more efficient firms, decreasing the productivity differential between firms with low and high MRPL and therefore decreasing misallocation.

Table 5: Standard Deviations of MRPs - Unbalanced Panel

Year	Std.Dev(MRPK)	Std.Dev(MRPL)
2006	1.2156	0.7371
2007	**1.2214**	**0.7435**
2008	1.2297	0.7280
2009	1.2165	0.6921
2010	1.2234	0.6795
2011	1.2030	0.6733
2012	1.2282	0.7059
2013	1.2439	0.7169
2014	1.2592	0.7258

5.3 HK indexes (Unbalanced Panel)

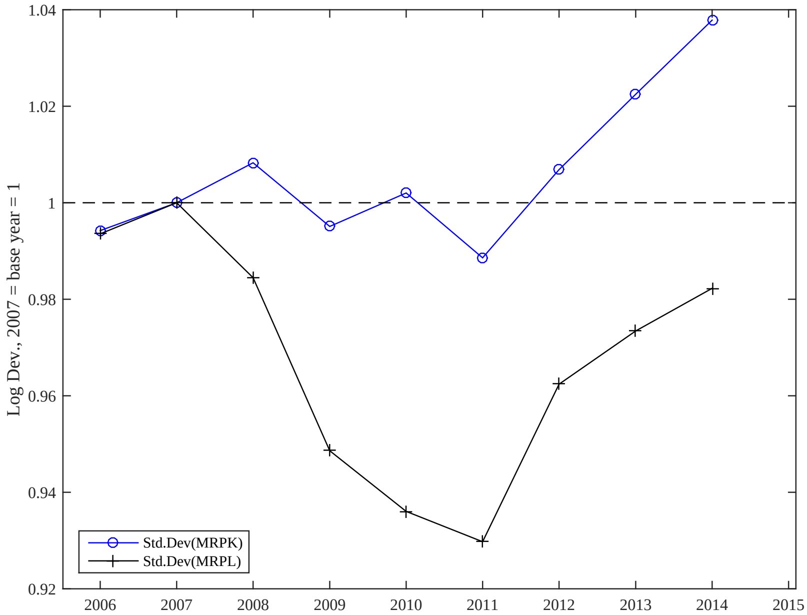
Table 6 and figure 6 show the HK misallocation indexes from 2006 to 2014. The output, blue line, and relative factor market distortion, black line, both fall at the beginning of the Great Recession by the end of 2007. τ_Y drops by almost 6% two years after the onset of the crisis and only partially *recovers* thereafter. τ_K drops by 5% in 2011 and *recovers* temporarily to its pre-crisis level in 2013.

Both indices infer that the HK model does not detect resource misallocation from high- towards low-productive firms with the onset of the Global Financial Crisis by the end of 2007. On the contrary, the model finds resources to be allocated to a more efficient use. Therefore, the drop in aggregate TFP cannot be explained by the misallocation hypothesis.

5.4 Counterfactual Simulations HK (Unbalanced Panel)

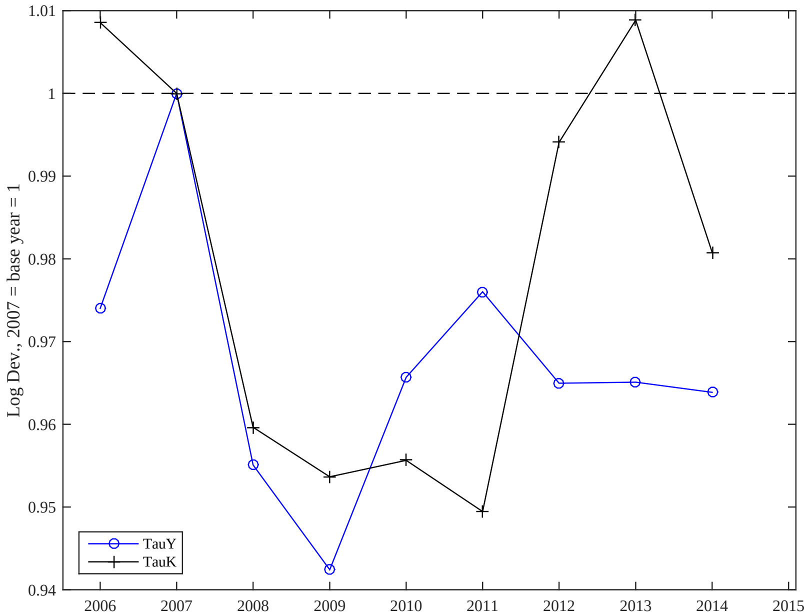
The first counterfactual simulation computes potential TFP assuming that misallocation does not change after 2007. The first step to do so is to quantify the degree of within-industry misallocation in the base year. In the second step, this measure is then imposed on the crisis years' productivity levels. The latter results in a TFP level that would have been observed had misallocation not changed with the beginning of the crisis. In the last step, observed and potential TFP are compared to quantify the effect resource misallocation has on the past-crisis TFP level. Figure 7 and the first

Figure 5: Standard Deviations of MRPs - Unbalanced Panel



Note: Industries are weighted by their industry total output shares.

Figure 6: HK Misallocation Measures - Unbalanced Panel



Note: Industries are weighted by their industry total output shares.

Table 6: HK Misallocation Measures - Unbalanced Panel

Year	τ_Y	τ_K
2006	0.9740131	1.0085
2007	**1**	**1**
2008	0.9550844	0.9596
2009	0.9424215	0.9536
2010	0.9656821	0.9556
2011	0.976019	0.9494
2012	0.9649659	0.9941
2013	0.9650905	1.0088
2014	0.9638635	0.9808

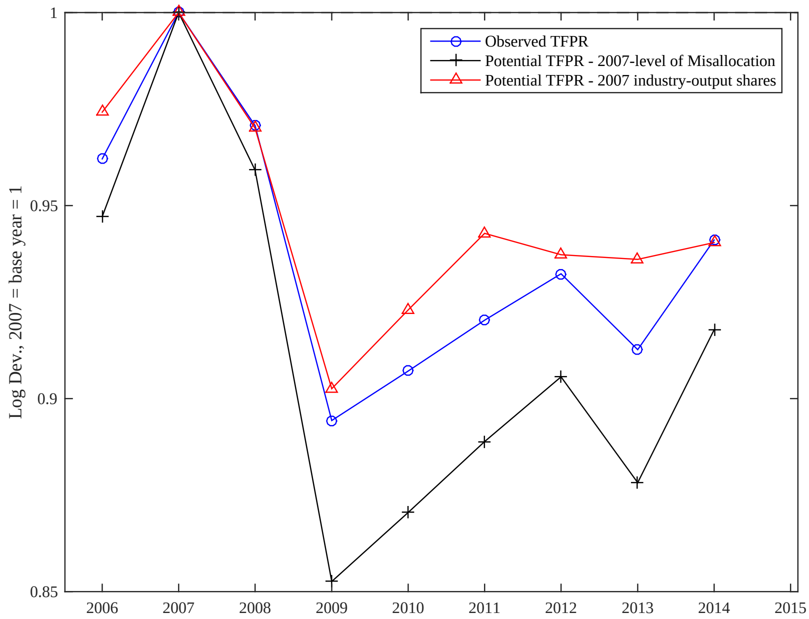
two columns in table A2 show the results. While observed TFP, blue line, drops by almost 10.5% two years after the beginning of the crisis, potential TFP, black line, falls by almost 15%. This is because within-industry misallocation through the HK model, subsection 5.3, improves after 2007. However, as the misallocation indexes begin to partially *recover* three years after the outbreak of the crisis, the gap between observed and potential TFP narrows again, from 4.17% (89.43-85.26%) in 2009 to 2.33% (94.11-91.78%) in 2014.[43]

The second counterfactual simulation fixes industry-output shares at their 2007 levels. This emphasises the importance of between-industry misallocation in the evolution of aggregate TFP, (Garcia-Santana et al., 2016). The red line in figure 7 and the last column in table A2 show the results. From 2007 to 2009 the values between observed and potential TFP is approximately zero. The difference widens in 2011 to 2.25% (94.28-92.03%) after which it approaches zero again in 2014. This implies that in the years 2010, 2011 and 2013 TFP would have dropped slightly less, had resources not moved away from industries with a higher productivity towards industries with a lower productivity. However it does not play a role during the outbreak of the crisis, nor does it explain why productivity stays depressed thereafter.[44]

[43] In order to compute potential TFP gains, the model had to be solved and resimulated. The author is indebted to Manuel Garcia-Santana who was kind enough to supply the computer code for solving the model.

[44] On the other hand, if potential TFP experienced a bigger drop when industry-output shares are constant compared to a constant level of within-industry misallocation, the conclusion would be that the misallocation between industries is more important in cushioning the drop in TFP.

Figure 7: Counterfactual TFP computations - Unbalanced Panel



Note: Industries are weighted by their industry total output shares.

5.5 OP Covariance (Unbalanced Panel)

From 2007 to 2008 the OP covariance term slightly increases, see figure 8 and table 7. In 2009, however, it heavily drops and therefore implies that more market share is allocated towards relatively less productive firms. Between 2010 and 2014 the covariance fully recovers and market shares move back towards firms with higher relative productivities.

In contrast to the former methodology, the OP model indicates that resource misallocation worsens, if only from 2008 to 2009. This disagreement between the findings of both measures of misallocation can be explained by the difference in assumptions. Whereas HK's fundamental assumption is that the volatilities of productivity measures determine resource misallocation, OP argue that relative markets shares and relative productivities need to move into opposite directions for resource misallocation to occur. Therefore and consistent with both theories, the beginning of the Great Recession tightened the distribution of firms and at the same time, and only for a year, reallocated market share towards relatively less productive firms.

Table 7: OP Covariance - Unbalanced Panel

Year	OP Covariance
2006	1.0613
2007	**1.7543**
2008	1.8157
2009	0.1365
2010	1.1788
2011	1.0245
2012	1.0662
2013	1.3993
2014	1.9937

5.6 Sensitivity Analysis OP (Unbalanced Panel)

This exercise fixes the industry-output shares at their respective 2007 level. This gives some indication of whether the allocation of market shares within or between industries drives the finding in subsection (5.5).

The blue line in figure 9 is the OP covariance term as shown above. The black line is the OP covariance term once the industry-output shares are fixed at their 2007 level. Except for slight differences in 2008 and 2011, both covariance terms overlap. This suggests that changes in relative market shares and relative productivities are driven by the dynamics of firms within industries as opposed to firms between industries. The changes in the allocation of market shares between industries in 2008 and 2011 are not strong enough to fundamentally drive the results and therefore are neglected.

6 Balanced Panel

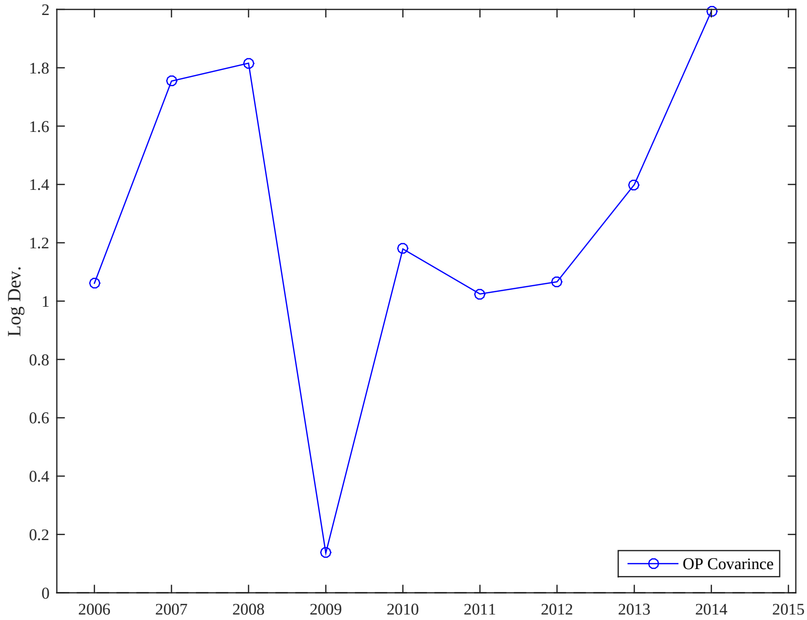
This section focuses on the behaviour of aggregate TFP and misallocation within the balanced panel.[45]

6.1 Aggregate TFP (Balanced Panel)

Figure 10 shows detrended aggregate TFP for the balanced panel, blue line, and for the unbalanced panel, black line. With the start of the Great Recession aggregate

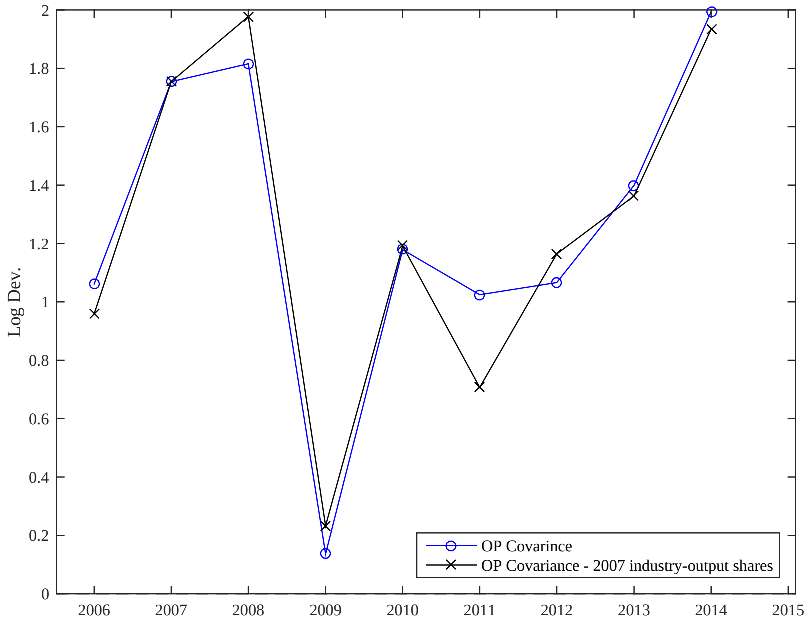
[45] To compile a balanced panel dataset, all firms that did not exist in 2006 and lasted until 2014 were erased. The result was a dataset that consists of almost 17,500 observations between 2006 and 2014. In comparison, the unbalanced panel consists of more than 40,000 observations. At first glance this hints towards substantial dynamics of firms leaving and entering the sample.

Figure 8: OP Covariance - Unbalanced Panel



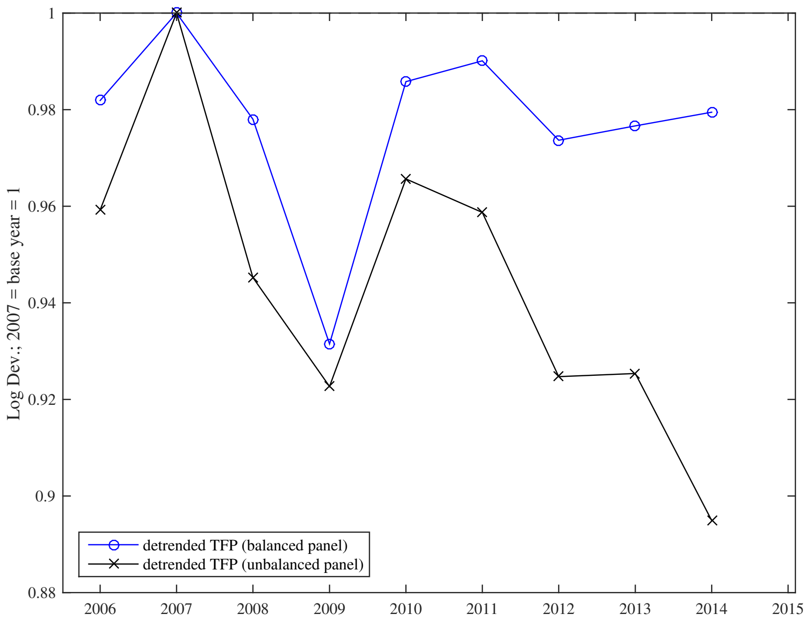
Note: Industries are weighted by their industry total output shares.

Figure 9: OP Covariance - Sensitivity Analysis - Unbalanced Panel



Note: Industries are weighted by their 2007 industry total output shares.

Figure 10: Detrended TFP - Balanced vs. Unbalanced Panel



Note: aggregate $\widehat{TFP}_t = \frac{\sum_{i=1}^{M} \widehat{Y_{i,t}}}{\sum_{i=1}^{M} \widehat{K_{i,t}}^{\alpha} \sum_{i=1}^{M} L_{i,t}^{1-\alpha}}$. *Where M is the number of firms in the entire economy.*

TFP for the balanced panel drops less than for the unbalanced panel, 2.2% vs. 6.8% in 2008 and 6.8% vs. 7.3% in 2009. In 2010 the former substantially recovers and closely approaches its pre-crisis trend level in 2011, whereas the latter continues to drop, thereby widening the TFP differential between both sets. In 2014 aggregate TFP for the balanced panel is 2% and for the unbalanced panel 10.5% below its pre-crisis trend.[46] This difference in TFP levels highlights that the unbalanced panel contains information that is crucial in explaining the severe and permanent drop in aggregate TFP during the crisis. By construction, this gap is the dynamics of entering and exiting firms.

6.2 Misallocation (Balanced Panel)

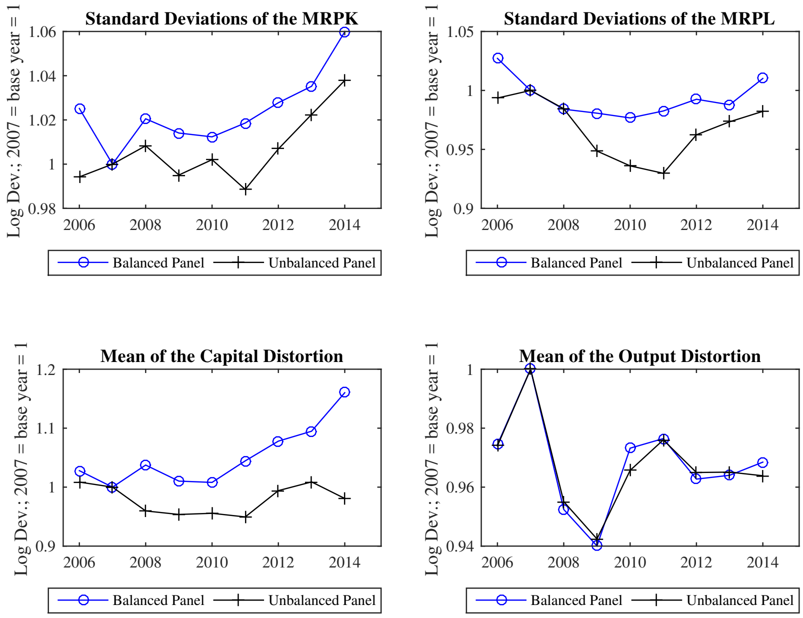
6.2.1 HK indexes

Figure 11 shows the mean values for the HK indexes. The left panel highlights the relative factor market distortion, τ_K, and the right panel the output distortion, τ_Y.

The former increases for the balanced panel, blue line, with the beginning of the crisis. This suggests that factor market distortions worsen for the firms that survive

[46]Table A3 shows the drop in detrended aggregate TFP for the balanced panel.

Figure 11: HK - Balanced vs. Unbalanced Panel



Note: Industries are weighted by their industry total output shares.

from 2006 to 2014. The measure seemingly improves for the unbalanced sample, black line.

The output distortions for the balanced and the unbalanced panel are the same throughout the whole time period, right panel. This indicates that surviving firms experienced an improvement in the output distortions in a similar way as entering and exiting firms.

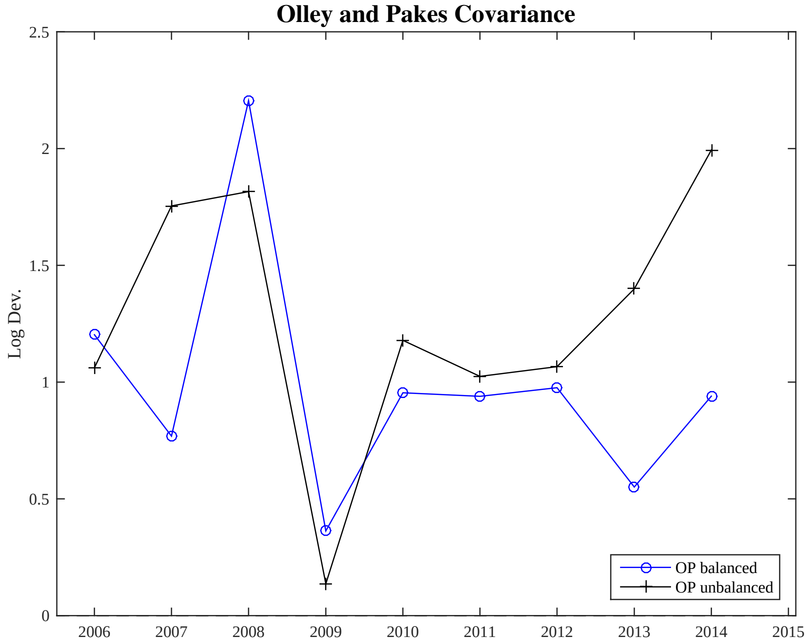
The analysis shows that neither factor market nor output distortions can account for the immediate drop of aggregate TFP in the balanced panel. Regarding the second half of the crisis period, however, relative factor market distortions might impede TFP to fully recover towards its pre-crisis trend level.

6.2.2 OP Covariance

Figure 12 shows the OP covariance term for the balanced panel, blue line, and the unbalanced panel, black line. In the first year of the crisis, balanced panel market shares are increasingly allocated towards more-productive firms. In 2009 this efficient allocation is reversed and drops below its pre-crisis level. In the year after, allocation recovers and stabilises marginally above its 2007 level.

The allocation of market share away from high-productivity firms from 2008 to

Figure 12: OP - Balanced vs. Unbalanced Panel



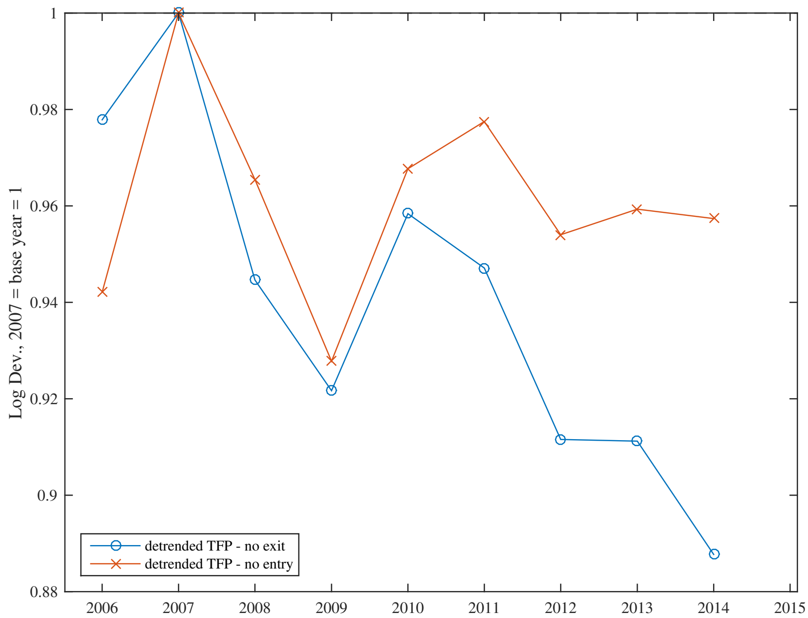
Note: Industries are weighted by their industry total output shares.

2009 might contribute in the severe drop in TFP during that year. However, it does not explain why TFP already starts to drop in 2007 and why it stays permanently below its pre-crisis trend level.

7 Firm Dynamics

The comparison between the unbalanced and the balanced panel highlights two of the main results found in this study. 1) Aggregate TFP for the unbalanced drops considerably more than for the balanced panel. 2) Resource misallocation cannot account for the drop in aggregate TFP in the unbalanced, but can partially explain the drop in the balanced panel. The reason for both findings lies in the composition effects of both panels. That is, whereas the unbalanced panel contains firms that enter and exit the sample, the balanced panel does not. Therefore, both results are due to the dynamics of firms moving into and out of the sample.

Figure 13: TFP - Entry vs. Exit



Note: aggregate $\widehat{TFP}_t = \frac{\sum_{i=1}^{M} \widehat{Y_{i,t}}}{\sum_{i=1}^{M} \widehat{K_{i,t}}^{\alpha} \sum_{i=1}^{M} L_{i,t}^{1-\alpha}}$. *Where M is the number of firms in the entire economy.*

7.1 Firm dynamics and aggregate TFP

To check whether the drop in aggregate TFP is due to the entry of low-productivity or the exit of high-productivity firms, figure 13 plots TFP for two different samples. In the first, firms are prohibited to exit but are allowed to enter, blue line, and in the second, firms are free to exit but cannot enter, orange line. Both samples experience a comparable downturn from 2007 to 2009 of around 8%, and a comparable recovery from 2009 to 2010 to about negative 4% compared to pre-crisis trend level. From 2010 until the end of 2014, however, both assume different patterns. On the one hand, the sample which allows firms to exit but not to enter stabilises at this level until the end of 2014. On the other hand, the sample in which firms are free to enter but cannot exit keeps on declining to a value of around negative 11.5% compared to trend level. This highlights that during the immediate crash, high-productivity firms exit and low-productivity firms enter the economy. Once the economy has partly recovered from its initial shock in 2010, high-productivity firms stop exiting, but low-productivity firms still enter, which leads to a continues decline of aggregate TFP from its pre-crisis trend level.

7.2 Firm dynamics and resource misallocation

Firm dynamics also explain the apparent improvement in misallocation measures in the unbalanced panel, see section 5. The preceding subsection shows that with the beginning of the crisis high-productivity firms exit and low-productivity firms enter the economy. Figure 4 highlights that the former causes the 90th percentile of the productivity distribution to contract. The 10th percentile, on the other hand, increases. This indicates that the entry of low-productivity firms does not contribute to a decline in TFP of the least efficient firms. Rather, entering firms must have a productivity level that is low enough to drag aggregate TFP down, but strong enough not to increase the left tail of the productivity distribution. It follows that in the years between 2008 and 2011, the productivity distribution moves closer together, ultimately leading to an improvement in the HK misallocation measures, figure 6. From 2011 onwards, however, this process reverts. The productivity of the least efficient firms again falls and the productivity of the most efficient firms rises. This increases the productivity distribution, leading to an apparent worsening of the HK indexes.

For the unbalanced panel, the drop in the OP covariance term from 2008 to 2009, figure 12, is driven by the reallocation of market share from high towards less productive *incumbent* firms. The pattern and the magnitude of both samples are almost identical. From 2009 onwards, however, entering and exiting firms determine the apparent recovery in the unbalanced sample. This is because the entry of low-productivity firms increases the relative TFP endowment of the incumbent firms. Meaning that t-1 low-productivity firms become, conditional on the exit of high and entry of less productive firms, t+1 high-productivity firms. This algebraically renders the degree of misallocation in favour for a more efficient allocation of market shares. Table 8 shows the yearly entry and exit rate, and the difference between both. Coinciding with the rise of the OP covariance term in the unbalanced sample, the entry rate rises in 2009 whereas the exit rate falls. This suggests that an increasing fraction of the sample consists of firms that lower the productivity average, thereby changing the relative productivity endowment of incumbent firms.

8 Sectoral Analysis

This section decomposes the economy into its individual sectors.

8.1 Sectoral TFP

Figure 14 shows TFP for the *manufacturing* sector, upper left-hand side, and for the *service* sector, upper right-hand side. The blue line represents the balanced and the

Table 8: Churn Rate

Year	Entry Rate (in %)	Exit Rate (in %)	Difference (percentage points)
2006-2007	16.4	14.3	2.1
2007-2008	15.9	15.1	0.8
2008-2009	15.6	14.7	0.9
2009-2010	18.1	12.3	5.8
2010-2011	17.6	11.0	6.6
2011-2012	17.0	10.3	6.7
2012-2013	18.7	9.7	9.0
2013-2014	19.4	12.4	7.0

black line the unbalanced panel.

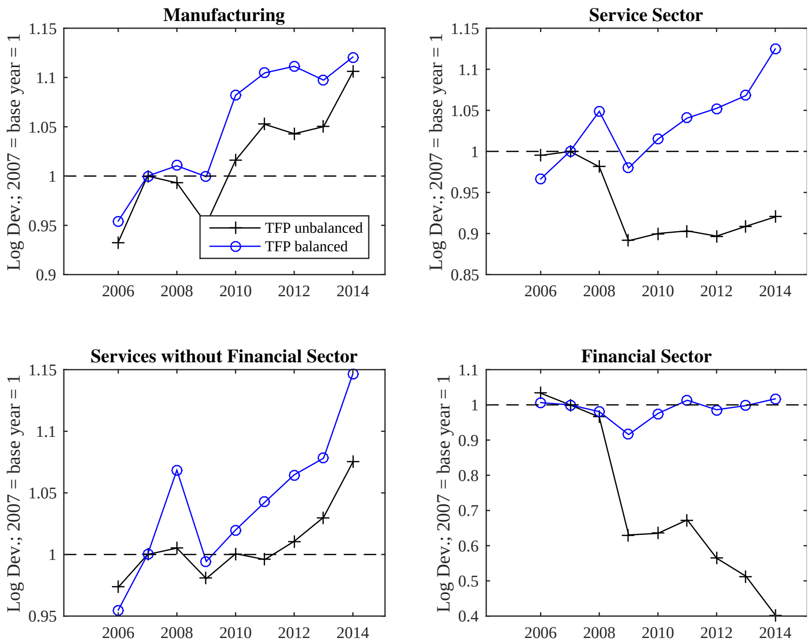
Manufacturing TFP for either sample drops with the onset of the crisis, stabilises shortly after and exceeds its pre-crisis level by 2010. For the service sector, however, TFP in each panel behaves differently. In the balanced panel it keeps on increasing from 2007 to 2008. From there it drops by around 8% in 2009, just to subsequently recover thereafter above its pre-crisis value. For the unbalanced panel, on the other hand, it permanently declines by the end of 2007 to negative 11% and stays around this level until the end of the sample period.[47]

Given the obvious importance of the service sector in the behaviour of aggregate TFP, the bottom row in figure 14 highlights its decomposition into *services without the financial sector*, left-hand side, and the *financial sector* on its own, right-hand side.[48] The former shows that TFP for both panels rises from 2007 to 2009, drops from 2009 to 2010 and fully recovers in the years after. In the latter the balanced panel behaves similar. That is, TFP in the financial sector drops from 2007 to 2009 and fully recovers to its pre-crisis level thereafter. For the unbalanced panel, however, it plummets by around 40% in the first two years of the crisis. It stabilises until 2011 and begins another descent until the end of the sample period. By the end of 2014, the financial sector lost around 60% of its TFP. This substantial drop highlights the importance of the financial sector's performance during the Global Financial Crisis and its influence on aggregate TFP.

[47] Since the *manufacturing* and the *service* sector are the biggest sectors in the UK economy, this study focuses on these sectors. Sectoral TFP for the *agricultural*, *mining and quarrying*, *utility*, *construction*, *trade*, and *public* sector is shown in figure B3 in the appendix.

[48] To be precise, the financial sector also contains *insurance* activities.

Figure 14: Sectoral TFP for the UK between 2006 and 2014



8.2 Sectoral Misallocation

Sections 8.2.1 and 8.2.2 measure misallocation on a sectoral level for the unbalanced and the balanced panel respectively.

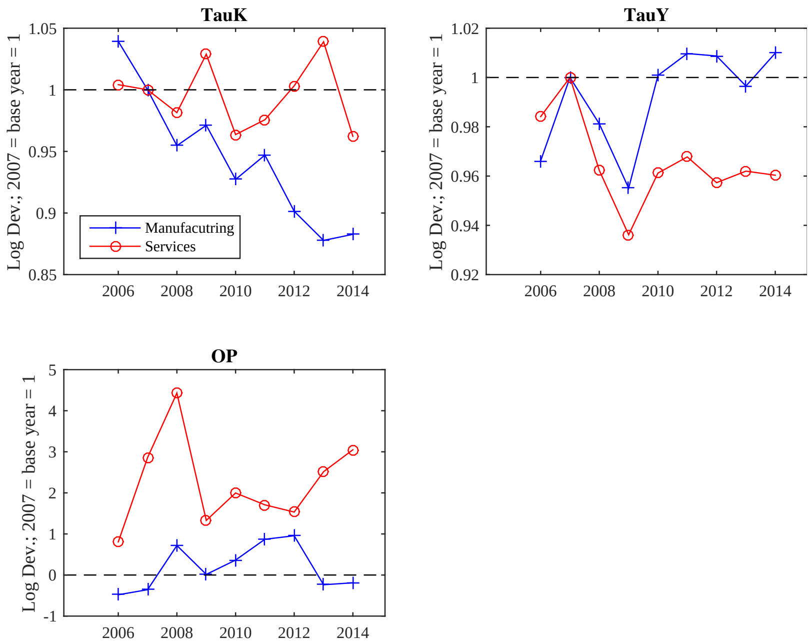
8.2.1 Unbalanced Panel

Figure 15 highlights that misallocation for the manufacturing sector, blue line, improves during the immediate aftermath of the crisis. Both HK measures drop and the OP covariance term rises. The relative factor market distortion and the OP covariance term imply a permanent decrease in resource misallocation. The output distortion, on the other hand, increases from 2009 to 2010 back to its pre-crisis level.

The same is true for the service sector, red line. That is, misallocation improves in the first year of the crisis. Following that year, however, the relative factor market distortion and the OP covariance term worsen. The former maintaining a high volatility around its pre-crisis level. The latter redistributing market share away from high-productivity firms towards low-productivity firms until the end of 2012.

Figure 16 decomposes the service sector into services without the financial sector, red line, and the financial sector, blue line. The relative factor market distortion worsens for the former sample and improves for the latter. The output distortion improves for both panels. The OP covariance term for the financial sector experiences

Figure 15: Unbalanced Panel - Sectoral Misallocation I



Note: Industries are weighted by their industry total output shares.

vast changes in reallocation. In 2007 the term rises and plummets in the years after. From 2012 to 2014 it marginally increases again but fails to recover its pre-crisis level. For services without finance, the OP covariance term steadily ascents from the beginning until the end of the sample period. Overall it is apparent that the financial sector drives the OP covariance term in the service sector and that its firms are more dynamic than firms in the rest of the service sector.

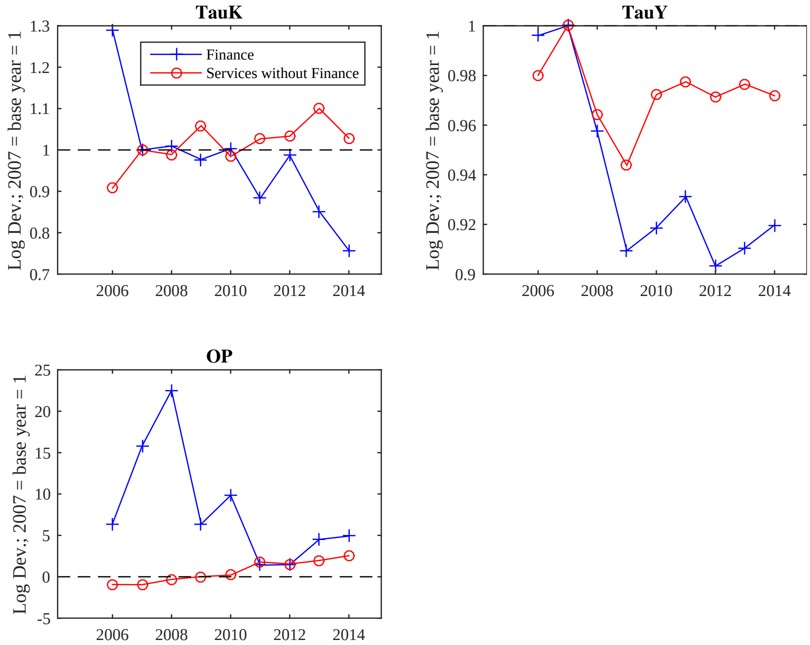
8.2.2 Balanced Panel

Figure 17 presents the misallocation measures for the manufacturing sector, blue line, and the service sector, red line, in the balanced panel.

According to the HK indexes and the OP covariance term, misallocation in the manufacturing sector improves in the first year of the crisis. In the years after, all three measures revert and misallocation worsens until the end of 2014. The service sector, on the other hand, experiences an improvement in the allocation of market share and a decrease in output distortions from 2007 to 2008. Both revert thereafter and gradually approach their pre-crisis levels. With the exception of 2009 and 2010, the relative factor market distortion permanently worsens during the crisis periods.

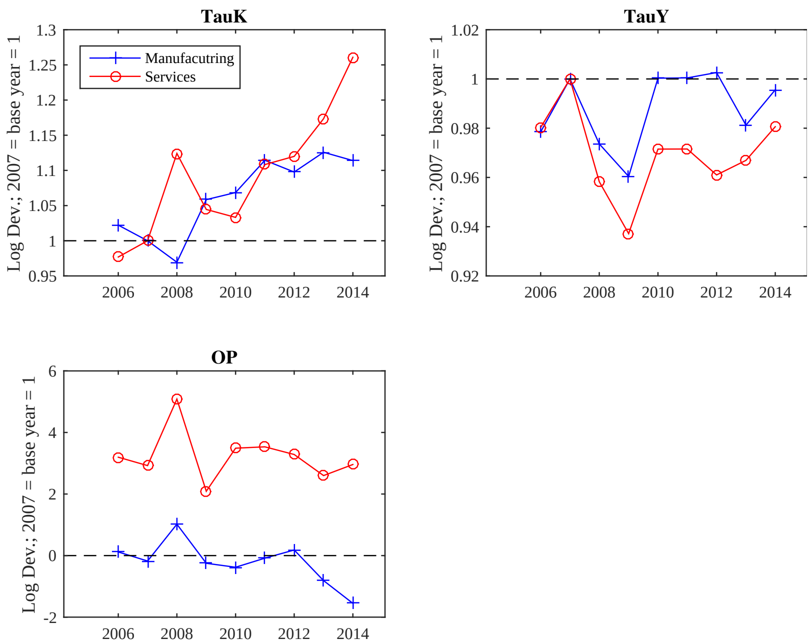
Figure 18 decomposes the service sector into services without the financial sector,

Figure 16: Unbalanced Panel - Sectoral Misallocation II



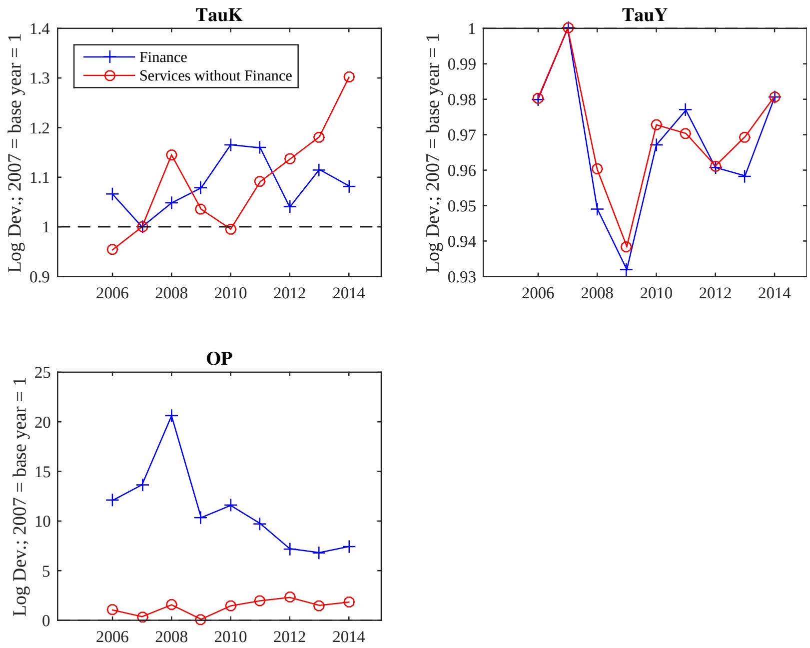
Note: Industries are weighted by their industry total output shares.

Figure 17: Balanced Panel - Sectoral Misallocation I



Note: Industries are weighted by their industry total output shares.

Figure 18: Balanced Panel - Sectoral Misallocation II



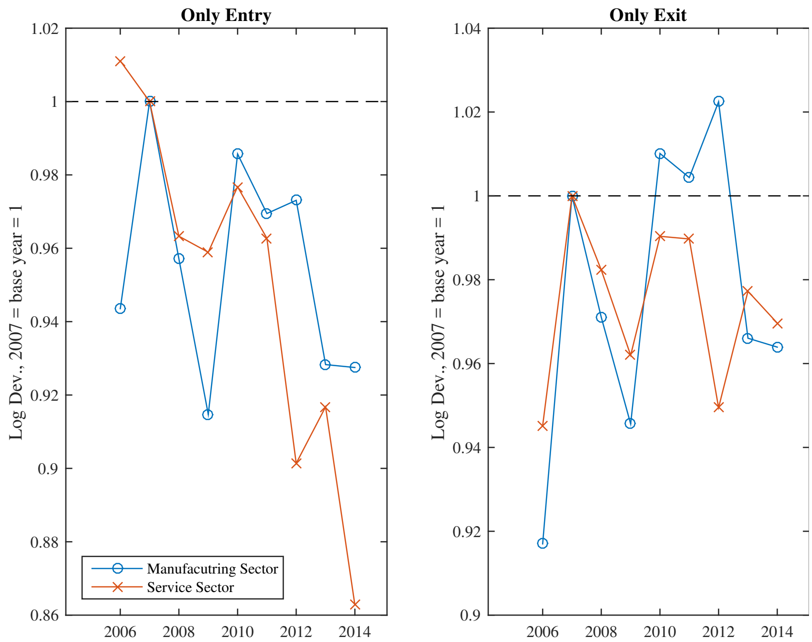
Note: Industries are weighted by their industry total output shares.

red line, and the financial sector, blue line. For both sets the HK indexes move in tandem. That is, the relative factor market distortion worsens with the beginning of the crisis until the end and the output distortion improves with the onset of the crisis and gradually approaches its pre-crisis level thereafter. Comparable to the unbalanced panel analysis above, the OP covariance term for the financial sector experiences vast changes in reallocation. In 2007 it rises and plummets in the years after. Except for 2009, the OP covariance term for services without finance steadily ascents. Like in the unbalanced panel analysis above, the change in financial sector market shares throughout the crisis drives the OP covariance term for the whole service sector.

8.3 Sectoral Firm Dynamics

Figure 19 shows sectoral detrended TFP for a sample in which firms are allowed to enter but not to exit, left-hand side, and in which firms are allowed to exit but not to enter, right-hand side. Except for 2012, both sets, the manufacturing sector, blue line, and the service sector, orange line, show similar patterns. That is, they drop and rise in the same years. This suggests that the dynamics of entering and exiting firms were similar in the two major sectors of the economy. On the other hand, considering the absolute productivity level highlights that with the onset of the crisis

Figure 19: Sectoral Firm Dynamics I



Note: aggregate $\widehat{TFP}_t = \frac{\sum_{i=1}^{J} \widehat{Y_{i,t}}}{\sum_{i=1}^{J} \widehat{K_{i,t}}^{\alpha} \sum_{i=1}^{J} L_{i,t}^{1-\alpha}}$. *Where J is the number of firms in the respective sector.*

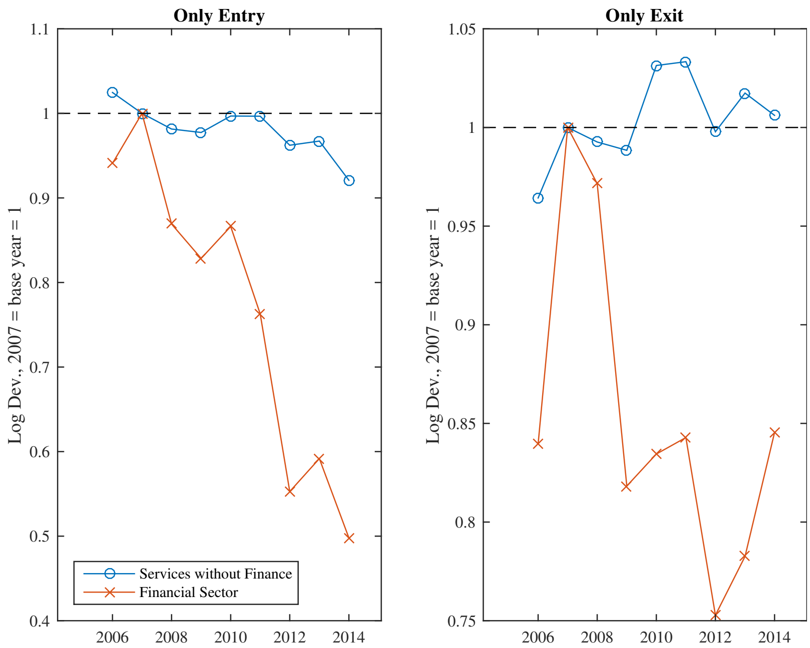
the service sector experiences a higher increase of low-productivity firms entering and high-productivity firms exiting the economy.

Figure 20 presents the same analysis and decomposes the service sector into Services without the Financial Sector, blue line, and the Financial Sector, orange line. The figure distinctly shows that the financial sector drives the results for both panels. That is, low-productivity firms that enter and high-productivity firms that leave the economy are concentrated in financial sector and thereby, through the magnitude of the service sector, drive the steep and long-lasting drop in aggregate TFP.

9 Conclusion

Research shows that financial crises are accompanied by severe and long-lasting drops in TFP. The most recent Global Financial Crisis does not seem to be any different from this pattern. On the contrary, Gerth and Otsu (2017) find significant correlations between financial variables and long-lasting drops in aggregate productivity measures for a myriad of European countries. This finding matches a branch of structural models that saw their advent in the aftermath of the financial crisis that began by

Figure 20: Sectoral Firm Dynamics II



Note: aggregate $\widehat{TFP}_t = \frac{\sum_{i=1}^{J} \widehat{Y_{i,t}}}{\sum_{i=1}^{J} \widehat{K_{i,t}}^{\alpha} \sum_{i=1}^{J} L_{i,t}^{1-\alpha}}$. *Where* J *is the number of firms in the respective sector.*

the end of 2007. Even though each of these models chooses different measures to indicate financial distress in the economy, the mechanism how a financial shocks propagates is uniform. That is, through resource misallocation. This study therefore tries to empirically determine whether these models are valid to explain the behaviour of the UK economy during the last 8 years. In order to do this, the paper relies on the FAME dataset. This is a micro-level dataset that contains more than 9 million firms within the UK. Together with the Hsieh and Klenow (2009) and the Olley and Pakes (1996) methodologies, this firm-level dataset is then used to quantify potential within-industry resource misallocation.

The results are surprising. That is, while the manufacturing sector recovers three periods after the beginning of the crisis, the service sector drives the severe and long-lasting drop in aggregate TFP in the UK from 2008 to 2014. Therefore, analysing only the manufacturing sector leads to spurious results. Second, resource misallocation does not account for the drop in sectoral TFP of any of these sectors and therefore fails to explain the drop in aggregate productivity. Third, the drop in aggregate TFP is due to low-productivity firms entering and high-productivity leaving the sample. Observing turnover for the manufacturing and the service sector highlights the fourth finding. That is, the pattern of firm dynamics in and out of the sample is the same for both sectors. And last, the financial sector, as part of the service sector, drives productivity levels and firm dynamics of the service sector. These findings conclude that structural models that rely on the misallocation mechanism of firms within industries to explain low-levels of TFP fail to represent the behaviour of the UK economy during the Great Recession in the UK.

There are several extensions to this study. First, industries are defined as firms with a common 2-digit UK SIC code. It would be interesting to see whether the findings still hold if a narrower definition is used. This, however, comes at a cost. Narrowing the industry definition trades off precision in the variables used to compute productivity and misallocation measures. That is to say, value added has to be constructed in a less accurate way. Second, past-within productivity effects of firms that are about to exit or future-within productivity effects of firms that are about to enter cannot be identified. This might lead to possible under- or overestimation of productivity measures. To elaborate on this issue, future research should focus on dynamic productivity decomposition techniques that decompose the effect surviving, entering and exiting firms have on the evolution of aggregate TFP within the crisis economy.

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A Tables

Table A1: Aggregate TFP - Unbalanced Panel

Year	TFP
2006	0.9592
2007	**1**
2008	0.9452
2009	0.9227
2010	0.9657
2011	0.9587
2012	0.9247
2013	0.9254
2014	0.8949

Table A2: Counterfactuals - Unbalanced Panel

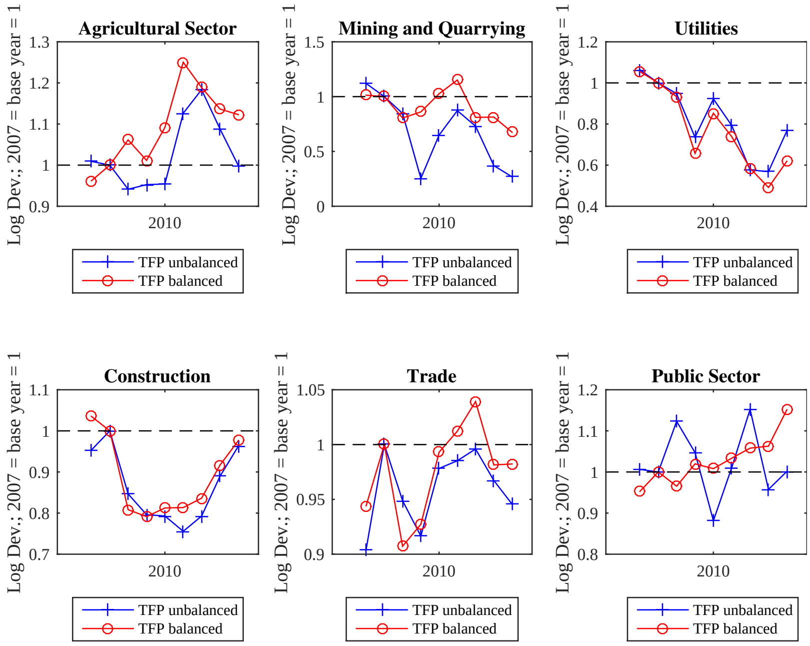
Year	observed TFPR	Potential TFPR 2007-level of Misallocation	Potential TFPR 2007 industry-output shares
2006	0.9621	0.9471	0.9742
2007	**1**	**1**	**1**
2008	0.9707	0.9592	0.9700
2009	0.8943	0.8526	0.9026
2010	0.9071	0.8705	0.9230
2011	0.9203	0.8889	0.9428
2012	0.9323	0.9056	0.9373
2013	0.9127	0.8782	0.9361
2014	0.9411	0.9178	0.9404

Table A3: Aggregate TFP - Balanced Panel

Year	TFP
2006	0.9819
2007	**1**
2008	0.9780
2009	0.9315
2010	0.9858
2011	0.9901
2012	0.9737
2013	0.9767
2014	0.9795

B Figures

Figure B3: Sectoral detrended TFP for the UK between 2006 and 2014 period



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